Transgrid

2025 Transmission Annual Planning Report

Acknowledgement of Country

In the spirit of reconciliation, the Transgrid Group acknowledges the Traditional Custodians of the lands where we work, the lands we travel through and the places in which we live.

We pay respect to the people and Elders past and present, and celebrate the diversity of Aboriginal and Torres Strait Islander peoples and their ongoing connections to the lands and waters of NSW and the ACT.

Cover: Joseph Arrowsmith - Substations Technician

Murrumbidgee River, Riverina NSW

Artwork: Yura. Gili. Nanga. the indigenous interpretation of Power. People. Possibilities

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Purpose of the Transmission Annual Planning Report

Transgrid

As the Transmission Network Service Provider in NSW, Transgrid leads the forward planning of the state's transmission system.

Each year, we undertake a rigorous planning review in line with National Electricity Rules – ensuring critical transmission infrastructure is delivered when it is needed and at least cost to consumers. This work is essential to unlocking the clean energy transition.

Our annual planning looks beyond today. We consider future changes in energy use and supply, including demand growth, generation developments and system changes. With rooftop solar and electrification reshaping when and how energy is used, we're adapting to a widening 'demand envelope': higher peaks and lower minimums. By planning for what's next, we're building a resilient, efficient network that keeps pace with the transition.

This Transmission Annual Planning Report is an important part of our asset management approach. It aligns with our broader Network Asset Strategy to ensure we continue delivering safe, reliable and efficient network services to the communities we power.

Producing our Transmission Annual Planning Report involves joint planning with:

- The Australian Energy Market Operator (AEMO) at the national level
- The Energy Corporation of NSW (EnergyCo) at the state level
- Each distribution network service provider in NSW (Ausgrid, Endeavour Energy, and Essential Energy) and the ACT (Evoenergy)
- Powerlink in Queensland, ElectraNet in South Australia, AEMO Victorian Planning and Transmission Company Victoria.

Together with these partners, we're committed to building the network of the future in the most efficient way – so the energy transition delivers value to consumers by keeping electricity reliable and affordable.

We also work closely with EnergyCo to ensure Renewable Energy Zones (REZs) can connect to the national transmission backbone without undermining system security – a critical element of achieving a stable and sustainable energy transition.

Each year, we assess what's changing across the system, from new generation and storage projects, to planned retirements, to shifting demand and asset conditions. This helps us decide where upgrades are needed and how to manage the changing grid to keep it reliable.

In particular, we look at:

- Emerging network constraints and how best to fix them
- What to do with assets reaching the end of their serviceable lives.

In both cases, the information in the Transmission Annual Planning Report helps third parties come up with options, including non-network solutions, to meet these needs.

We put all the options on the table through our investment framework to find the best solution. We're looking for options that support system strength and reliability while keeping multiple pathways open as the energy system evolves. This allows us to both respond to changing stakeholder needs and deliver our capital program efficiently.

Transgrid makes sure long-term transmission planning meets Australia's national needs by contributing to AEMO's Electricity Statement of Opportunities and Integrated System Plan. These publications also feed into the Transmission Annual Planning Report, and we report on relevant matters arising from them.

This is how we not only build the infrastructure needed now but also prepare for future demand and net zero goals beyond 2035.

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Foreword

Strong partnerships and community trust are essential to unlocking investment and delivering affordable, secure electricity for all energy consumers as we enter a new deep transition phase and accelerate towards 90% renewable energy.

Australia has completed the initial phase of the energy transition. In 2025, we are moving into its most transformative decade yet.

Over the past 20 years, we have been in a ramp-up phase, with much planning, building and connecting of renewables into the grid. But the technical fundamentals of the power system have remained the same, dominated by coal power and relying on the long established transmission network.

We now enter a new decade of the transition – the deep transition phase between 2025 and 2035 – which is the focus of this Transmission Annual Planning Report. Coal is rapidly closing, while even more renewable generation, storage and transmission will be built. How the system is supported and how consumers interact with energy will be far more dynamic and complex. During this time, we forecast NSW will transition from around 40% renewable energy now to around 90% in 2035. Navigating this phase presents complex challenges to minimise costs and maximise system security. Success will require collaborating with all participants in energy sectors and building on a foundation of trust in affected communities.

Beyond 2035, Australia will enter the final phase of transition. This new transitioned era is our destination: a decarbonised grid operating in a post-transition mode. While the final few percentage points of generation will still shift to cleaner sources, our task will be to efficiently run a highly renewable system, adapting to economic growth, regional shifts in demand and the needs of an electrified society. You can see our thinking about what will happen in this phase in the final section of Chapter 1.

Planning for the intensity of the deep transition phase

Transgrid is working across the energy sector to anticipate the challenges and opportunities that lie ahead in the next decade.

There's a lot to do in the next 10 years, and it will take true collaboration to move the energy transition forward while keeping the grid stable and reliable. We need generation, storage and network investments to be planned and delivered in lockstep. It will take the aligned efforts of AEMO, EnergyCo, Transgrid and the Distribution Network Service Providers (DNSPs) to accelerate progress, ensure renewable generation and security services are ready on time as coal retires, and deliver real benefits for energy customers. We can see the power of collective action at work in the rapid growth in the pipeline of storage projects – supported by NSW Government funding to accelerate key initiatives.

In NSW, the planning focus is to serve energy consumers and customers by ensuring an affordable, reliable and secure supply during the transition to renewable generation. As this year's Transmission Annual Planning Report shows, we are working with the sector to progress the main transmission projects that will form the backbone of the National Electricity Market in NSW and the ACT, connecting more affordable renewables at speed and scale.

We are also preparing to keep the grid stable as the demand/supply balance becomes more volatile when coal retires and more renewable generation comes online. Our models predict peak demand growing higher and minimum demand falling faster than previously projected. By the early 2030s, the impressive rise of rooftop solar may see minimum demand hitting zero, a tipping point for how the grid is planned and operated.

At the same time, as our economy continues to electrify, industrial loads will spike in new areas. Business and industry already consume two-thirds of the energy across the grid. A massive new demand driver maybe data-centres, which could draw much more energy than electric vehicles. Creating enough clean energy in time to meet growing data-centre demand will be challenging. But doing so presents a huge opportunity to create new top-line revenue for NSW – exporting megawatts as megabytes.

Our new transmission backbone will be essential for bringing the large quantities of clean energy from interstate and new Renewable Energy Zones (REZs) to the future demand hubs that will power the state's prosperity.

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The variability, complexity and uncertainty associated with this shift highlight the need for coordinated investment and deeper sector-wide collaboration. This coordination is essential to maintain affordability and reliability for consumers as the energy transition accelerates. As a planner, builder and operator of the transmission backbone in NSW and the ACT, Transgrid is working to enable that coordination.

This includes helping our generation and large-load customers achieve fast and efficient connections through tools like our Transmission Connection Opportunities Portal, which provides these customers with information on transmission infrastructure and system conditions, so they can make timely development decisions.

Nurturing and keeping trust with consumers and communities

We know we are building major infrastructure during a cost-of-living crisis. That's why we are focused on delivering transmission as efficiently as possible – reducing the risk of delays that can drive up costs for consumers.

It's also why we're procuring services from non-network solutions like Battery Energy Storage Systems that defer or avoid transmission expenditure.

To maintain public confidence in the energy transition, we need to reduce risk for users and consumers. With so many different players, proponents and investors, projects are unlikely to line up perfectly in time or sequence. That's why we're calling for our sector to come together and create a healthier buffer – regardless of interim energy-generation mix – to ensure reliability of supply given the complexity of the task and presence of new technologies.

As we build and operate the NSW energy backbone, we are also managing complex interactions with more than 18,000 landowners within our development corridors. This critical work can present a challenge at times for our sector, but securing and maintaining social licence is fundamental to realising the government's clean energy vision. Our engagement approach is grounded in early and honest consultation. By embedding landowner feedback into route selection, easement design and construction planning, we aim to reduce disruption, build trust and enable timely access for delivery.

Keeping our grid operating reliably

As the electricity system transitions, we remain committed to ensuring that connected customers, industry, homes and businesses in NSW and the ACT continue to enjoy a secure and reliable supply.

As the NSW System Strength Service Provider, Transgrid is now responsible for ensuring sufficient system strength to keep the grid stable. As coal retires, energy security will depend on Transgrid addressing the more frequent and growing gaps we are forecasting in system strength. The extra challenge is we are doing this at a time when many solutions have yet to reach maturity.

Transmission Annual Planning Report 2025 outlines how we are planning to meet this new responsibility for energy users, connected customers and consumers. It details the extensive modelling, market sounding, and global and local research we've undertaken to find the right portfolio of system security solutions. It also outlines our consultative approach to selecting the tools needed to safely operate a complex, modern grid.

Powering Greater Sydney into the future

Greater Sydney is Australia's economic powerhouse. At Transgrid, our planning looks beyond individual projects and regulatory periods. We are focused on planning a transmission network that enables the strategic growth and prosperity of Greater Sydney.

Strategic network planning and development is critical to managing demand growth, particularly in high-density areas like Greater Sydney and fast-growing greenfield regions in Western Sydney, where new industrial and residential loads are emerging.

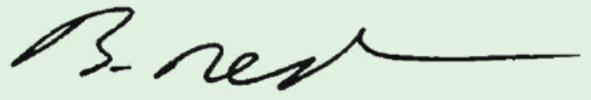
For the first time, this year's Transmission Annual Planning Report outlines our multi-decade of potential enhancements to Greater Sydney's supply corridors, enabling renewable energy to power a growing, electrifying economy. By linking REZs in NSW and the National Electricity Market with Greater Sydney, transmission will supplement distributed and consumer energy resources to support the growth of future-focused industries while driving regional development and job creation.

Based on our network planning and development strategy, we are investigating opportunities for transmission capacity upgrades and strategic property acquisitions. This is how we ensure the NSW metropolitan hubs continue to enjoy the supply reliability, that's fundamental to their economic growth.

Enhancing coordination and strategic decision-making

As we publish this Report, the NSW Transmission Planning Review is considering potential reforms to deliver more effective and timely planning. We strongly agree that greater coordination in planning will help deliver the energy transition with greater clarity and efficiency for NSW consumers and our customers. We look forward to continuing to engage with the Planning Review Panel as they finalise their report.

Transgrid remains focused on building a strong, strategic grid that protects consumers and realises the clean energy transition. As our Transmission Annual Planning Report 2025 demonstrates, the work we're doing is guided by a long-term view, one that balances cost, reliability and progress towards net zero.



Brett Redman
Chief Executive Officer
Transgrid Group

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About Transgrid

Transgrid operates and manages the high-voltage electricity transmission network across NSW and the ACT, connecting generators, distributors and major energy users. We deliver power to more than three million homes and businesses, working to keep it safe, reliable and affordable.

Our network transports electricity from diverse generation sources – wind, solar, hydro, gas and coal – to large industrial customers and the distribution networks that deliver power to homes and businesses.

It is the backbone of the National Electricity Market, keeping electricity flowing across regions, enabling energy trading and building a more resilient power system for Australians.

Our NSW and the ACT, network includes:

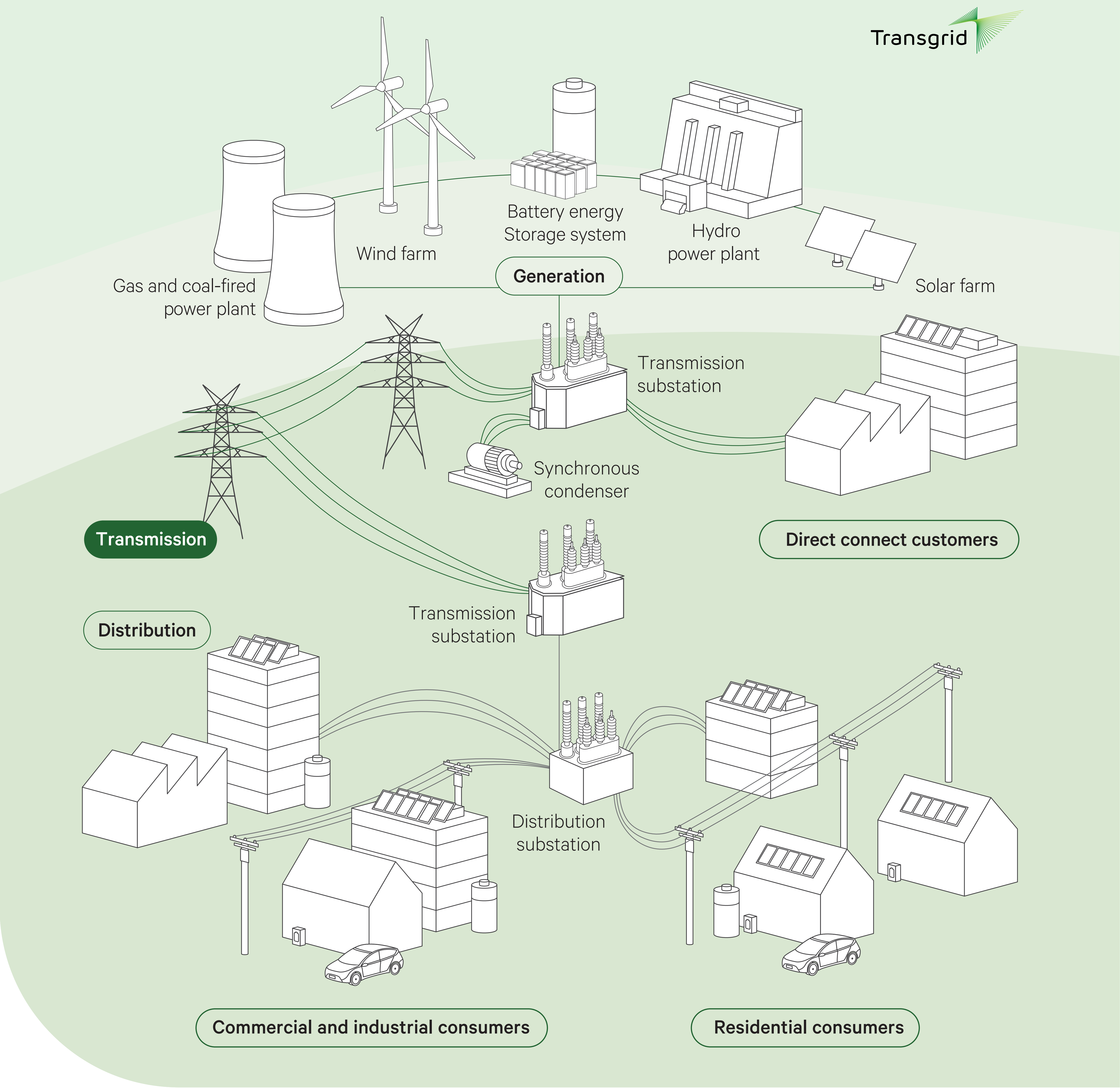
- 131 substations and switching stations
- 13,461 kilometres of high-voltage transmission lines
- 109 kilometres of underground cables
- 6 key interconnectors linking NSW to Qld, Vic and, for the first time this year, SA.

State interconnectors are an important part of Australia's clean energy future. We need them to move renewable power from where it's being generated to where it's needed.

Transgrid is investing in new transmission infrastructure and adopting innovative technologies to modernise the grid, connect more renewable sources and, support electrification of homes, transport and industry on the path to net zero.

Figure 1 illustrates Transgrid's role in the electricity supply chain. Figures 2 and 3 show our transmission network and key interconnections.

Figure 1: Transgrid within the electricity supply chain



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Transgrid

Figure 2: Transgrid's electricity network map

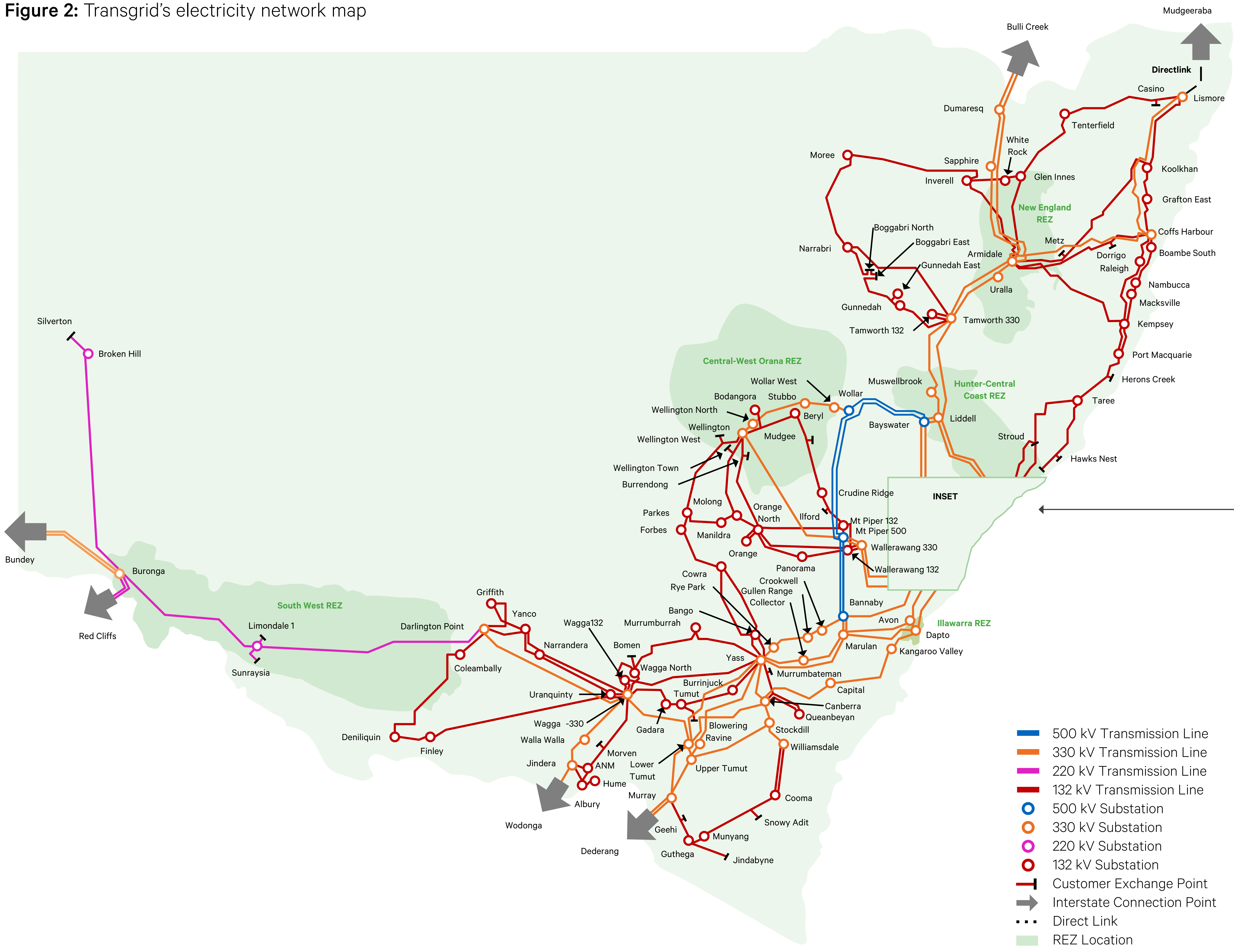
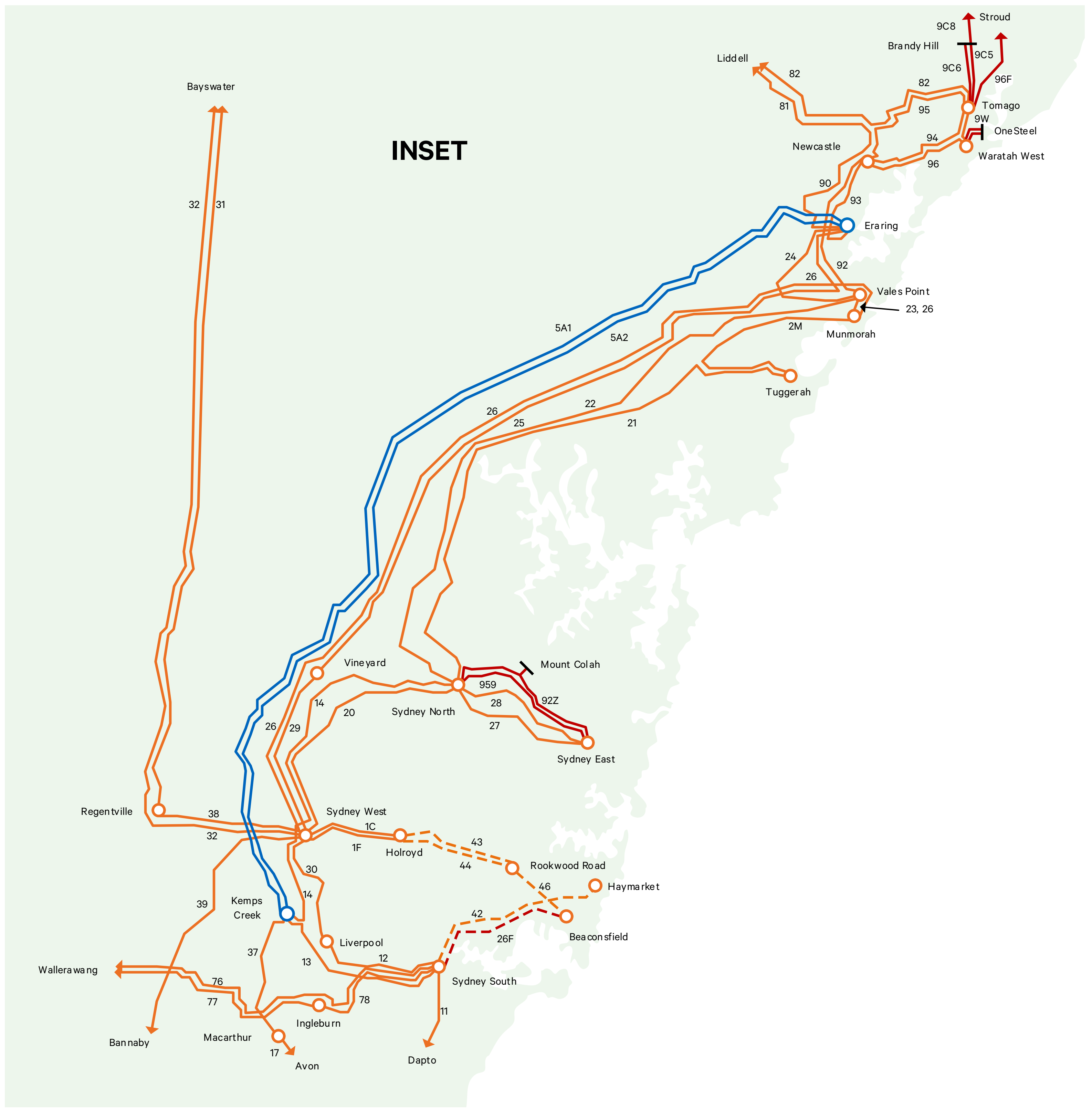


Figure 3: Transgrid's electricity network map – Inset



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Executive summary

Transgrid

Transgrid 's 2025 Transmission Annual Planning Report reflects the intensity and volatility of the energy transition. As we enter this phase, the NSW transmission system will evolve rapidly to accommodate renewables, introducing new levels of risk.

As **Chapter 1** describes, by 2035 we will have reached the new transitioned era of renewable energy. Almost all coal generation will be retired, replaced by a significant build-out of renewable energy sources and infrastructure, much of which is already underway. We have seen record growth in generator connections over the past 12 months and future pipeline, including a rapid growth in energy storage projects in response to government policy changes – trends that will only accelerate.

To connect renewable generation into the NSW major load centres, we are building a new, greatly expanded transmission backbone. **Chapter 2** presents the new transmission projects that will make up the future grid, the progress on our augmentation projects and our collaborative work with EnergyCo and Distribution Network Service Providers (DNSPs) around REZ connections. For the first time, it also shares recent work on our multi-decade view of how to develop the supply corridors feeding into the Sydney, Newcastle and Wollongong areas as we reach the New Transitioned Era and our green economy demands more renewable energy to be fed into our cities.

As the composition of energy mix changes, our demand forecasts in **Chapter 4** show the 'demand envelope' is widening, increasing reliability challenges. Peak demand is growing as data-centres emerge as a new load and electrification progresses. At the same time, minimum demand is falling faster than expected – with serious implications for grid management. For the first time, we are predicting minimum demand will fall to zero by the early 2030s. Transgrid is responding by enhancing coordination with DNSPs and the Australian Energy Market Operator (AEMO), supporting flexible demand solutions, accelerating transmission projects like Sydney Ring South and investing in system strength.

Chapter 4 also shows household rooftop solar and batteries, and electric vehicle (EV) adoption continue to grow rapidly.

These consumer energy resources are increasing demand variability but, if coordinated well, could contribute to demand smoothing in an increasingly volatile grid.

In another sign of the rapidly progressing energy transition, **Chapter 5** explains how Transgrid is planning to meet our new system security responsibilities as coal retires. This chapter explains the proposed nature and cost of a diverse portfolio of system strength solutions that will also meet inertia requirements and provide significant voltage support. It also details plans for the large quantity and diversity of storage required to firm a grid powered by renewables – and the amount of installed capacity of gas-powered generation that will be needed as a backup during renewable energy droughts.

Chapter 5 also outlines our phased plan for enhancing Transgrid's control room systems, which are reaching their operability limits. Urgent technology investment will be critical to Transgrid's ability to plan and coordinate the energy transition – and enable the safe operation of a modern grid. This report shares Transgrid's plan to ensure the ongoing security and reliability of the transitioning electricity system as in the long-term interests of energy consumers, by:

- Expanding our transmission network to form the backbone of a modern energy system and planning for its strategic development across multiple decades (see **Chapter 2**)
- Using emerging technologies and innovative solutions to avoid significant capital investment and keep costs as low as possible for consumers (see **Chapter 3**)
- Planning and preparing to solve the challenges of meeting minimum system strength requirements at all times (see **Chapter 5**)
- Working closely with AEMO and industry peers to determine the control room enhancements needed to safely and reliably operate a complex, modern power system and identify the most responsible investment pathway (see **Chapter 5**).

In **Chapter 1**, we also take a look at our planning for the new transitioned era beyond 2035, when we believe remote Inland Renewable Energy Opportunity Areas may play an important role in meeting demand for an electrified economy.

What's new in 2025 Transgrid Annual Planning Report

44% drop in forecast minimum demand in the next 2 years

Zero minimum demand forecast by early 2030s

8 GW of additional rooftop solar capacity forecast to be installed by 2035

5,200 GWh of forecast EV charging in 2035

At least **800 MW** of additional forecast data-centre load by 2035

4,115 MW of additional renewable generation and energy storage have committed to join the network in the past 12 months

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Chapter 1

Lilly Flick – Pre-apprentice

Australia's clean energy transition enters a new phase

We are accelerating renewable connections, building critical infrastructure and learning to operate a modern grid that will deliver secure and reliable electricity for customers and consumers into the future.

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This chapter describes the phases of the energy transition, and what we are doing now, next – and in the future – to keep the momentum going.

In the last decade, wind and solar generation increased five-fold, while the share of coal generation fell to around 60%. This initial phase is now ending, and we are now entering a new, highly dynamic phase, in which the grid will change dramatically. By 2035, at the end of a decade in deep transition, 90% of generation in NSW will come from renewables.

This process is unlikely to be completely smooth. We welcome state and federal government policies that are supporting and coordinating infrastructure development across the energy value chain – but new projects are often experiencing delays and challenging constraints in labour markets and supply chains. Meanwhile, ageing coal power stations in NSW are fast approaching the end of their technical lives and announced closure dates. A whole-of-system response and innovative solutions will be needed to manage challenges that may arise. To keep on track, we need to maintain a reasonable supply buffer to provide resilience against unexpected delays and outages, and ensure reliable energy supplies for consumers throughout the energy transition.

The past 12 months have seen record growth in generator connection activity -- with much more on the way.

We are also seeing a step-up in demand for electricity, including from new sectors like data-centres and the electrification of transport, buildings and industry. The growing uptake in consumer energy resources like rooftop solar, increasingly paired with home batteries, means electricity demand is becoming more dynamic and flexible – and if properly coordinated can play a role in supporting the grid.

Keeping up with the need for a vast amount of renewable generation as coal is switched out will require enormous investment in both infrastructure projects and in solving the multiple challenges presented by a low-emissions grid.

A renewable grid, with its intermittent, weather-dependent generation, is a more dynamic and complex system. It requires new sources of system security and new operating technologies and capabilities. For example, human control room operators need digital support to process the significantly higher volumes of real-time data from the grid.

So this is not just about the extraordinary task of building the new network infrastructure to connect the record numbers of renewable generators joining the grid. It's also about adding system security services, including up to 10 large synchronous condensers and services from 5 GW of grid-forming batteries. And it's about giving our control room operators new tools and training to operate a very different grid. All these complex tasks are time critical and required in a particular order. And we do not expect everything to line up perfectly. We need government policy and industry collaboration to focus on managing the overlap between coal and renewables, so the sector has some margin in this high-stakes challenge.

And then it's about planning even further into the future.

As we reach the new transitioned era in the decade beyond 2035, Australia's energy demand will continue to increase – requiring even more renewable generation – potentially from remote inland renewable energy opportunity areas (REOAs). Section 1.6 describes where Transgrid believes these REOA could be located and how they are likely to integrate with the grid.

As we plan for the energy future, we're keeping our approach open and adaptable. That means welcoming all technologies that can help deliver reliable, affordable and clean power. And continuing to explore a range of development pathways – guided by what works best for communities, businesses and future generations.

Caleb Arthur-Wornham –
Transmission Line Apprentice

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1.1 The energy transition in NSW is entering its next phase

NSW is entering an intense phase that will see a mass buildout of renewable generation and connecting transmission, taking us to 90% of clean energy by 2035.

1.1.1 Ramping up

Over the past decade in the initial phase, we witnessed major structural changes in the state's electricity system, marked by a progressive shift away from coal-fired power toward a low-emissions, decentralised energy future.

A decade ago, NSW had less than 1 GW of utility-scale wind and solar generation. Around 85% of electricity generated in the state was from coal.

In 2025, NSW now has 8 GW of operational utility-scale wind and solar generation, another 8 GW of rooftop solar, and 1 GW of utility-scale battery storage. Wind and solar generation output has increased five-fold, while the share of coal generation has fallen to around 60%.

1.1.2 Reaching deep transition

This pace is set only to accelerate over the next 10 years. By 2035, almost all remaining coal-fired generation in NSW is scheduled to retire as units approach the end of their technical lives, including the Eraring Power Station in 2027, Bayswater power station by 2033 and Vales Point, which AEMO forecasts will close in 2033.[1]

To manage this transition effectively, we already have a significant build of renewable energy sources and supporting infrastructure underway and gaining pace. But far more will be needed.

By 2035, NSW will require more than 23 GW of additional utility-scale wind and solar capacity, enabled by a stronger transmission backbone and 10 GW of utility storage. This will be connected across the state's Renewable Energy Zones (REZs), as well as to Transgrid's transmission network and within distribution networks. Consumers are also set to invest in another 8 GW of rooftop solar and 3 GW of household battery storage – see Figure 1.1.

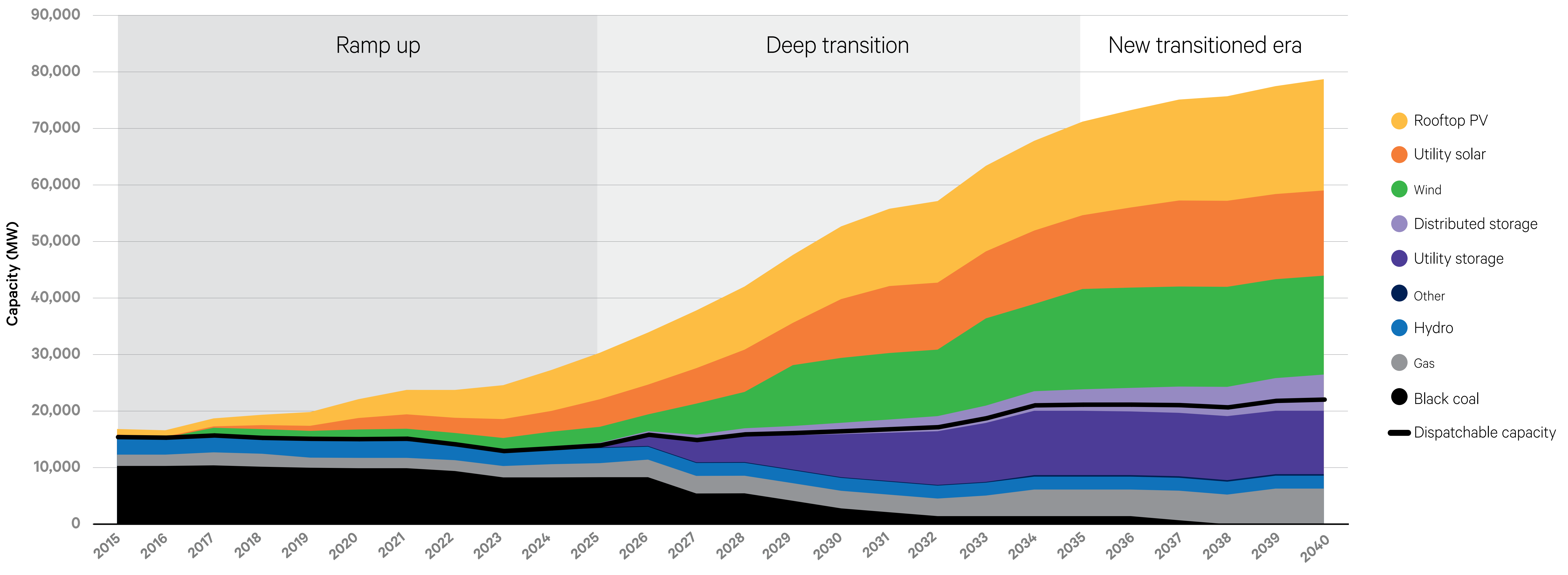
By 2035, coal is forecast to account for only around 5% of generation in NSW. Large-scale renewable generators and storage will account for over 70%, with another 20% from household solar and storage.

1.1.3 Partnering across the energy sector

A successful energy transition of this scale and pace requires the alignment of a broad range of energy stakeholders, as well as an enormous mobilisation of investment across the energy supply chain. In recent years, NSW has taken significant steps to ensure that energy transition plans and climate ambitions are translated into tangible energy system outcomes.

A key driver has been the NSW Electricity Infrastructure Roadmap, which targets the development of at least 12 GW of new renewable energy generation and 2 GW of long-duration storage by 2030 and an additional 12 GWh of long-duration storage by 2034. Significant strides have been made to turn this plan into reality, including awarding competitive tenders to more than 2.7 GW of renewable generation and 2.5 GW of storage capacity,[2] and progressing the development of five REZs: Central West Orana, New England, South West, Hunter-Central Coast, and Illawarra. Transgrid has several roles in supporting the Roadmap, including connecting new REZs to the NSW transmission backbone, as the Network Operator for the Waratah Super Battery and South-West REZs and as the Preferred Network Operator for the Hunter Transmission Project.

Figure 1.1: Installed generation capacity in NSW – historical and forecast[3]



1 AEMO, *Generating Unit Expected Closure Year*, April 2025. AEMO technical life assessment is subject to market conditions and technical considerations.
2 Includes LTESA tender rounds 1-5, up to February 2025
3 AEMO 2024 ISP, AEMO Draft 2025 Inputs, Assumptions and Scenarios Report, Jacobs 2025, Rooftop solar and Battery Forecasting for NSW (prepared for Transgrid), AER State of the Electricity Market (various historical), AEMO Generaiton Information, Transgrid analysis

1.2 Building the transmission backbone for the future

Transgrid

Transgrid is delivering a portfolio of major transmission infrastructure projects. These projects are designed to unlock REZs, support grid reliability and transport electricity from new generation hubs to demand centres. Our goal is to build the least-cost, high-capacity transmission backbone necessary to integrate new renewable energy and deliver reliable, affordable electricity for consumers. A stronger NSW transmission system also supports the NSW government objectives to connect additional generation, long-duration storage, and firming infrastructure and meet the NSW energy security target and reliability standard.

Our portfolio includes multiple committed and actionable transmission infrastructure projects. Committed projects, EnergyConnect and HumeLink, are currently under construction. Other projects in development include Hunter Transmission Project, network augmentations connecting the Central West Orana REZ to the NSW transmission backbone, VNI West, Sydney Ring South and QNI Connect.

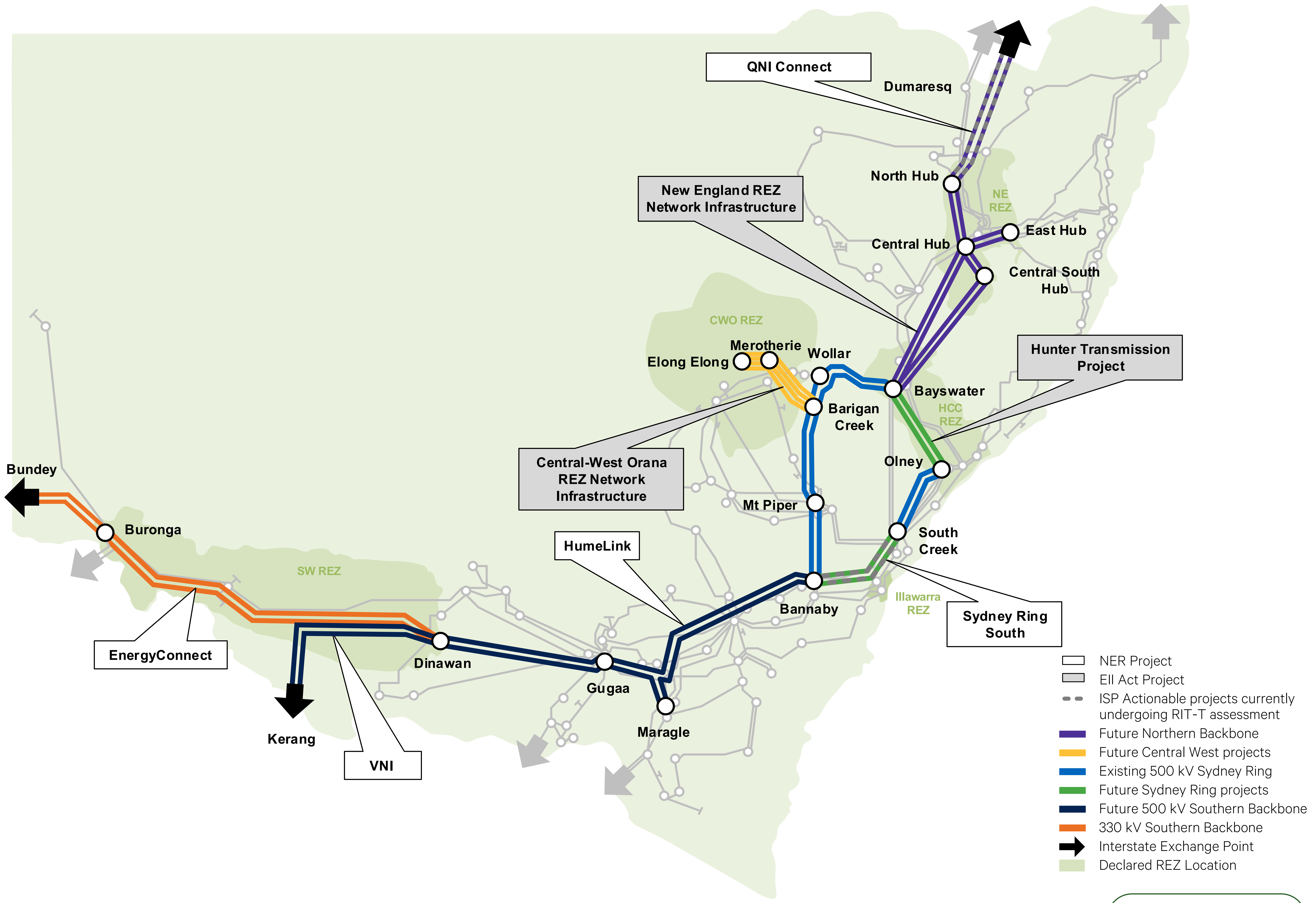
Transgrid is working in close collaboration with governments, industry and community stakeholders to urgently progress these projects.

In parallel, we are also executing a Network Asset Strategy as part of our Asset Management System, so we can:

- Manage both the risks posed by network assets themselves and the risks to the network posed by external threats, including bushfires and cyberattack
- Manage the network to deliver value to consumers
- Support positive reforms that ensure efficient regulation and a sustainable network.

This is essential to ensure we continue to deliver safe, reliable and efficient network services during Australia's clean energy transition.

Figure 1.2: NSW Major Network Development Plan[4]



4 Includes transmission projects delivered contestably under the NSW EII Act famework, which will not be constructed, owned or operated by Transgrid

As Chapter 2 explains, our program to deliver the three southern region projects is progressing. Stage 1 of EnergyConnect is now operational, interconnecting the energy grids of NSW, SA and Vic, with AEMO completing inter-network testing on EnergyConnect's western section. HumeLink has received its final major planning milestone. Early works have started and transmission line and substation construction is about to begin. We have identified a 200 m transmission line corridor for VNI West, and the project is continuing through an Environmental Impact Statement and community consultation.

Figure 1.3: NSW Major Network Development Plan (continued)

Southern Backbone
(2026–2030)

1,300 km Line

3 GW Renewables plus Snowy 2.0

2026

EnergyConnect
In-service by late 2026*, enabling the sharing of energy and unlocking renewables between NSW, SA and Vic.

2027

HumeLink
In-service by late 2027, enabling the integration of new, clean energy from South West REZ and unlocking the full capacity of Snowy 2.0 to reach the Sydney Ring.

2029-30

VNI West
Transgrid is examining a staged approach to VNI West delivery. Stage 1 in-service in 2029 to unlock clean energy from South-West REZ, and the full interconnector in-service by late 2030*, facilitating greater energy sharing between NSW and Vic and connecting into EnergyConnect.

Sydney Ring
(2029–2033)

220 km Line

10 GW Renewables

2029

Hunter Transmission Project
Transgrid is supporting the EnergyCo-driven Priority Transmission Infrastructure Project with in-service date Nov 2029, reinforcing supply to Sydney, Newcastle and Wollongong load centres and facilitating the flow of electricity between the Central West Orana and New England REZs and Sydney. This also includes enabling the 850 MW Waratah Super Battery to unlock extra transmission capacity into the Sydney region until the Hunter Tranmsission Project is complete.

2033

Sydney Ring South
Transgrid is considering multiple options, including staged approach to delivery, through the RIT-T. The expected in-service dates range from 2030 for new or upgraded substations, to 2033 for a new transmission line, which would give the Sydney region greater access to energy flows from southern NSW.

Northern Backbone
(2032–2034)

520 km Line

9 GW Renewables

2032/34

New England REZ Network Infrastructure
Enabling New England REZ capacity to reach the Sydney Ring. This project is being delivered by EnergyCo as the Infrastructure Planner via a contestable process to appoint a network operator. It is to be completed in two stages: Stage 1 in-service in Jul 2032, and Stage 2 in-service in Jan 2034.

2032

QNI Connect
In-service by 2032*, enabling greater sharing of renewable energy between NSW and Qld.

*Capacity will be released to market progressively following successful inter-network testing, which is dependent upon market conditions and may take around 12 months to complete following energisation.

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1.3 Record volumes of renewable generation and storage are connecting to the Transgrid network

Transgrid

We are continuing to add renewable energy and storage to the grid, working at pace with customers and AEMO (see Chapter 4.1.1).

The past 12 months have seen record growth in generator-connection activity. We are processing more applications than ever before from new generators and energy storage facilities wishing to connect directly to our transmission network.

Transgrid is currently supporting more than 10 GW of new renewable energy and storage projects, with another 4 GW of projects making early-stage enquiries. Since Transmission Annual Planning Report 2024, more than 6.6 GW has progressed through key project connection milestones. This includes 2.7 GW to reach Connection Application approval, 2 GW to achieve Market Registration and 1.9 GW to be commissioned to achieve full project output.

Connection interest from Battery Energy Storage Systems (BESS) has surged, with more than 3 GW progressing towards or achieving commissioning.

Transgrid has established 'engineering squads' to fast-track the connection of four major BESS projects in NSW, with the support of the NSW Government Department of Climate Change, Energy, the Environment and Water. These projects will play an important role in meeting the state's reliability targets as coal units retire.

We are continuing to look at how we can better support our current and future customers by streamlining the connection process, and progressing industry-wide reforms to make the connection process as seamless as possible.

1.3.1 Renewable energy enabled by distribution networks

The energy transition cannot be achieved through transmission investment alone. It requires coordinated effort across all parts of the energy system: households, distribution networks, transmission-connected generators and REZs.

Distribution Network Service Providers (DNSPs) are on the front lines of integrating consumer energy resources, managing reverse flows, upgrading network capacity and supporting voltage stability. DNSPs are also critical in enabling customer participation through community batteries, virtual power plants and flexible demand solutions. Transgrid works closely with DNSPs to align planning, forecasting and delivery.

NSW has now installed over one million rooftop solar units – on almost one in three households. Around 1 GW of new rooftop solar capacity is currently being installed 'behind the meter' in the state each year. This growth is expected to continue over the outlook period, with installed capacity forecast to double in the next decade from 8.2 GW now to 17 GW in 2035, and almost triple to 22 GW by 2045.

These solar installations will increasingly be paired with small-scale battery systems. While currently in the early phases, battery uptake is expected to increase, as system costs fall, solar feed in tariffs decline, and more people take advantage of government policies, including the NSW Consumer Energy Strategy and Peak Demand Reduction Scheme. By 2035, we forecast NSW will have at least 2.6 GW of distributed storage installed. As many as one third of these distributed batteries may be enrolled in virtual power plants, which will be able to rapidly respond in a coordinated way to help alleviate grid or energy market stress.

We also recognise opportunities to deliver larger-scale renewable generation and storage projects within distribution networks. These solutions should be pursued when they can be achieved faster and cheaper for consumers; for example, as Distribution REZs. Transgrid is undertaking joint planning with AEMO, EnergyCo and NSW DNSPs on early-stage concepts for Distribution REZs, including options for Hunter Central Coast, Dubbo, Marulan and Yass. We are working with DNSPs to identify the infrastructure upgrades required to connect Distribution REZs to the broader transmission network and assess and address relevant transmission network constraints.

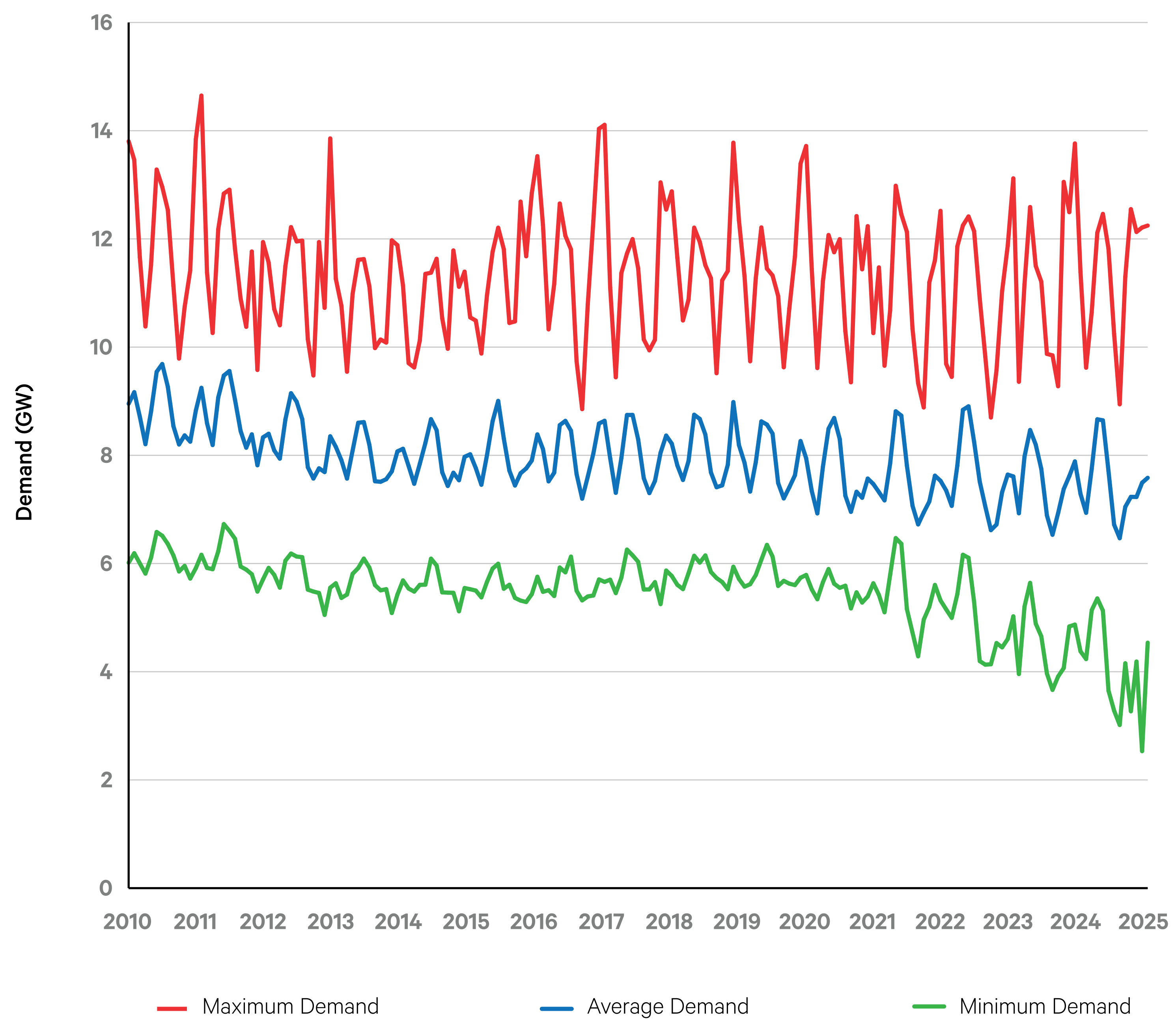
We are committed to collaborating with DNSPs to create a seamless, efficient and responsive energy system that meets the needs of all consumers.

1.4 The way we use electricity is changing

1.4.1 The 'demand envelope' for NSW is widening

NSW is experiencing more dynamic swings in electricity demand. Summer peaks continue to be high. While the rise of rooftop solar is causing minimum demand to rapidly decline – see Figure 1.4.

Figure 1.4: Historic NSW average, maximum and minimum demand[5]



1.4.2 Minimum demand has fallen sharply

Since 2020, minimum grid demand in NSW has fallen by around 40%. This typically occurs on weekend afternoons in spring, when the combination of mild conditions, sunny weather and increasing rooftop solar result in a high share of electricity being supplied behind the meter. On 16 February 2025, NSW experienced another record low minimum market demand. At just 2824 MW, it was around 13% lower than the previous record, which was set only four months earlier in October 2024.

Low levels of minimum demand can cause operational challenges for the grid. Traditional synchronous generators (like coal) often provide security services, not just electricity. Now many synchronous generators are retiring, Transgrid is developing a portfolio of solutions to provide system strength and inertia services from new sources. Rapid changes in supply and demand, such as when a cloud passes, can also make it more difficult to maintain stable voltages on the grid.

1.4.3 Data-centres are forecast to connect to the system in record volumes

Australia is experiencing a data-centre boom, driven by surging demand for AI, cloud computing and digital infrastructure. Very large data-centres (1 GW or larger) are rapidly seeking to connect to the NSW power system. Sydney, particularly Western Sydney, leading the market as the primary location in Australia for these 'hyperscalers', due to the area's access to power infrastructure, availability of land and high penetration of renewable generation.

During the year, Transgrid received unprecedented interest from data-centres wishing to connect to our network. At the end of FY25, we had more than 10 GW of projects lodging a Connection Enquiry, and over 4 GW at the Connection Application phase. And we understand that many more projects are progressing connections in distribution networks fed from Transgrid's transmission network.

Data-centres could be a major opportunity for the NSW economy, attracting high-tech investment, creating high skilled jobs and supporting the growth of digital infrastructure and innovation in the state. Given the early stage and rapid growth of the data-centre sector, it is unclear how many projects will progress, and how quickly their demand for electricity will ramp up. Accommodating hyperscale data-centres requires proactive planning to ensure the network is managed appropriately. The land, water and power demands of these new large-load entrants must be carefully balanced, but getting this right will unlock long-term benefits for the NSW economy and community.

5 Figure courtesy of Endgame Analytics

1.4.4 Electrification of transport, buildings and industry

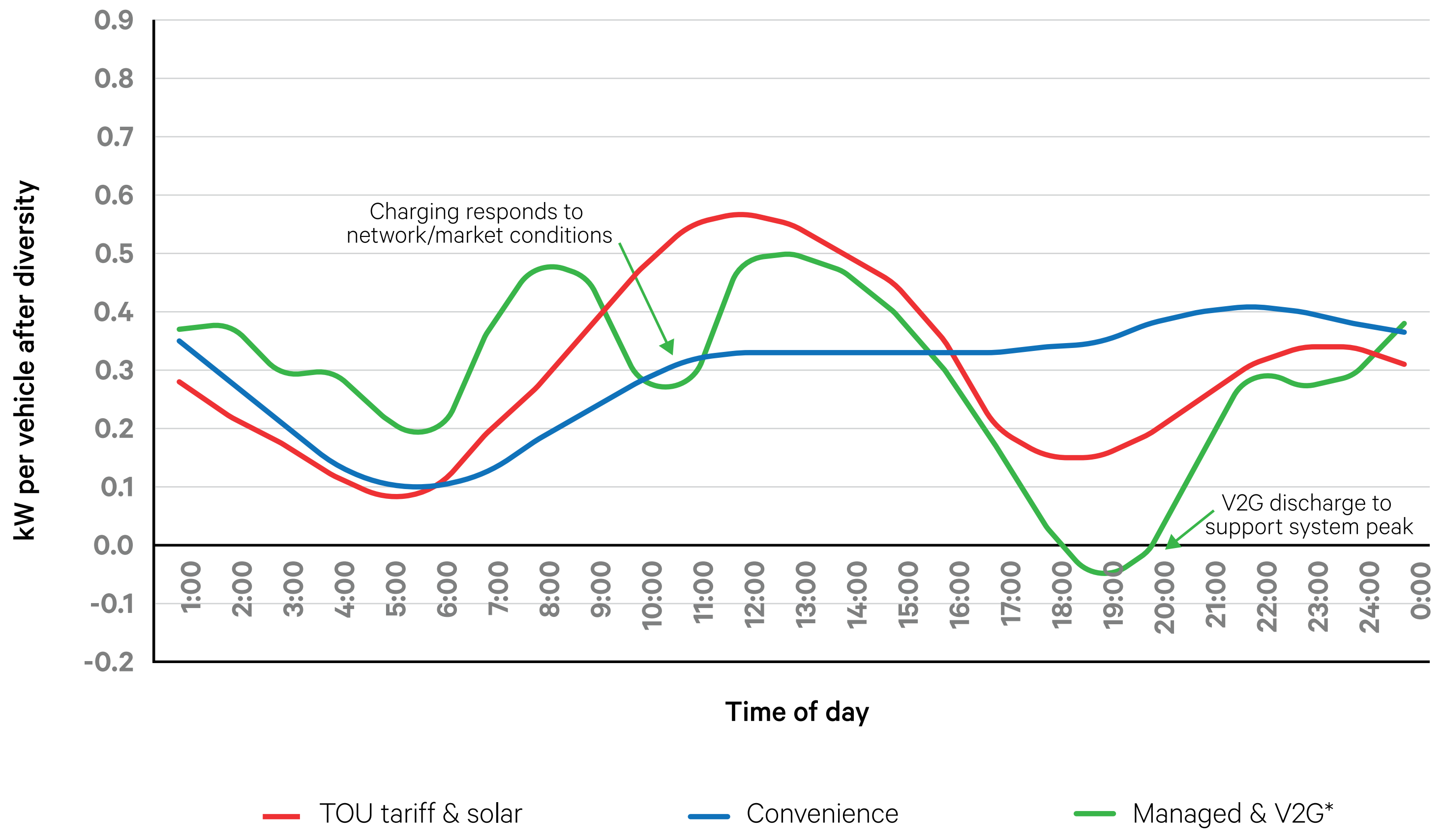
Transgrid is also planning for growth in electricity demand over the medium to long term as transport, buildings and industry electrify. Electrification is important for economy-wide decarbonisation and will be essential for Australia to meet its 2050 net zero targets.

Electric vehicle (EV) sales in NSW and ACT have grown over the past year and now represent around 10% of all new car sales.[6] Over the coming years, EV uptake is expected to accelerate further – driven by falling technology costs, the availability of more EV models in Australia, government policies, including the New Vehicle Efficiency Standard, and increasing availability of public charging infrastructure.

This shift will contribute to substantial electricity load growth. By 2035, there may be over 2 million EVs on NSW and ACT roads, over 80% of new car sales may be electric and EVs may collectively consume 5 TWh of electricity in the region.[7]

The impact of this demand on the power system will depend on how and when EV drivers charge their vehicles. If drivers mostly charge vehicles based on convenience, demand from electric vehicles is likely to exacerbate peak demand periods. However, this impact can be substantially reduced if EV drivers instead shift their home charging to take advantage of surplus solar generation, or use off-peak power, or enrol in smart-charging programs, where charging is remotely managed to meet driver requirements while avoiding periods of market and grid stress. See Figure 1.5.

Figure 1.5: Electric vehicle charging patterns[8]



Harnessing the flexibility of EV charging will be good for both EV drivers and the power system overall. EV drivers will have lower energy bills if charging is timed to soak up surplus renewable generation and avoid system peaks, and the better utilisation of electricity networks will lower unit prices for all consumers. EVs will also create a new source of grid services, particularly if vehicle-to-grid technologies become popular, where EV batteries can discharge to the local network to support grid reliability and security.

NSW and ACT are likely to shift toward electrification over the coming decades, as governments introduce policies to phase out gas use to meet sustainability targets and reduce energy costs for consumers. ACT has implemented a comprehensive policy to transition homes and businesses away from fossil-fuel gas, aiming for a fully electrified city by 2045. In most circumstances, new gas connections are prohibited, requiring all-electric designs for new residential and commercial developments. There is also support and incentives for some households to switch from gas to electric appliances. Several NSW Councils, including the City of Sydney, have implemented policies to phase out or limit the use of gas in new residential and commercial developments. Electrifying buildings will increase demand for electricity, particularly for heating and hot water, which are likely to increase winter peaks. Energy efficiency for new buildings and appliances will be important to offset this impact.

Industrial electrification will also play a key role in decarbonising the NSW economy. For example, Transgrid understands that BlueScope Steel is keen to invest in decarbonising its production processes as part of meeting its goal of net zero by 2050. The project has identified direct reduced iron technology to replace the blast-furnace process. Natural gas will be used as a reductant to replace coal ahead of the commercial availability of green hydrogen. This will create additional peak load of several hundred MW in the NSW network. This plan is in the early stages, and so not factored into our load forecasts, but it's a good example of the demand for 'additional electrification' as manufacturing companies plan to reduce their greenhouse gases emission levels.

6 Electric Vehicle Council, *State of Electric Vehicles 2024*
7 Energeia (2025) *Electric Vehicle Aggregate Charging Load Forecast Report*, prepared for Transgrid
8 Derived from Energeia (as above) and AEMO Draft 2025 Inputs, Assumptions and Scenarios Report

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1.5 Energy reliability may be challenging

The scale and pace of change in the NSW power system over the coming decade may be very challenging. This intense phase of the energy transition is unlikely to run without challenges. Supply buffers provide resilience in the event of unexpected delays or shocks to the system, ensuring reliable energy supplies for consumers throughout the energy transition.

After the Eraring Power Station retires, scheduled for August 2027,[9] Transgrid expects the balance between energy supply and demand on the NSW power system will become tight. The 2024 AEMO Electricity Statement of Opportunities highlights that, for NSW to meet the reliability standard, an ambitious combination of multiple projects and market developments must progress as planned. This means:

- Existing, committed and anticipated generation projects must be delivered according to their announced timeframes
- Firming and renewable energy developments that are receiving state or federal government funding and other support must proceed as planned
- Actionable transmission investments must proceed as planned
- Growth in coordinated consumer energy resources and flexible demand must increase at pace

This leaves little flexibility. If some of these projects do not progress and others encounter commissioning delays as has occurred previously, NSW may experience reliability gaps. New renewable generation and supporting infrastructure must be commissioned *before* ageing coal units withdraw from the power system.

Our network studies also show that, without the commitment and connection of additional generation and energy storage capacity, there may be times when the grid lacks sufficient reserves or supply to meet demand.

We welcome state and federal government policies that support project delivery and coordinating infrastructure development across the energy value chain. Support for firming capacity, such as the NSW Electricity Infrastructure Roadmap 2030 target of 2 GW of long-duration energy storage (and an additional 12 GWh by 2034) and the federal Capacity Investment Scheme, will be critical. However, despite best efforts, new energy projects are often being delayed and experiencing challenging constraints in labour markets and supply chains.

Energy reliability risks are already starting to emerge (see Chapter 5). Modelling by the Report predicts a risk of Lack of Reserve (LOR1) conditions when Eraring Power Station retires. Any outage of the remaining coal-fired generators will further increase the generation adequacy gap and could result in energy shortfalls. As these units approach the end of their technical lives, they are likely to become less reliable and experience increasing outage rates.

A whole-of-system response and innovative solutions will be needed to maintain reliable energy supplies in NSW throughout the transition. Critical transmission projects must be delivered at pace. But additional support may also be needed to drive the uptake and coordination of consumer energy resources and demand flexibility as well as the acceleration of storage and firming projects. NSW may also need to support the reliable operation of existing coal units until sufficient new energy and capacity sources are available to replace them.

Bowen Solar Farm,
Wagga Wagga NSW

9 Origin Energy has stated that provisions exist to extend Eraring Power Station until 2029 if energy reliability risks persist.

1.5.1 Reinforcing supply for Sydney, Newcastle and Wollongong

Around 80% of electricity supplied by the grid in NSW is consumed in the Sydney, Newcastle and Wollongong (SNW) region. Within the next decade, demand in this region is set to increase because of population growth, new data-centres and urban electrification. At the same time, the Eraring Power Station retirement will significantly reduce dispatchable generation capacity in the region.

Transgrid is supporting the Hunter Transmission Priority Transmission Infrastructure Project to reinforce supply to the region from the north and facilitate power flows to Sydney from Central West Orana and New England REZs. Our analysis shows that this project alone will not be sufficient.

Additional reinforcement is required through the Sydney Ring South project, which will bolster supply from southern NSW into Sydney. This project is a critical enabler, providing the capacity buffer necessary to execute the long-term network strategy for the SNW region

The region will also need at least 6 GW[10] of additional firm capacity by 2035 to maintain reliable and affordable energy supplies. This is likely to comprise a combination of several technologies, which each have their strengths and limitations.

- **Peaking generation**, powered by natural gas and liquid fuels. This operates infrequently but provides important system backup during periods with low availability of solar and wind generation, particularly during winter when low-renewable periods can stretch for several consecutive days. The SNW region has a unique combination of transmission and gas-supply constraints, making it a challenging location to develop additional gas-peaking generation. Transmission system limitations in the south constrain additional generation near Wollongong from reaching load centres, while the power system has capacity in the north around Newcastle but very limited gas supply infrastructure.
- **Utility-scale Battery Energy Storage Systems (BESS).** There is strong market interest in developing BESS projects, which can be delivered relatively quickly. However most of the 2.3 GW of anticipated, committed and existing BESS projects in the SNW connection pipeline are only two to four hours in duration. This limits their role in supporting the power system over prolonged periods.
- **Distributed storage, virtual power plants, Demand Side Participation and flexible demand.** The growing popularity of consumer energy resources technologies, including rooftop solar, home batteries, electric vehicles and smart devices, is creating new opportunities for aggregation and coordinated control to increase, reduce or shift demand in response to market and network signals. This has great potential to support and balance a renewable power system and deliver value for people who own consumer energy resources, the broader energy system and consumers. New projects including the Hunter-Central-Coast REZs and Illawarra REZs will each contribute up to 1 GW of capacity. However, many consumer energy technologies are in the early stages of adoption. We don't yet know how quickly they will ramp up, how many consumers will elect to enrol in virtual power plants and load-flexibility programs, or how dispatchable this capacity will be.

Given these challenges and uncertainties, it may not be possible to develop enough new capacity by 2035 using these technologies alone. Transgrid is therefore investigating options to strengthen the transmission system to the south of Sydney to facilitate additional power flows to Sydney from South-West REZs, Snowy 2.0, Vic and SA – known as the Sydney Ring South project (see section 2.1). This will provide the SNW region with resilience and flexibility to meet load growth from emerging sectors, with supply coming from local resources or those further afield.

Waratah Super Battery site, Munmorah NSW

10 Based on results from Transgrid market modelling for capacity located within SNW region only.

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1.6 Investing in system security

The major changes to our energy sources are introducing unprecedented challenges for maintaining system security and reliability. The electricity system remains within a secure operating envelope when technical parameters, such as voltage, frequency, current, power quality and fault levels, are maintained within defined limits. These technical limits are necessary to keep the electricity system safe and secure. Poor system security can lead to blackouts and power disruptions.

As coal-fired generators retire, the grid is losing essential sources of system security. Without sufficient replacement services, the grid will not be able to operate safely or at very high levels of renewables for even short periods of time. Meanwhile, the increasing supply of renewable energy, with its intermittent, weather-dependent generation, is making the NSW electricity system substantially more volatile.

To manage this increasingly complex and volatile power system, within the next decade, Transgrid will need to:

- Build new network infrastructure
- Add system security services
- Invest in the new tools and capabilities required to successfully operate an electricity system with increasingly high levels of renewable generation.

It will be technically possible to operate the NSW electricity system at up to 100% instantaneous renewables. But only once these foundational pre-requisites of energy reliability, system security and operability are in place. They are not negotiable. We must urgently accelerate the delivery of these investments and capabilities.

We are working closely with AEMO to meet specified levels of electricity system security services in NSW, including system strength and inertia (see Chapter 5).

1.6.1 Planning for system strength

As the System Strength Service Provider for NSW, Transgrid is responsible for ensuring sufficient system strength services are available to maintain the stability of the NSW electricity system.

From 2 December 2025, a new system strength framework will begin under the National Electricity Rules, requiring Transgrid to deliver system strength on a forward-looking basis to standards set by AEMO. Under this framework, Transgrid will be required to ensure minimum system strength requirements are met in full at all times of the year. We must also deploy system strength solutions above the minimum levels to facilitate the stable connection and operation of renewables.

Transgrid is planning a portfolio of non-network solutions and new network infrastructure to meet these system security obligations. Through a Regulatory Investment Test for Transmission (RIT-T) for system strength needs in NSW, we have identified an optimal mix of solutions, which will also meet inertia requirements and provide voltage support. This includes:

- **Synchronous condensers**, which are synchronous motors that spin freely (with no fuel combustion or power generation), used specifically to provide system security services. Transgrid requires 10 large synchronous condensers by FY30 (each providing 1050 MVA fault current), in addition to synchronous condensers (or equivalent) in the New England and Hunter-Central-Coast REZs.
- **Grid-forming BESS** featuring grid-forming inverter technology, enabling projects to both trade in energy markets and also provide system strength, synthetic inertia, fast frequency response and voltage support. We will also need services from 5 GW of new grid-forming BESS by FY33, which we expect will mostly be met by upgrading committed, anticipated and forecast BESS with grid-forming capability.
- **Services outside the energy market**, such as existing synchronous hydro units that may be able to operate in synchronous condenser mode, or generators with units upgraded to operate in synchronous condenser mode. We have identified 650 MW of synchronous generation to be modified to enable synchronous condenser mode.
- **Existing and committed synchronous generators** dispatched in the energy market, such as hydro, and coal and gas where necessary. Our plan includes the potential to redispatch 14 hydro, gas and coal units where needed to fill system strength gaps.

As detailed in Chapter 5, Transgrid plans to meet its new system strength obligations as quickly and efficiently as possible.

1.6.2 Preparing to operate a more complex electricity system

A renewable grid is a more dynamic and complex system, and requires new operational capabilities.

To meet consumer expectations for reliable electricity, we need stronger analytical and operational capabilities to plan, manage and operate an electricity system that is becoming more distributed, dynamic and unpredictable.

The power system transformation is creating a much greater need for information and analysis across our control and planning functions. This is particularly due to an increase in the number and new types of transmission assets, in combination with unprecedented changes in generation and load interacting with our network. Renewable generation and storage also have far more variability compared to the consistent profile of retiring baseload generation, which historically enabled network operators to quickly return the system to secure operations following contingency incidents like weather events, equipment failures or trips.

Transgrid has already observed that the NSW electricity system is sitting closer to the edge of its secure operating envelope. This means the system is more likely to tip into insecure operating conditions if a credible contingency occurs, requiring increased scrutiny from operators who must intervene more frequently to maintain system resilience.

Transgrid is developing enhanced operational technology in our control rooms and offices, including our Supervisory Control and Data Acquisition system. Without upgrades, we are concerned that:

- We would need to operate the system in a more conservative way using static operating limits, to have confidence that the system will remain within its required technical envelope. This might require constraints to be imposed more frequently, which would potentially limit the output of some low-cost renewable generation.
- There is an increased likelihood of emergency outages or disruptions when our operators are overburdened, especially when processing multiple sources of information following extreme weather and other contingency events, which are increasing in frequency.

By developing upgraded tools and otherwise proactively addressing these issues, we believe adverse outcomes can be minimised. We also expect these tools will enable us to operate the power system more efficiently, which will yield benefits for consumers. Benefits include lower market prices and reduced greenhouse gas emissions because of fewer constraints on low-cost renewable generation, and reduced risk of unmet energy demand from contingency events.

Transgrid is applying the RIT-T to multiple technology options, including providing reactive capabilities through enhancing existing core operating technologies with further enhancements to provide proactive capabilities.

Our assessment indicates that the market benefits from enhancing control-room tools and capabilities and tools will exceed the costs of these investments – particularly when it comes to developing proactive capabilities. Transgrid is working with stakeholders to urgently progress these plans.

Ben Bowdidge –
System Operator

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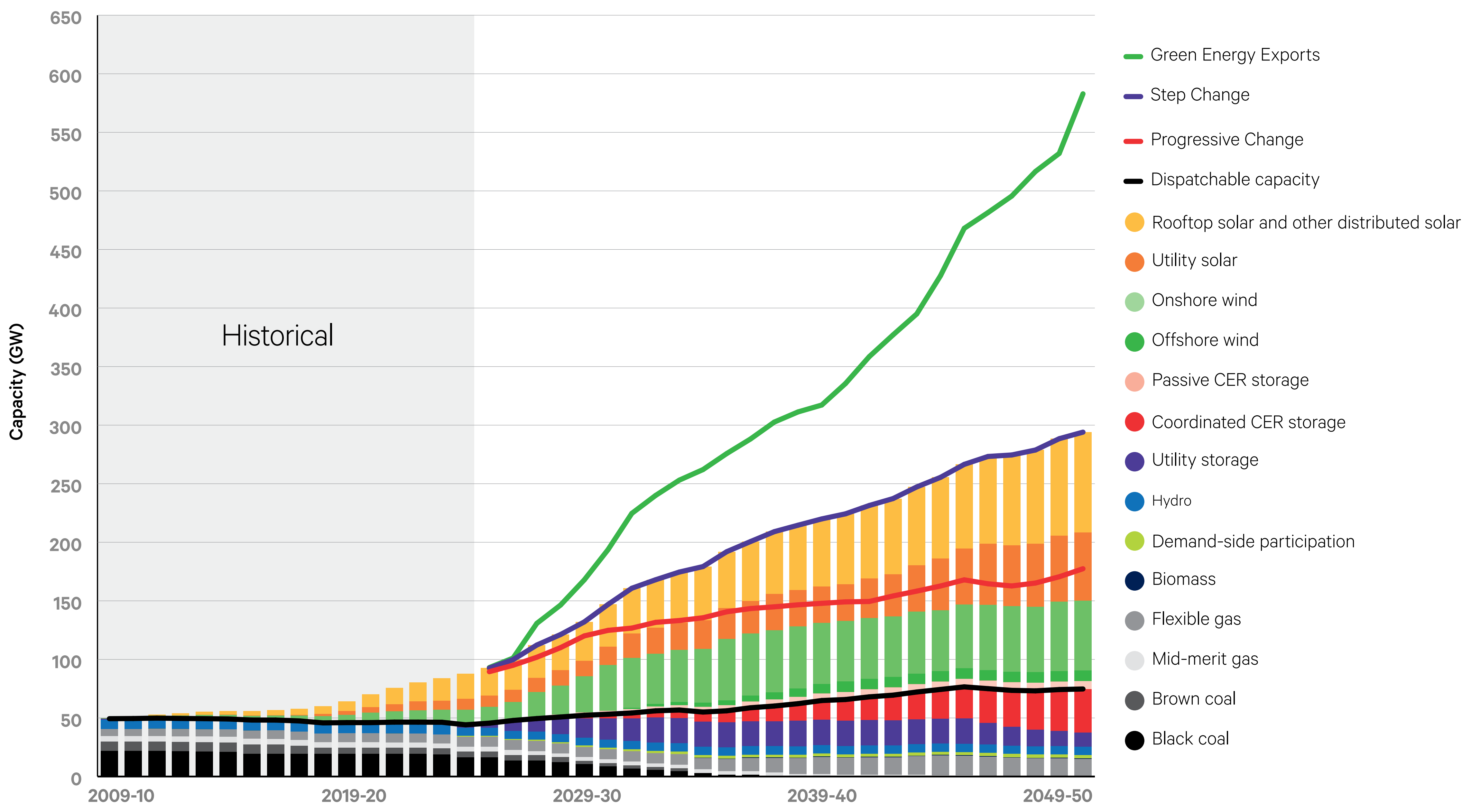
1.7.1 Future emerging energy requirements

In the decade beyond 2035, as we reach our new transitioned era, Australia's energy demand will continue to increase due to population growth, industry and transport electrification, as well as the development of emerging industries. Most of this new capacity is expected to be provided by renewables, requiring significant investment in additional renewable generation capacity, and transmission and storage infrastructure.

Figure 1.6: NEM generation capacity per year per scenario (2010–2050)[11]



An energy system largely fed by renewables creates additional challenges, not only in maintaining system security, but also managing the risk of renewable energy droughts.

To maintain system security and minimise the impact and likelihood of renewable droughts, we need system-wide solutions with:

- Diverse sources (by generation type and geography) of renewable energy
- Integrated energy storage of all depths
- Peaking generation powered by gas and eventually renewable fuels
- Supporting transmission infrastructure

Industry stakeholders continue to debate preferred system-wide solutions – a debate that increasingly hinges on considerations of deliverability, social licence and overall system cost. These discussions have led to the consideration of alternative energy infrastructure, such as remote inland Renewable Energy Opportunity Areas to meet expanded future electricity demand growth, depending on the scenario that eventuates.

1.7.2 The case for Remote Inland Renewable Energy Opportunity Areas[12]

AEMO's 2024 Integrated System Plan projects that, in NSW by 2050, around approximately 89% future wind-generation capacity will be concentrated within three geographically close REZs: Central-West Orana, New England and Hunter-Central Coast.

Remote Inland Renewable Energy Opportunity Areas would diversify and expand NSW's renewable energy infrastructure.

In last year's Transmission Annual Planning Report, Transgrid proposed several potential Remote Inland Renewable Energy Opportunity Areas, including Broken Hill, Noona and Northwest Horizon based on their:

- High-quality solar and wind resources, including high-capacity factors and greater geographical diversity compared to existing REZs
- Low population and landowner density, reducing potential social and planning constraints
- Underutilised land, with minimal competing land uses, facilitating streamlined development.

The substantial transmission investment required for Remote Inland Renewable Energy Opportunity Areas may be offset by:

- Reduced build requirements of long-duration energy storage in the system
- Reduced risks associated with renewable energy droughts
- Downward pressure on wholesale prices, including a reduction in market price ceiling/spike events.

11 Source: AEMO 2024 ISP

12 Transgrid is referring to Inland Renewable Energy Zones as a discussion of possible future network expansion options, in a similar way to AEMO's considerations of candidate REZ options in the development of the ISP. Transgrid is not advocating for Ministerial declaration of any additional REZs under the NSW EII Act at this time

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1.7.3 Early integration of Remote Inland Renewable Energy Opportunity Areas into centralised planning

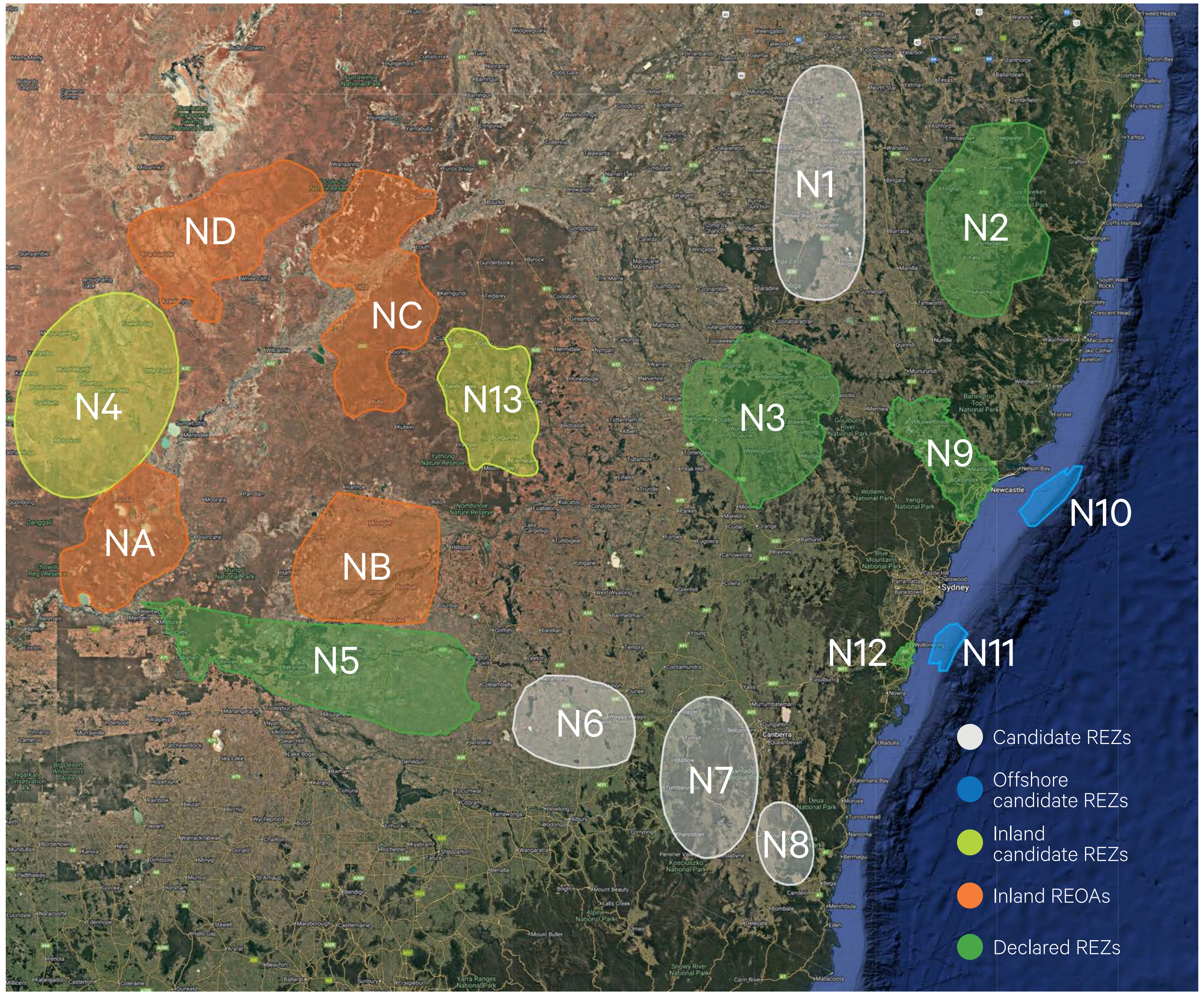
Industry stakeholders increasingly recognise the opportunity to improve generation diversity by developing REZs in remote locations. As such, Transgrid has further developed its Remote Inland Renewable Energy Opportunity Areas (REOAs) propositions to include the Western NSW, South Cobar, and East Hillston REOAs, as shown in Figure 1.7. These opportunities can be enabled with fewer kilometres of transmission augmentation and can serve as staging opportunities – or stepping stones – towards further Remote Inland REOAs enablement over time.

Stakeholders have begun evaluating candidate REZ[13] locations and their integration into centralised energy system planning frameworks. Notably, AEMO has recently updated its representation of ISP candidate REZs. This update includes adding the new South Cobar candidate REZ (N13) and new transmission options to support the Broken Hill candidate REZ (N4), as detailed in the 2025 Electricity Network Options Report.

Table 1.1: New NSW candidate Renewable Energy Zone options

ID	Candidate REZ Option	Hosting Capacity (MW)	Description
N13	South Cobar	1,000–2,400	Utilising VNI West uplifting Dinawan to 500 kV, implement a 500 kV DCST transmission solution to South Cobar via Dinawan.
N4	Broken Hill	800–2,400	Utilising the VNI West 500 kV backbone to the VIC border, implement a 500 kV DCST transmission solution to Broken Hill via Moulamein.

Figure 1.7: NSW Renewable Energy Zones and Renewable Energy Opportunity Areas[14]



	ID	REZ / REOA Name
Candidate REZs	N1	North West NSW
	N6	Wagga Wagga
	N7	Tumut
	N8	Cooma-Monaro
Offshore candidate REZs	N10	Hunter Coast
	N11	Illawarra Coast
Inland candidate REZs	N4	Broken Hill
	N13	South Cobar
Inland REOAs	NA	Western NSW
	NB	East Hillston
	NC	Noona
	ND	Northwest Horizon
Declared REZs	N2	New England
	N3	Central West Orana
	N5	South West NSW
	N9	Hunter-Central Coast
	N12	Illawarra

13 Candidate REZs have been identified and investigated by AEMO in the ENOR and ISP"
14 Source: AEMO 2025 Electricity Network Options Report & Transgrid analysis

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1.7.4 'New' and 'Future' Remote Inland Renewable Energy Opportunity Areas

Additional options beyond those considered for the 2026 Integrated System Plan are expected to emerge. Already, Transgrid has submitted transmission solution options to AEMO's 2025 Electricity Network Options Report for the 2026 Integrated System Plan for establishing the Broken Hill and South Cobar candidate REZs. These options leverage major transmission investments currently under development and utilise corridors that will also enable two new REOAs: Western NSW and East Hillston.

Table 1.2: Future proposed Renewable Energy Opportunity Area options

ID	REOA Option	Enablement pathway
NA	Western NSW	The Broken Hill candidate REZ transmission solution leverages the VNI West 500 kV backbone and the PEC 330 kV backbone to extend the transmission system in a staged approach, unlocking the Western NSW REOA along the way.
NB	East Hillston	The South Cobar candidate REZ transmission solution leverages the VNI West 500 kV transmission backbone to extend the transmission system north from Dinawan substation, unlocking the East Hillston REOA along the way.

These REOA locations could be developed incrementally ahead of the Broken Hill and South Cobar candidate REZs, minimising transmission augmentation costs while accelerating the availability of renewable hosting capacity. This accelerated approach could also enhance system resilience by increasing renewable energy diversity, supporting the grid as NSW coal generation units retire.

Looking ahead, further modular expansion of the Inland REZ/REOA transmission network – to more remote locations such as Noona REOA and Northwest Horizon REOA – could provide additional portfolio diversity and social licence benefits.

1.7.5 Next steps

The industry recognises the strategic value of continually assessing alternative development pathways and identifying optimal renewable energy locations to support the next phase of the NSW energy transition. Transgrid remains committed to maintaining a flexible and technology-neutral approach to potential development pathways, including Remote Inland Renewable Energy Opportunity Areas to meet the state's energy needs throughout the 2030s and beyond.

We will continue to collaborate with key stakeholders to advance the development of Remote Inland Renewable Energy Opportunity Areas by:

- Supporting AEMO in its assessment of candidate REZ options as part of the 2026 ISP
- Maintaining active participation in Joint Planning Forums alongside EnergyCo and NSW Distribution Network Service Providers
- Continuing to build internal capabilities to support the early-stage development of Remote Inland Renewable Energy Opportunity Areas, including preparing detailed network planning materials, commercial frameworks and applied market modelling.

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Substation at Bannaby NSW

Transmission network developments

As we enter a new, deep phase of the energy transition, the transmission buildout will accelerate to connect renewable energy to load centres.

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Transgrid is responding by developing a transmission network that is ready for 90% renewable energy by 2035. At that point, nearly all coal-fired generation will be retired and replaced with a mix of renewable energy and firming/storage solutions.

To enable this transition at the lowest cost to consumers, Transgrid is expanding its transmission network to form the backbone of a modern energy system. This expansion, detailed in Section 2.1, includes a portfolio of transmission projects that add new capacity to and relieve constraints on the existing network. Careful co-planning with EnergyCo and Distribution Network Service Providers (DNSPs) means these upgrades will support the development of new Renewable Energy Zones (REZs) and the continued growth of open-access generator connections.

DNSPs in NSW and the ACT play a growing role in achieving net zero by 2050. Their efforts in integrating renewables, managing demand and maintaining grid reliability are vital. Our regular joint planning with DNSPs is key to delivering a cohesive, least-cost energy transition for consumers.

Energy demand is evolving rapidly. We're seeing a widening gap between rising peak demand and falling minimum demand, driven by increasing rooftop solar penetration. While lower minimum demand presents new challenges that we are actively addressing, it also reflects the growth of solar – currently the lowest-cost energy source for consumers and a valuable contributor during periods of low wind generation. The rise in peak demand is linked to emerging technologies that are reshaping our society, including data-centres, electric vehicle charging, and the electrification of buildings and industry. Section 2.2 explores the impact of this demand growth on forecast network constraints, while Chapter 3 outlines the innovative solutions being adopted to support this shift.

Operating a complex, renewables-based power system safely and reliably requires new tools and capabilities. We also need to evolve our capital works replacement program to ensure that assets are replaced, retired or refurbished as needed. Where viable, we prioritise non-network options to defer the cost of asset renewal. Details of these projects can be found in Section 2.4 (asset replacement) and Section 2.5 (asset retirements).

In planning and delivering transmission projects, Transgrid is committed to building and maintaining trust with landowners, communities, businesses, local governments and other stakeholders. We engage, consult and collaborate with those impacted by our projects to understand concerns and incorporate community input into our decisions.

Our goal is to leave a positive and lasting social legacy for generations to come.

Commercial rooftop solar panels

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2.1 Proposed major developments

Transitioning to a renewable future

The shift from coal to renewable energy will be supported by a new transmission backbone, stretching from SA and Vic to Qld. This critical infrastructure will enhance system resilience and enable the efficient, secure transfer of energy from REZs and other renewable generation sites to major population centres and emerging green industries.

As the primary Transmission Network Service Provider for NSW and the ACT, Transgrid is responsible for planning the shared transmission network. Our goal is to ensure the safety, security and reliability of the electricity system, while aligning with long-term network development plans. This work is closely coordinated with the development pathway outlined in AEMO's 2024 Integrated System Plan, particularly in integrating REZ infrastructure into the broader Transgrid network.

Major projects in NSW are delivered through either the NER framework or the EII Act framework – with the Integrated System Plan projects driving the NER framework and the EII Act delivering REZs and Priority Transmission Infrastructure Projects, such as the Waratah Super Battery and the Hunter Transmission Project. Transgrid is planning and delivering the NER major projects outlined in this Chapter 2.1, and is supporting EnergyCo in its role as Infrastructure Planner to plan and deliver the REZs and Priority Transmission Infrastructure Projects.

We are working in close partnership with EnergyCo to plan, develop and deliver REZs and their transmission connections. This collaboration supports the EnergyCo Network Infrastructure Strategy,[15] a 20-year strategy that outlines projects and options to meet the objectives of the Electricity Infrastructure Investment Act 2020 and the NSW Electricity Infrastructure Roadmap. These initiatives aim to deliver at least 12 GW of renewable generation, and 2 GW and 16 GWh of long-duration storage by 2030, rising to 28 GWh by 2034 – at the lowest cost to consumers.

In parallel, we are helping to plan the distribution networks for REZs across NSW. Using existing distribution infrastructure to connect renewables can be cost effective and help to accommodate changing energy demand patterns. We plan jointly with EnergyCo and Distribution Network Service Providers (DNSPs) to ensure network upgrades are coordinated and effective across both transmission and distribution systems. Major transmission developments aligned with AEMO's 2024 Integrated System Plan and the NSW Roadmap are underway to address emerging constraints, support REZ connections and enable a clean, reliable and affordable energy future. These developments span the Central, Northern and Southern regions of the transmission network (see Figure 2.1).

Transgrid is committed to working closely with landowners, communities, First Nations peoples, regulators and local councils to minimise environmental and community impacts throughout the planning, construction, and operation of new transmission lines. We prioritise meaningful and respectful engagement to reduce visual and physical impacts, protect agricultural land and biodiversity, preserve Aboriginal heritage, and maximise economic and social benefits for local communities.

Collector Wind Farm

15 EnergyCo Network Infrastructure Strategy for NSW published 25 May 2023

Transgrid

This section describes the following projects in detail:

Central region

- Sydney Ring North – Hunter Transmission Project,[16] including the Waratah Super Battery
- Sydney Ring South
- Central West Orana REZ
- Hunter-Central Coast REZ
- Illawarra REZ

Northern region

- QNI Connect
- New England Network Infrastructure

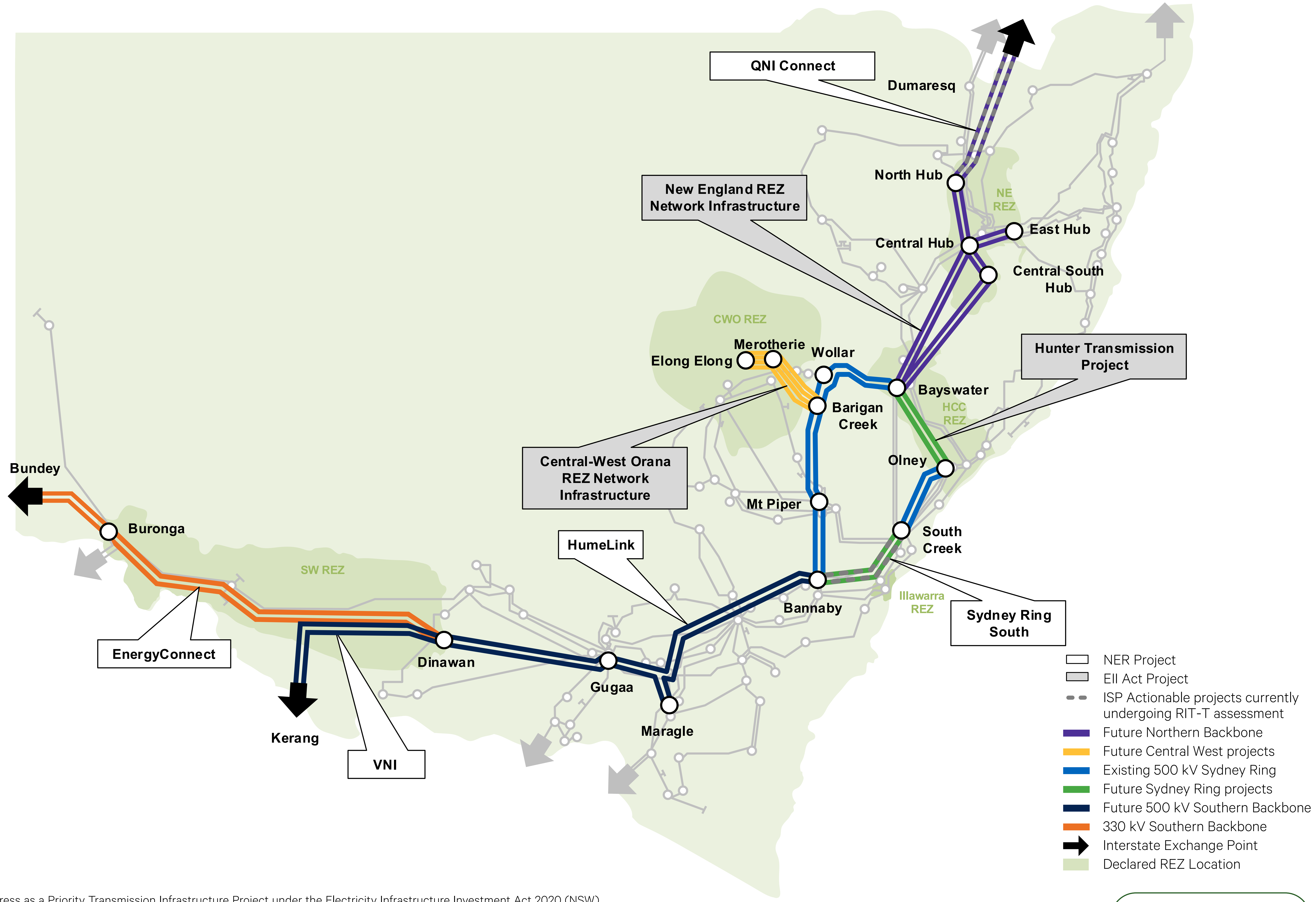
Southern region

- EnergyConnect
- HumeLink
- VNI West
- South West REZ

Future major developments

- Wondalga Switching Station
- Long-term development strategy for the Sydney, Newcastle and Wollongong supply network.

Figure 2.1: Central, Northern and Southern regions with proposed major developments[17]



16 The Hunter Transmission Project (Sydney Ring North) was declared Critical State Significant Infrastructure (CSSI) and will progress as a Priority Transmission Infrastructure Project under the Electricity Infrastructure Investment Act 2020 (NSW).

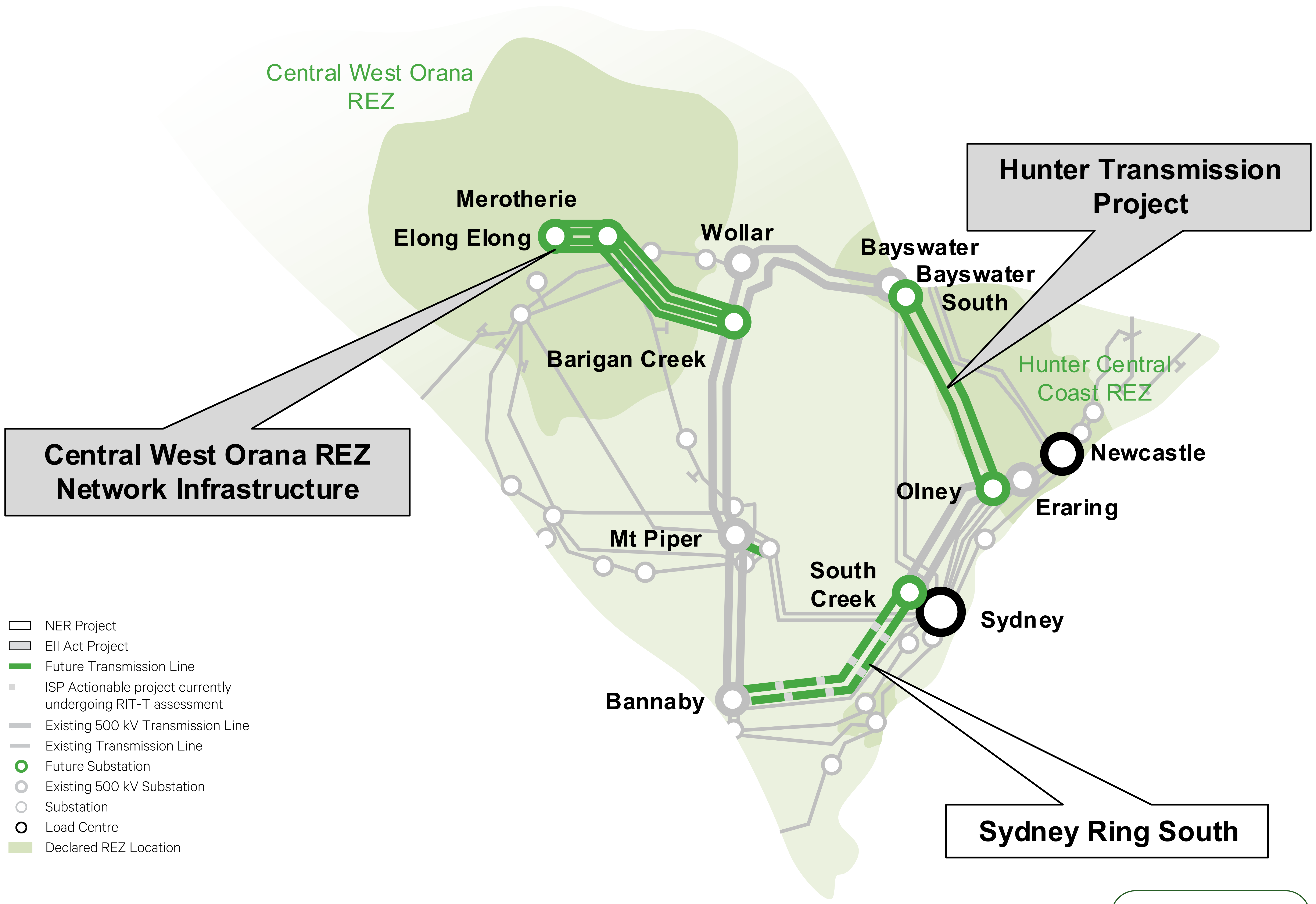
17 Includes transmission projects delivered contestably under the NSW EII Act framework, which will not be constructed, owned or operated by Transgrid

2.1.1 Central Region

The Central Region extends from Bayswater substation in the north to Bannaby substation in the south. Major developments in this region, shown in Figure 2.2 and Figure 2.3, include the completion of the 500 kV Sydney Ring and the Central West Orana REZ.

The 500 kV Sydney Ring will provide security to Sydney through diverse supply routes from collector points at Barigan Creek (CWO REZ), Bayswater (New England REZ and QNI) and Bannaby (Snowy 2.0, HumeLink, VNI West and PEC).

Figure 2.2: The Central Region map[18]



18 Includes transmission projects delivered contestably under the NSW EII Act framework, which will not be constructed, owned or operated by Transgrid.

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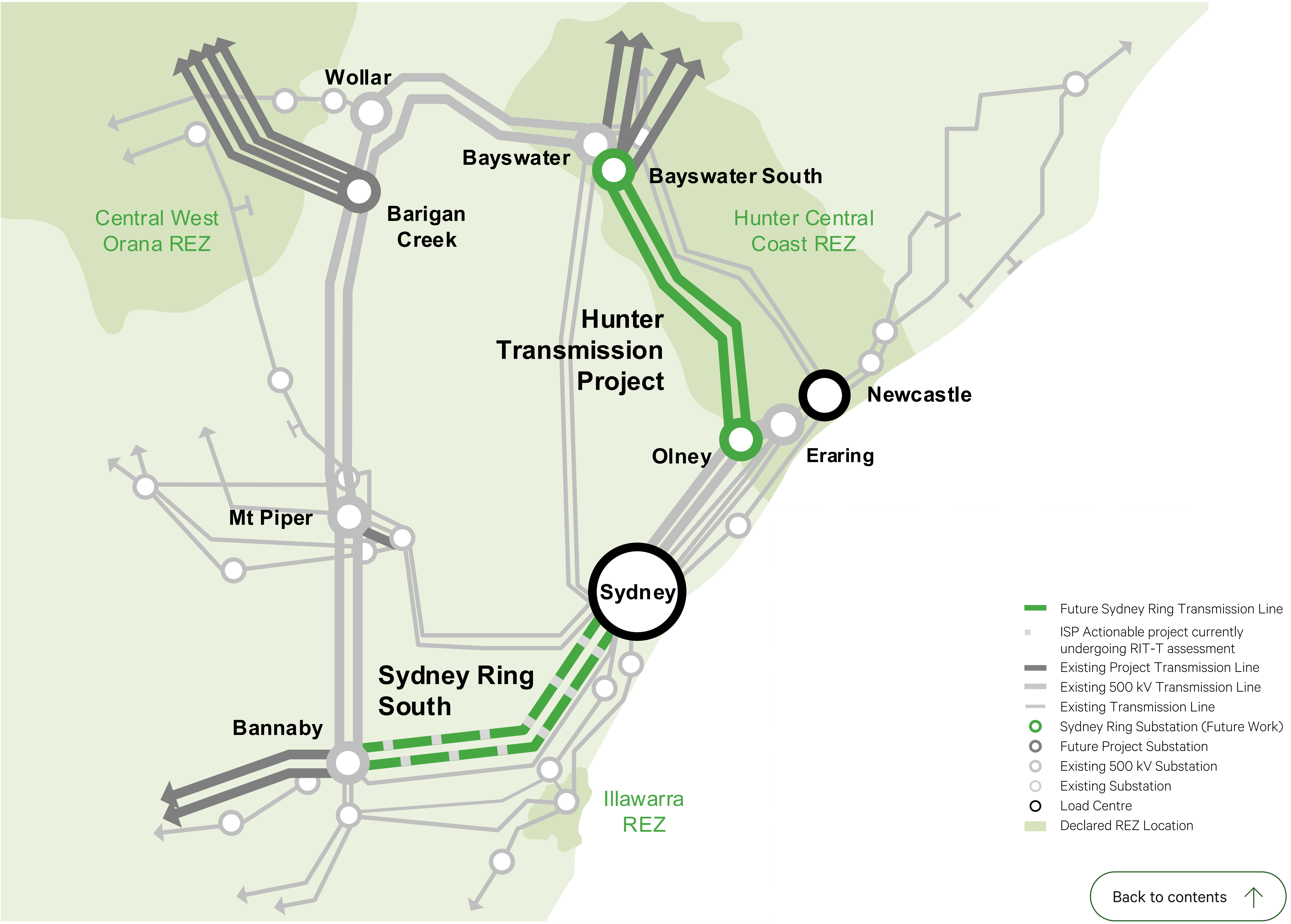
Planned project – Sydney Ring North (Hunter Transmission Project)

The Sydney, Newcastle and Wollongong (SNW) area includes significant urban, commercial and industrial loads that create about three-quarters of the demand for electricity in NSW. When power stations at Vales Point and Eraring on the Central Coast retire, energy will largely come from generation outside of the SNW region. To reinforce the network to deliver this energy, the 500 kV ring between the Upper Hunter, Central West, Southern Tablelands and Sydney, Newcastle and Wollongong is being further developed, as described below.

Currently, the transmission capability into the key SNW load centres is mainly determined by the thermal capacity of the:

- 330 kV transmission lines between substations in the Upper Hunter and the Central Coast
- 330 kV transmission lines from Bannaby to Sydney and the South Coast.

Figure 2.3: Reinforcement to Sydney/Newcastle/Wollongong load centres[19]



19 Includes transmission projects delivered contestably under the NSW EII Act framework, which will not be constructed, owned or operated by Transgrid

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Given the increased reliability risk in NSW,[20] the timely completion of the Sydney Ring North projects is critical to reinforce the energy supply in the SNW region. These projects include:

Waratah Super Battery (WSB)

Planner: EnergyCo
Network Operator: Transgrid
Transgrid's role: Non-contestable works

This is a Priority Transmission Infrastructure Project (PTIP) to alleviate constraints on the existing transmission network during periods of high demand. As the Network Operator for the WSB, Transgrid is delivering a System Integrity Protection Scheme (SIPS) that uses up to 700 MW /1,400 MWh of capacity from a BESS within the SNW region to increase transmission capacity between regional NSW and the SNW region, till HTP Stage 1 is commissioned. The project is scheduled for completion in 2025. The scope includes:

- Implementing a SIPS capable of monitoring key 330 kV lines, detecting overloads and relieving them by discharging the BESS
- Upgrading the existing network to maximise the benefits of the WSB project, including uprating a number of 330 kV transmission lines (including the Yass to Marulan, Yass to Collector, Collector to Marulan and Bannaby to Sydney West lines) and existing substation assets that would otherwise limit the SIPS' ability to increase power transfers into the SNW area from regional NSW.

Hunter Transmission Project (HTP) Stage 1

Planner: EnergyCo
Network Operator: Transgrid
Transgrid's role: Non-contestable works

This EnergyCo project includes a new double-circuit 500 kV line between new Bayswater South and new Olney 500 kV switching stations to help import electricity from the Central West Orana and New England REZs. HTP is an actionable project in AEMO's 2024 Integrated System Plan and is proceeding as a PTIP. It is scheduled for completion by Nov 2029. The scope includes:

- Establishing a new Bayswater South 500 kV switching station near the existing Bayswater substation, and cutting it into the existing 500 kV network
- Establishing a new 500 kV switching station in the Olney State Forest, near Eraring, and cutting it into the existing 500 kV network
- Constructing new 500 kV double-circuit line between the two new switching stations (approx. 100 km)
- Installing two 500/330 kV 1,500 MVA transformers at Eraring substation
- Installing line reactors at the Bayswater South switching station on the new double-circuit transmission line.

HTP Stage 2

Planner: EnergyCo
Network Operator: To be appointed
Transgrid's role: Non-contestable works

This "Plan for the Future" project in EnergyCo's 2023 Network Infrastructure Strategy may be required after 2033 to unlock further generation capacity from future stages of the Central West Orana and New England REZs. The scope would potentially include:

- Developing the second 500 kV double-circuit between Bayswater and Eraring,[21] potentially using Transgrid's existing easement by demolishing an existing 330 kV single-circuit line and rebuilding it as a 500 kV double-circuit line in the same easement. This may necessitate rebuilding a section of the other 330 kV single-circuit line to double-circuit 330 kV construction.

20 May 2024 Update to the 2024 Electricity Statement of Opportunities (aemo.com.au)
21 Further studies are required to fully define the scope, and the line origination and destination may be extended from Wollar to Sydney.

Planned project – Sydney Ring South

Planner: Transgrid
Network Operator: Transgrid
Transgrid's role: Planner/Integrated System Plan Actionable

There is limited capacity to supply SNW from the south due to limitations in the network that will become most prevalent from the early 2030s. The current rate of uptake of utility-scale BESS, consumer energy resources and demand side participation will likely be insufficient to meet the needs of the region within a suitable timeframe, leading to increased likelihood of Lack of Reserve conditions.

To support long-term energy security for SNW load centres, and give NSW consumers access to more diversified energy, we need to 'close the loop' by building out the southern part of the Sydney Ring by the early to mid-2030s. This will also support load growth driven by electrification and the development of data-centres, particularly in the Greater Western Sydney and the Illawarra areas, and address future constraints on generation from Southern NSW.

The Sydney Ring will connect with valuable generation sources in Southern NSW, including:

- The expanded Snowy Hydro scheme, which will provide dispatchable capacity, long-duration storage and system strength benefits
- South-West REZ, which will have 2.5 GW of transmission capacity supporting aggregate generation capacity of 3.56 GW, including a high proportion of wind-generation projects that tap into strong, complementary wind resources – providing generation at different times to those in northern and central NSW
- HumeLink, which will connect interstate capacity from SA via EnergyConnect and from Vic via VNI West into Bannaby.

Various options are being considered for Sydney Ring South:

As an actionable Integrated System Plan project, Sydney Ring South is progressing through a Regulatory Investment Test for Transmission (RIT-T), which assesses the benefits of each credible option and will decide which solution is best for consumers.

The options under development for Sydney Ring South may include part or combinations of:

- Power-flow control solutions to enhance utilisation of the existing transmission lines supplying the SNW region, subject to assessment of feasibility.
- A new 500/330 kV substation at South Creek with up to three transformers cutting into existing 500 kV lines 5A1 and 5A2 and 330 kV lines 32, 38 and 39, plus duplication of line 39 between South Creek and Sydney West to enhance the ability to supply growing demand in Greater Western Sydney.
- A new 500 kV double-circuit transmission line between Bannaby and the new South Creek substation, which may initially be operated at 330 kV to defer capital costs associated with construction of the 500 kV switchyard at South Creek. This new transmission line could also terminate at the existing Kemps Creek substation but would need to initially be operated at 500 kV.
- Non-network solutions to bridge the augmentation stages and maximise benefits to consumers.

The RIT-T process will refine the detailed scope and cost of each option, including assessing potential corridor routes and sites for new substations. This is particularly important for works in Greater Western Sydney, where constraints are quickly emerging due to the development of the Western Sydney International Airport and surrounding precincts.

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NSW Electricity Infrastructure Roadmap project – Central West Orana REZ (CWO REZ)

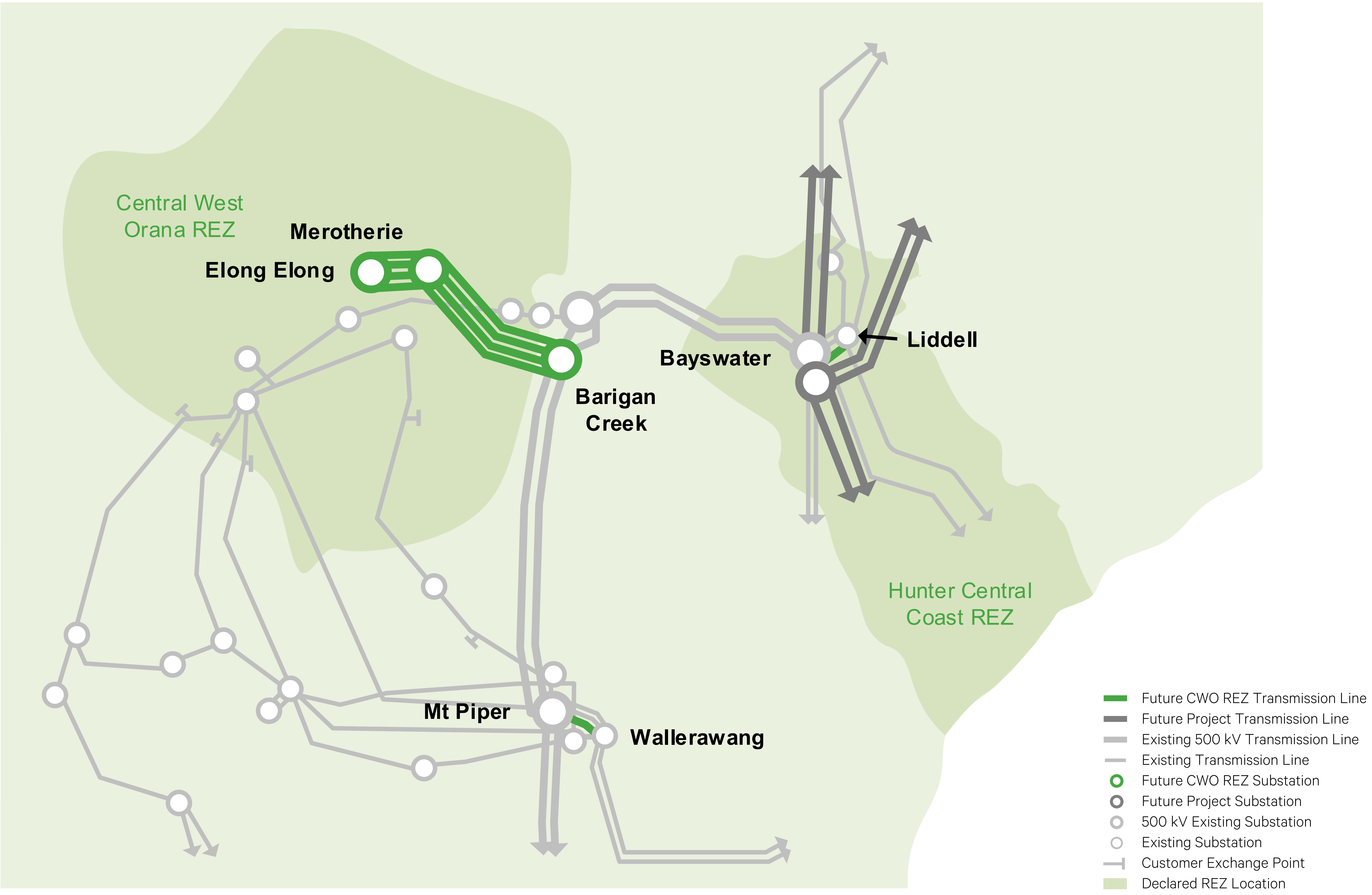
Planner: EnergyCo
Network Operator: ACEREZ
Transgrid's role: Non-contestable works

The CWO REZ was the first to be rolled out under the NSW Government's Electricity Strategy and NSW Electricity Infrastructure Roadmap. The region was chosen for its proximity to the existing backbone transmission network and strong mix of energy resources, including renewable energy.

The connection of this REZ to the transmission backbone is critical. The 500 kV network infrastructure between Bayswater and Mt Piper is both a component of the 500 kV backbone of the NSW shared network and a critical part of the National Electricity Market (NEM). As the operator of the NSW shared network, Transgrid must ensure that any connection to the shared network does not, in any way, compromise or increase risks to the safety, system security, system stability or operational reliability of the network.

In May 2025, the NSW government granted approval[22] for 10 renewable energy projects – totalling 7.15 GW of wind, solar and grid-scale batteries – to connect within CWO REZ. The projects are expected to start connecting by 2028. The CWO REZ network infrastructure project (CWO RNIP), consists of an expandable network, spanning from Wollar to Elong Elong via Merotherie in the Central-West and Orana region of NSW.[23] The high-level scope for CWO RNIP (at least 4.5 GW transfer capacity) includes:[24]

Figure 2.4: Central West Orana REZ[25]



22 https://www.energyco.nsw.gov.au/news/multi-billion-renewables-investment-private-sector-power-2-7-million-nsw-homes
23 CWO REZ – public report – FINAL DRAFT.docx (nsw.gov.au)
24 Option 1A for CWO REZ in EnergyCo 2023 NIS. Note that the total available downstream capacity for NE REZ, HCC REZ and CWO REZ combined is approximately 3,000 MW until Hunter Transmission Project Stage 1 is commissioned.
25 Includes transmission projects delivered contestably under the NSW EII Act framework, which will not be constructed, owned or operated by Transgrid

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- A 500 kV network (with some components operated at 330 kV), including a new switching station at Barigan Creek and energy hubs at Merotherie and Elong Elong (the Core Infrastructure).
- A 330 kV hub-to-project network to connect to the Core Infrastructure via energy hubs through shared infrastructure at Merotherie and Elong Elong.
- System strength infrastructure, including a system strength solution for an installed 1,750 MVA to ensure the network has adequate system strength to enable output from the renewable energy generation and storage projects from day one.

Transgrid's transmission project to support this REZ is an anticipated 2024 Integrated System Plan project, expected to be completed by 2028. The high-level scope of network augmentation includes:

- Cutting Line 81 Liddell – Newcastle into Bayswater to form the third line between Bayswater and Liddell
- Constructing a 330 kV single-circuit line from Mt Piper to Wallerawang
- Cutting in new 500 kV Barigan Creek Switching Station into lines 5A3 and 5A5, and upgrading the protection system and transpositions of 500 kV lines to manage voltage unbalance between Bayswater and Bannaby
- Augmenting the existing Bayswater, Liddell, Mt Piper and Wallerawang substations to accommodate additional lines and upgrade protection systems where required
- Potentially installing a Special Protection Scheme for non-credible contingency of double-circuit outage to fulfil NER S5.1.8 Planning requirements.

NSW Electricity Infrastructure Roadmap project – Hunter-Central Coast REZ (HCC REZ)

Planner: EnergyCo
Network Operator: Ausgrid
Transgrid's role: Non-contestable works

The HCC REZ is strategically located at the confluence of significant existing transmission infrastructure and valuable solar and wind renewable resources. The region also boasts port infrastructure, transport infrastructure and a skilled workforce.

These features mean this REZ can provide low-cost insurance (via readily-available network expansion) to support renewable connections should unexpected delays occur in delivering the CWO or New England REZs.

The new network capacity brought online for the HCC REZ will be 1 GW.[26] The capacity will be delivered via a staged delivery with the first 350 MW of capacity released in late-2025, an additional 280 MW of capacity released in June 2028, and the final 370 MW of capacity released in July 2028.

NSW Electricity Infrastructure Roadmap project – Illawarra REZ

Planner: EnergyCo
Network Operator: To be appointed
Transgrid's role: Non-contestable works

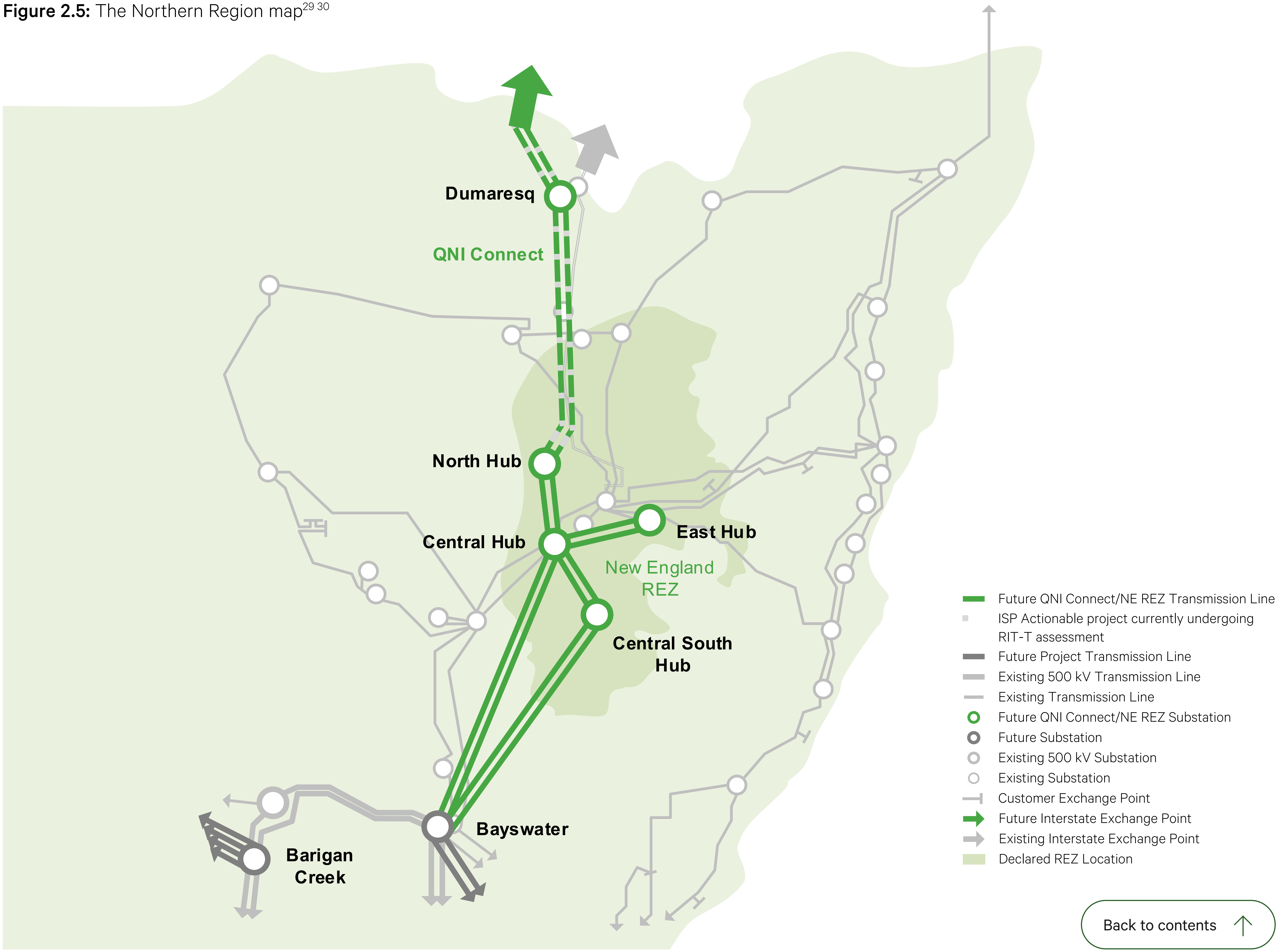
The Illawarra REZ area is supplied through Transgrid's Dapto substation and Endeavour's 132 kV network. The Illawarra hosts large peaking generation, port infrastructure, transport infrastructure, industry, and a skilled workforce. It is already earmarked by the NSW Government as a potential urban REZ[27] based around consumer energy resources. This urban REZ would be perfectly situated to expand into a larger scale REZ to support a decarbonised economy.[28]

26 Note that the total available downstream capacity for NE REZ, HCC REZ and CWO REZ combined is approximately 3,000 MW until Hunter Transmission Project Stage 1 is commissioned.
27 EnergyCo media release: Government engages community on plan for the Illawarra REZ
28 EnergyCo website: Illawarra Renewable Energy Zone

2.1.2 Northern Region

The Northern Region extends from Bayswater in the north through to the Qld state border. Figure 2.5 depicts its major developments.

Figure 2.5: The Northern Region map[29 30]



29 Includes transmission projects delivered contestably under the NSW EII Act framework, which will not be constructed, owned or operated by Transgrid

30 Connection of QNI Connect to North Hub is subject to Joint Planning with EnergyCo.

Transgrid

The Northern Backbone comprises a QNI Connect segment and a New England REZ Network Infrastructure segment, forming a backbone from the Sydney 500 kV Ring up to Qld. Two alternative routes from North Hub to the border are being investigated for the QNI Connect transmission line.

Northern Backbone

QNI Connect	NE REZ Network Infrastructure

Planned project – QNI Connect (QNIC)

Planner: Transgrid/Powerlink
Network Operator: Transgrid/Powerlink
Transgrid's role: Planner/Integrated System Plan Actionable

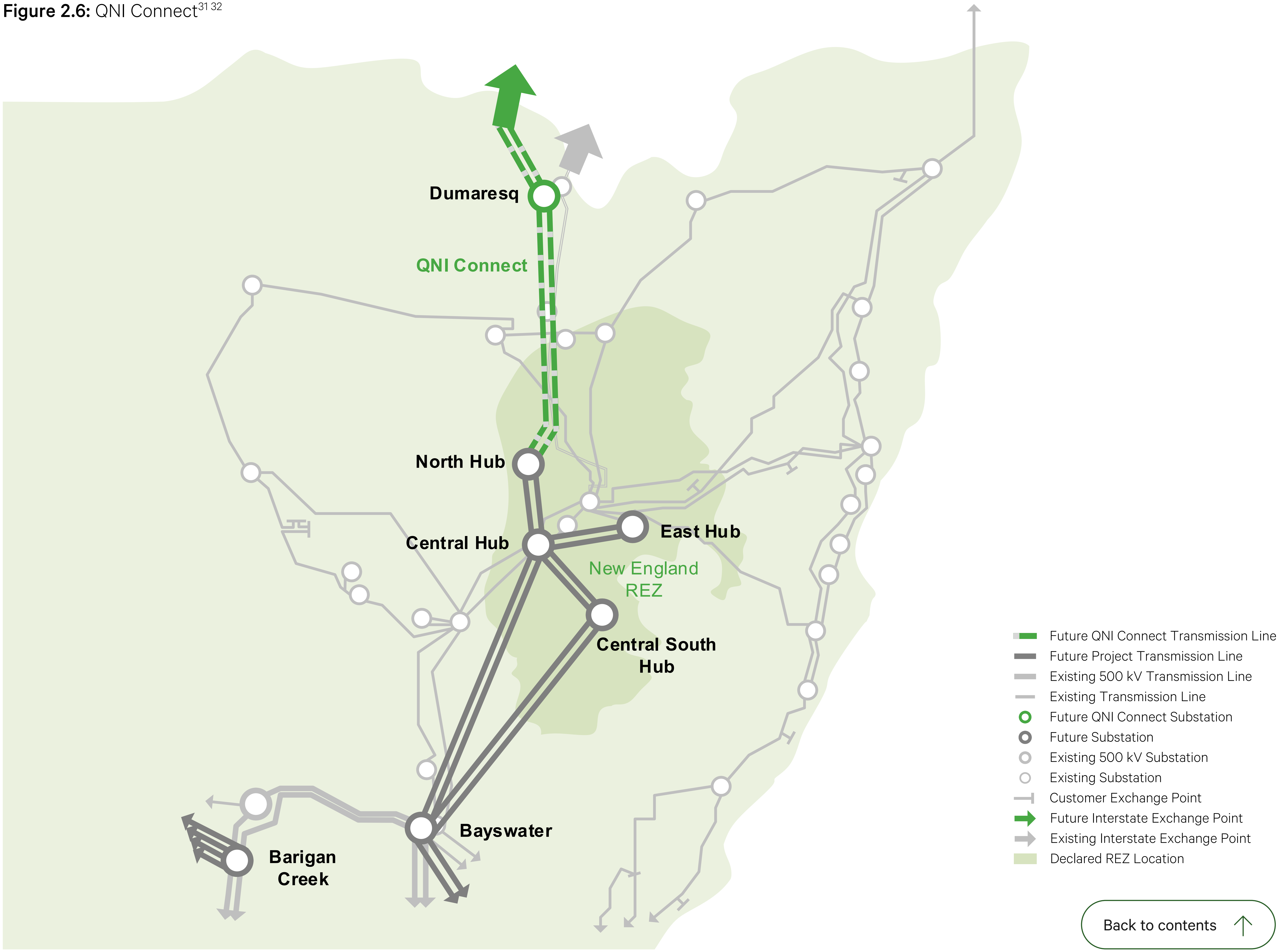
This second Qld – NSW Interconnector is an actionable 2024 Integrated System Plan project proposed as a new, high-capacity, 330 kV or 500 kV circuit overhead transmission line.

A stronger Qld and NSW interconnector could support greater integration of renewable generation, allow for the efficient transport of electricity, and enhance the reliability and stability of the electricity grid during the energy transition. The additional transmission capacity could also deliver net market benefits by:

- Efficiently maintaining supply reliability in NSW, following further coal-fired generation closures and the decline in ageing generator reliability
- Facilitating efficient development and dispatch of generation in areas with high-quality renewable resources in northern NSW, through improved network capacity and access to demand centres
- Enabling more efficient sharing of resources between NEM regions.

All viable network and non-network options are being explored jointly between Powerlink and Transgrid.

Figure 2.6: QNI Connect[31 32]



31 Includes transmission projects delivered contestably under the NSW EII Act framework, which will not be constructed, owned or operated by Transgrid
32 Connection of QNI Connect to North Hub is subject to Joint Planning with EnergyCo.

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As part of the 500 kV network option, both two line routes are being investigated. The eastern route will offer additional benefits including:

- Reinforcing future security of supply to Lismore
- Enabling future energy hubs in the north of the New England REZ to connect to this backbone as it runs through locations that are rich in wind resources.

A 330 kV network option would involve:

- A new 330 kV single-circuit or double-circuit line from the Qld border near Dumaresq to a new substation at New England North Hub
- Reactive power compensation required for the transmission lines.

A 500 kV network option would involve:

- A new 500 kV double-circuit line from the Qld border to a new substation at New England North Hub – two routes are being explored, a western route and an eastern route
- Reactive power compensation required for the transmission lines.

These network options can be optimised with capacity to the New England REZ (discussed in the following section). They can be staged by geography, operating voltage or number of circuits to maximise net economic benefits. Both the 2023 Infrastructure Investment Objectives Report[33] and the 2024 Integrated System Plan selected the New England REZ network option 1(A) and 2(A) as the optimal options for New England REZ Network infrastructure. These network options will build approximately 50 km of new 500 kV lines (initially 330 kV operated) from Central Hub to Northern Hub. Offering cost-reduction and community benefits, the Northern Hub is the preferred starting point for the QNI Connect transmission line (saving a distance of 50 km) through to the Qld border.

The 330 kV double-circuit western route from New England (North Hub) to Dumaresq to Bulli Creek to Braemar was selected as a credible option in the initial Integrated System Plan preparatory work. A new eastern route from New England (North Hub) to Tenterfield is also under consideration as an alternate potential viable line corridor. Both routes are being investigated, and these options will be updated based on current market conditions, generation and demand connection volume.

Two non-network options were submitted to AEMO on QNI Connect. Both will be assessed as part of the Regulatory Investment Test.

As an actionable Integrated System Plan project, QNI Connect will progress through a RIT-T process with a likely in-service date in Mar 2032 subject to final assessments of options.

Insulator

33 The 2023 Infrastructure Investment Objectives Report, AEMO Services, December 2023

Transgrid

Northern Backbone

QNI Connect | **NE REZ Network Infrastructure**

Planned project – New England REZ Network Infrastructure

Planner: EnergyCo
Network Operator: To be appointed
Transgrid's role: Non-contestable works

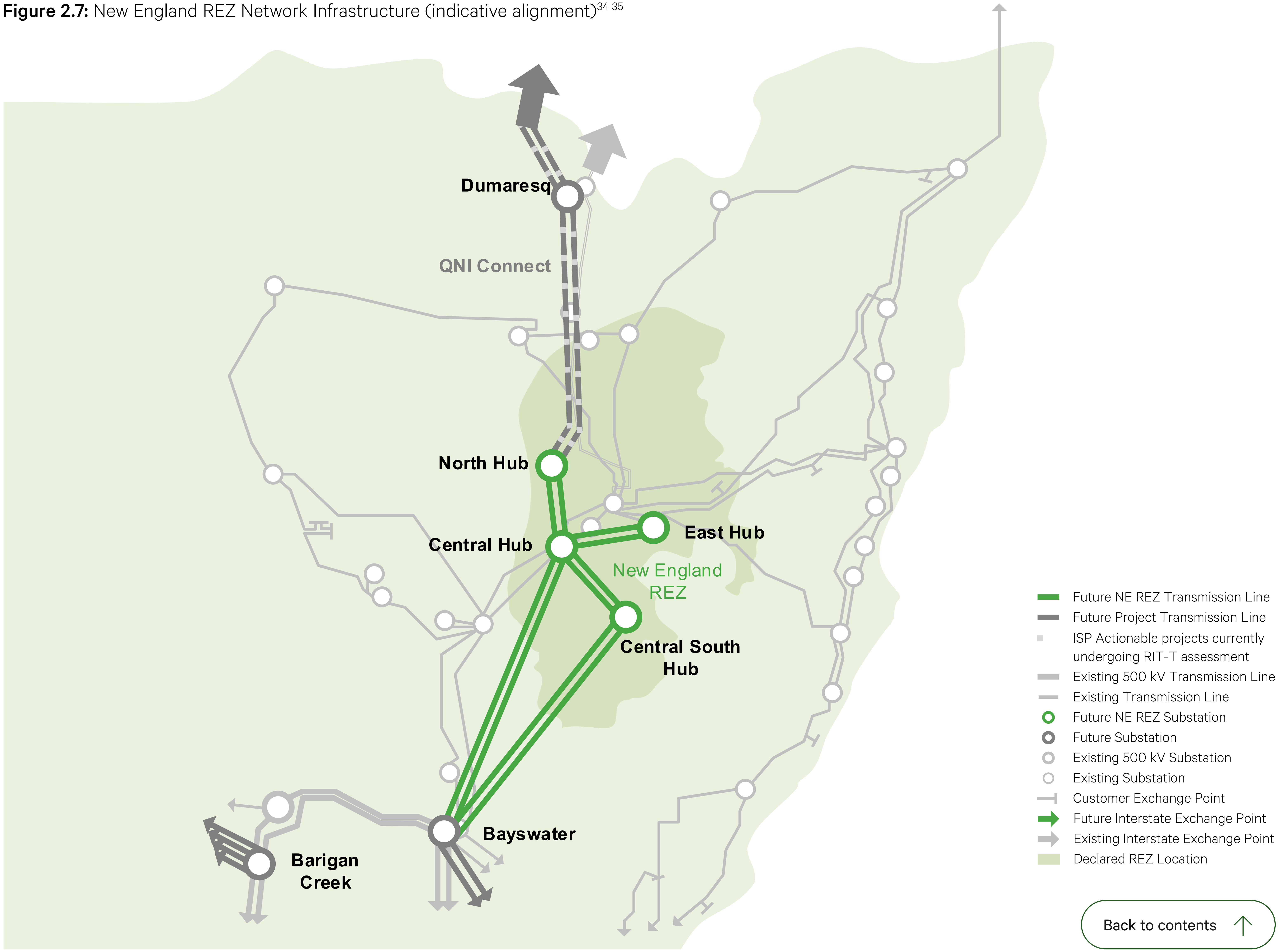
New England REZ (NE REZ) will connect to the 500 kV Sydney Ring at Bayswater substation and a new Bayswater South switching station, helping to secure supply for NSW and Qld customers. The 2024 Integrated System Plan suggests installing both NE REZ and QNI Connect transmission infrastructure will benefit NEM consumers by reducing overall energy costs, increasing reliability, facilitating the energy transition, optimising REZ integration and efficient generation capacity-sharing between NSW and Qld. Additional transmission capacity provides the opportunity to improve security through generation reserve-sharing between NSW and Qld.

The New England REZ Network Infrastructure is an actionable 2024 Integrated System Plan project and forms part of the NSW Electricity Infrastructure Roadmap. Generation export capacity is reported to be up to 8 GW with future expansion potential. Transgrid has received significant interest from renewable energy proponents seeking to connect to the existing transmission network in this area ahead of NE REZ development.

The transmission infrastructure includes two new 500 kV transmission lines between Bayswater and the New England REZ, as well as a network of new 500 kV and 330 kV transmission lines and new energy hubs within the zone.

EnergyCo is managing a competitive procurement process and is seeking registrations of interest to deliver and operate New England REZ. The options identified in the 2024 Integrated System Plan are under review and development in terms of staging and configuration of the new energy hubs within the zone, with Stage 1 capacity release date mid-2032 and Stage 2 capacity release date early-2034.

Figure 2.7: New England REZ Network Infrastructure (indicative alignment)[34 35]



34 Includes transmission projects delivered contestably under the NSW EII Act framework, which will not be constructed, owned or operated by Transgrid

35 Connection of QNI Connect to North Hub is subject to Joint Planning with EnergyCo."

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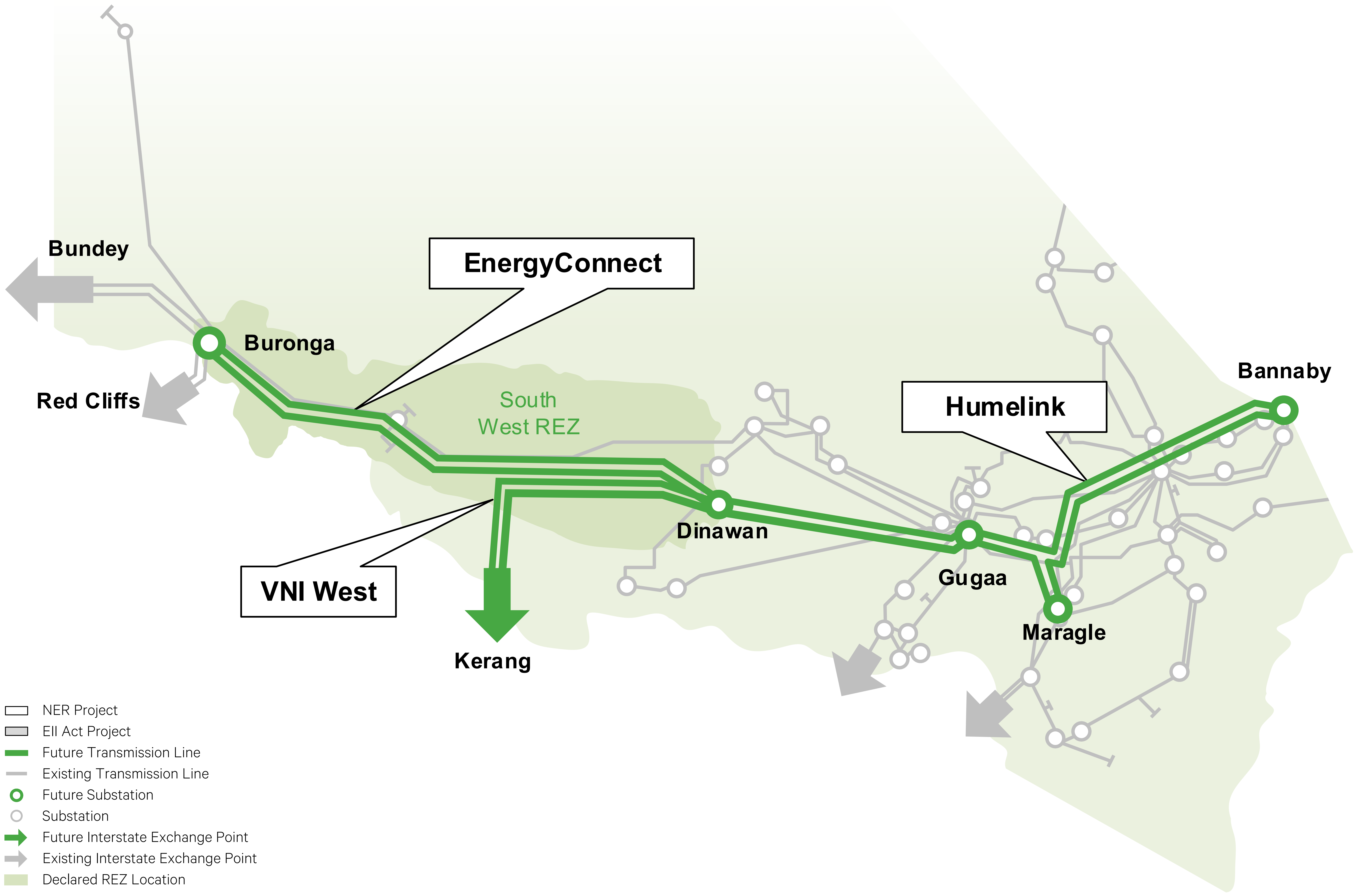
2.1.3 Southern Region

The Southern Region extends from Bannaby in the south through to the Victorian and South Australian borders. Figure 2.8 shows the major transmission network developments in this region.

Transgrid has developed a portfolio-wide program to deliver the three Southern Region projects – EnergyConnect, HumeLink and VNI West – by bundling procurement into a single program: Powering Tomorrow Together. This approach is enabling us to benefit from economies of scale, compete globally for highly sought-after equipment and resources, and deliver projects faster and cheaper for consumers.

The 500 kV Southern Backbone comprises a VNI West segment and a HumeLink segment through to Bannaby – forming a backbone from Vic to the Sydney Ring. The 330 kV EnergyConnect transmission line will feed into the Southern Backbone at Dinawan.

Figure 2.8: The Southern Region map



Considered project – EnergyConnect

Planner: Transgrid/ElectraNet
Network Operator: Transgrid/ElectraNet
Transgrid's role: Planner/Integrated System Plan Committed

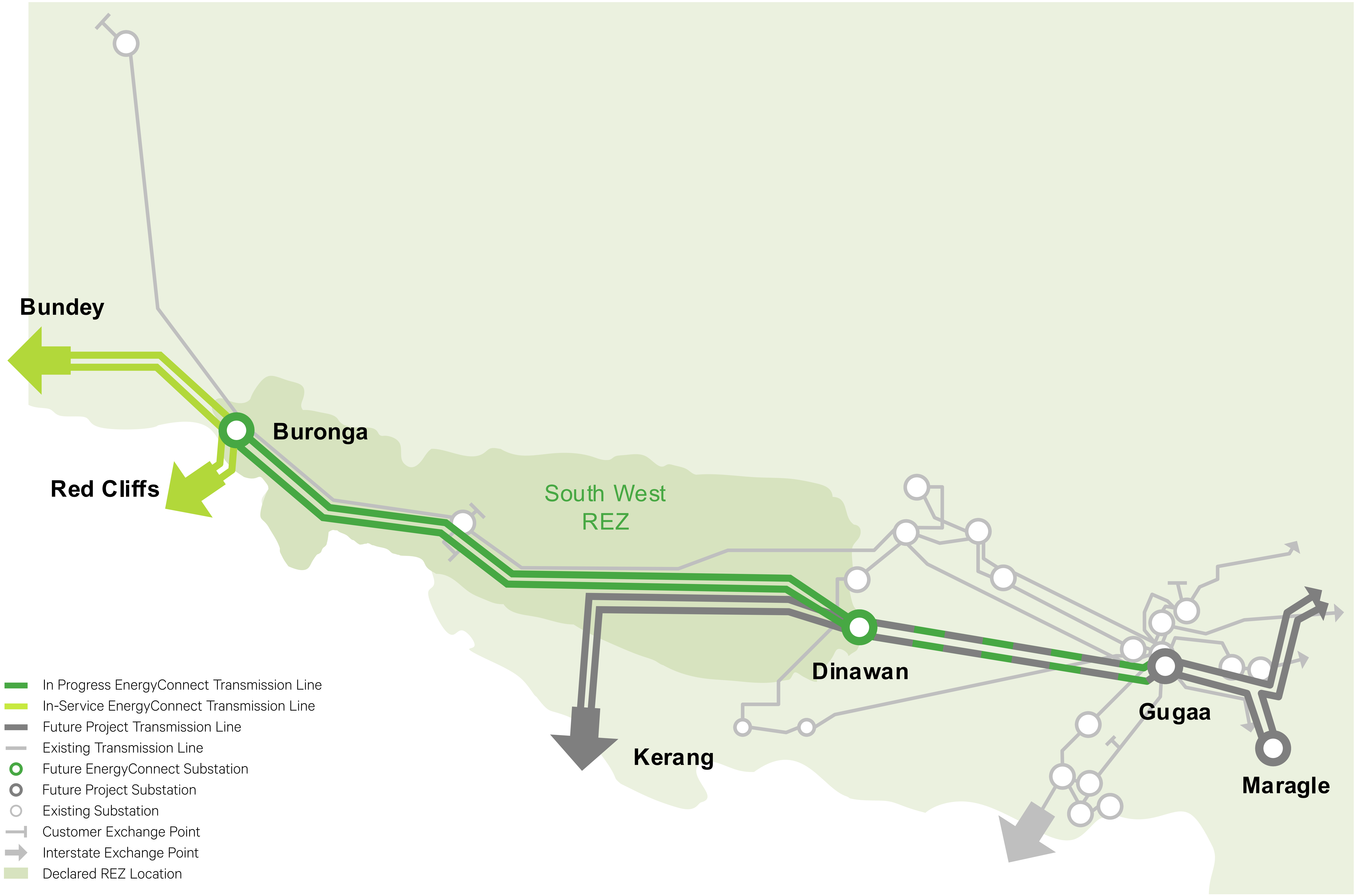
The EnergyConnect 330 kV transmission line feeds into the Southern Backbone at Dinawan as shown in Figure 2.9. The interconnector between NSW and SA will enable excess low-cost renewable energy in SA to supply NSW and Vic. It will also allow generation in the eastern states to displace higher cost gas-fired generation in SA when renewable generation in the state is low.

Stage 1 of EnergyConnect is now fully operational with 150 MW of capacity released in both directions, marking the successful transfer of energy between NSW, SA and Vic.

Additional benefits of the project include:

- Unlocking additional renewable generation resources in South Western NSW
- Enhancing security of supply for SA
- Reducing the risk of supply interruptions by creating a more robust and interconnected transmission network and improved resilience. This is essential for realising benefits of HumeLink and VNI West and improving transfer capacity between SW NSW and HumeLink
- Creating shared system inertia and strength to support system security in SA.

Figure 2.9: EnergyConnect



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The scope of the project in NSW includes:

- A new 330 kV substation known as 'Dinawan', located south of Coleambally
- A new 330 kV double-circuit line between Bundey in SA and Buronga
- A new 330 kV double-circuit line between Buronga and Dinawan
- A new 500 kV double-circuit line between Dinawan and Wagga Wagga initially operated at 330 kV[36]
- A new double-circuit 220 kV line from Buronga to Red Cliffs in Victoria to replace the existing 220 kV single-circuit line
- New 330 kV phase shift transformers at Buronga
- New 330/220 kV transformers at Buronga
- Augmenting existing substations at Buronga and Wagga Wagga
- Static and dynamic reactive plant at Buronga and Dinawan
- A Remedial Action Scheme to cater for non-credible double-circuit trip events.

The indicative capacity of this interconnector is 800 MW. The AER approved the Transgrid and ElectraNet Contingent Project Applications in May 2021. EnergyConnect is in delivery and stage 2 is expected to be in-service by late 2026.[37]

Regulatory consultation completed project – Victoria to NSW Interconnector West (VNI West)

Southern Backbone

EnergyConnect | **VNI West** | HumeLink

Planner: Transgrid/AEMO Victorian Planning
Network Operator: Transgrid (NSW Operations)
Transgrid's role: Planner/Integrated System Plan Actionable

The Victoria to NSW Interconnector West – known as VNI West – is a proposed new 500kV double-circuit transmission line that will form a second major interconnection between the NSW and Victorian high-voltage networks. As showing in Figure 2.10, it will provide renewable energy from the South-West of NSW, the Far South of Victoria and the Far West (SA), working in conjunction with other major projects such as EnergyConnect and HumeLink to form the backbone for Australia's future energy systems.

Additional interconnection between NSW and Victoria will help maintain reliability of supply in Victoria, as Victorian coal-fired generators are scheduled to retire in the late 2020s and the 2030s. It will also mitigate reliability risks and provide insurance against unexpected early plant closures. The route will also allow for the connection of low-cost renewable generation and enable additional capacity for the South West REZ by uplifting transmission capacity from Dinawan to Gugaa to 500 kV. Four renewable energy and storage projects have been granted access rights in the South West REZ, with a total allocated capacity of 3.56 GW. Connection activities for these projects are underway and targeting commissioning from 2029, helping to align delivery with coal retirements in NSW and interconnector upgrades.

Following the announced delay of the Victorian section of VNI West interconnector to allow for further planning and landholder engagement, Transgrid is reviewing the schedule for the NSW section of this critical project.

With these changed circumstances, Transgrid is examining a staged approach to delivery of VNI West (NSW). This will allow us to align costs with the timing of benefits to NSW and the ACT consumers as more affordable renewable energy flows interstate.

Benefits of additional interconnection will come from:

- **Unlocking Renewable Energy:** Connecting Renewable Energy Zones in NSW and Victoria to the national electricity grid
- **Boosting Grid Resilience:** Improving the ability to share electricity across regions and respond to fluctuations in supply and demand
- **Enhance Reliability:** Enables access to firm capacity from Snowy 2.0 to provide backup during low renewable output
- **Future Proofing the Grid:** Working in conjunction with other major projects such as EnergyConnect and HumeLink to form the backbone for Australia's future energy systems.

The Transgrid scope for Stage 1 - VNI West project includes:

- Upgrading 330 kV double-circuit line between Dinawan and Wagga Wagga to 500 kV operation
- A new Dinawan 500 kV switchyard with three 500/330 kV 1,500 MVA transformers (the third transformer is driven by the development of South West REZ)
- 500 kV line shunt reactors at both ends of the Dinawan – Gugaa
- Installation of 330 kV reactors at Wagga Wagga to manage system voltages
- Cut-in existing 330 kV line TL51 into Gugga and forming a new double-circuit 330 kV line between Wagga Wagga and Gugga by rebuilding the existing single-circuit line (TL51) between these locations as a double-circuit
- Potentially a need for a Special Protection Scheme for non-credible contingencies to fulfil NER S5.1.8 Planning requirements.

The Transgrid scope for Stage 2 - VNI West project includes:

- A new double-circuit 500 kV transmission line from Dinawan to the Victorian border.

The RIT-T was completed in October 2023. VNI West is expected to be in-service by late 2030.[38]

36 Commitment by Transgrid (supported by underwriting by the Federal Government) in September 2021 to the Dinawan to Wagga Wagga portion of EnergyConnect being built at 500 kV to lower the subsequent costs for expanding interconnection between Vic and NSW.
37 EnergyConnect Industry Update – April 2024
38 The capacity release and timing is conditional on availability of suitable market conditions and good test results.

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Regulatory consultation completed project – Reinforcement of the southern NSW network (HumeLink)

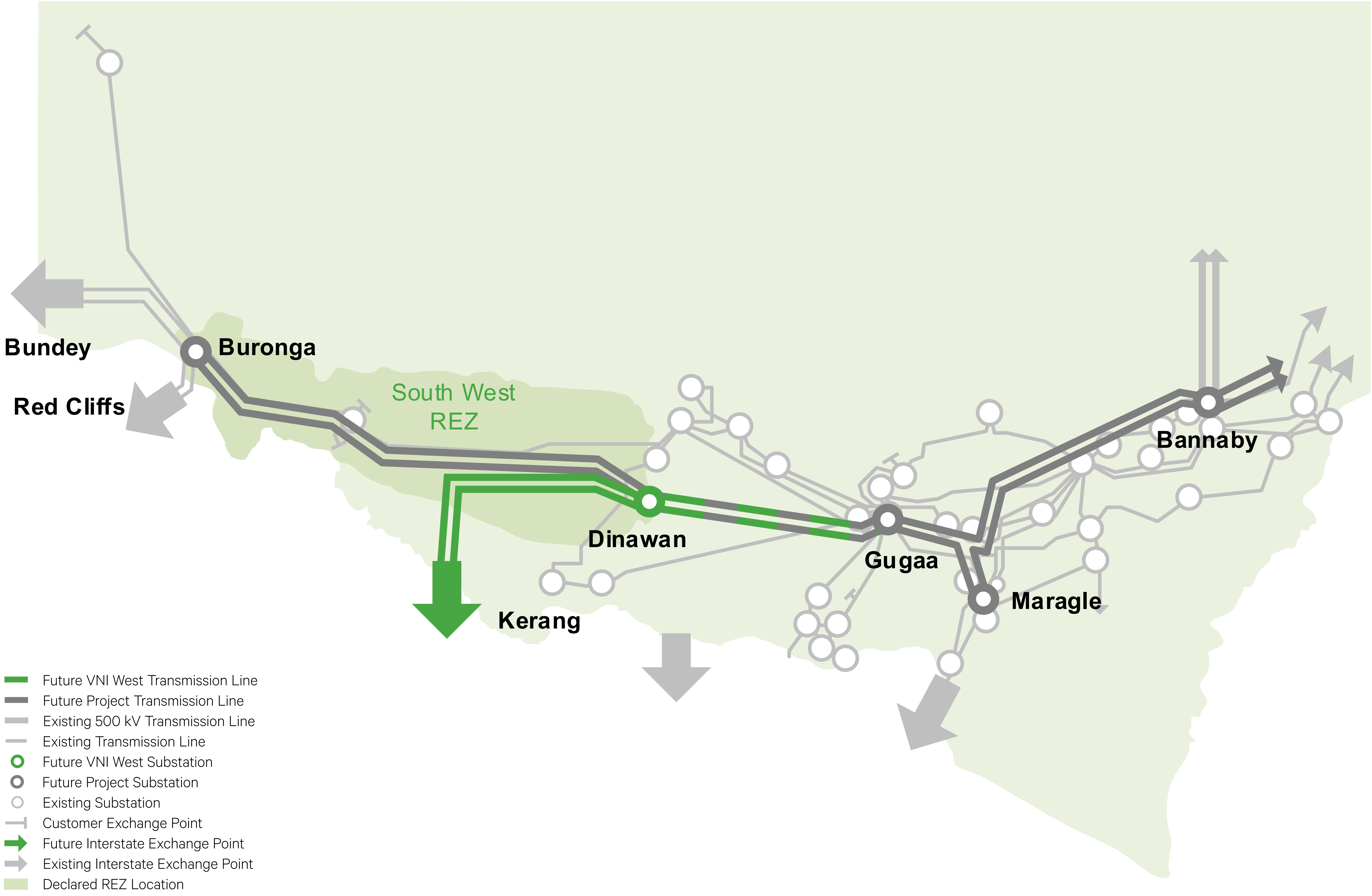
Planner: Transgrid
Network Operator: Transgrid
Transgrid's role: Planner/Integrated System Plan Committed

HumeLink feeds into Bannaby on the Sydney Ring, adding an important element of the southern NSW backbone transmission network. This is essential to provide access to renewable and peaking generation in southern NSW and Vic. It will help meet demand in the major load centres of Sydney, Newcastle and Wollongong at a lower cost than building new generation within these load centres. HumeLink is a committed 2024 Integrated System Plan project. It's in-service date is scheduled for late 2027.

The existing transmission capacity between southern NSW and the major load centres of Sydney, Newcastle and Wollongong is already heavily utilised at times of peak demand. Transgrid has therefore investigated options to reinforce the NSW southern network to:

- Increase the transfer capacity and stability limits between the Snowy Mountains and major load centres of Sydney, Newcastle and Wollongong
- Enable greater access to lower cost generation to meet demand in these major load centres

Figure 2.10: VNI West preferred option



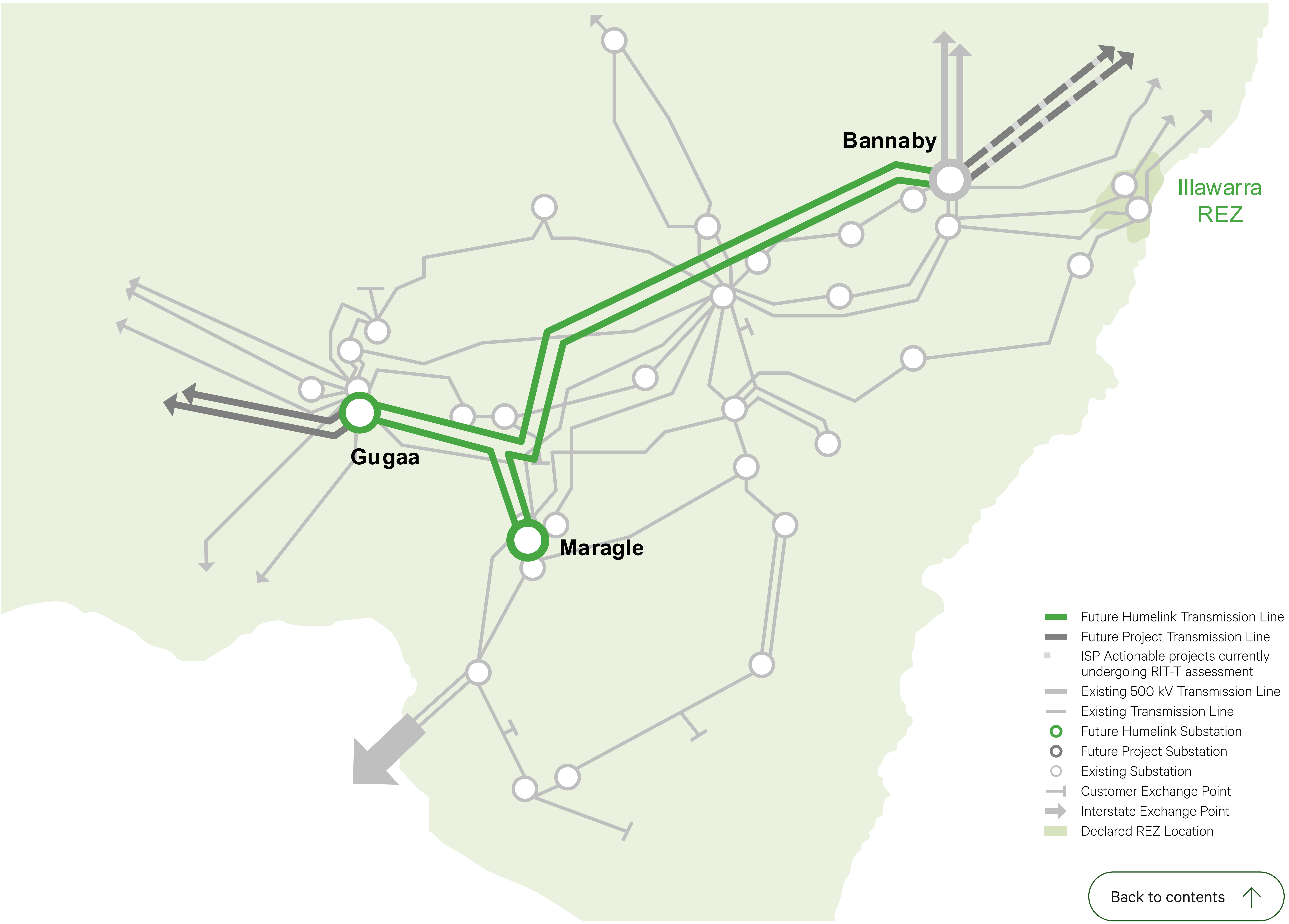
- Facilitate the development of renewable generation in high-quality renewable resource areas in southern NSW as well as southern states, which will further lower the overall investment and dispatch costs in meeting NSW demand, while also ensuring that emissions targets are met at the lowest overall cost to consumers
- Increase the competitiveness of bidding in the wholesale market.

State and Commonwealth Government approval for the project was granted in late 2024. Construction is expected to start in the second half of 2025.

HumeLink is one of the state's largest energy infrastructure projects, with about 365 km of proposed new transmission lines, and new or upgraded infrastructure at three locations. The high-level scope includes:

- New Gugaa (near Wagga Wagga) 500/330 kV Substation and 330 kV connection to the existing Wagga Wagga Substation
- Three new 500/330/33 kV 1,500 MVA transformers at Maragle Substation and two new 500/330/33 kV 1,500 MVA transformers at new Gugaa substation
- New 500 kV transmission circuit built on double-circuit transmission structures between:
  - Maragle and Bannaby 500 kV Substations
  - Maragle and Gugaa 500 kV Substations
  - Gugaa and Bannaby 500 kV Substations.
- Line reactors on each new 500 kV line
- Augmenting the existing substations at Maragle, Wagga Wagga and Bannaby to accommodate the additional transmission lines/transformers.

Figure 2.11: HumeLink



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NSW Electricity Infrastructure Roadmap project – South West REZ (SW REZ)

Planner: EnergyCo
Network Operator: Transgrid
Transgrid's role: Non-contestable works

The SW REZ is centred around Hay and Balranald, encompassing areas west up to Buronga and east up to Dinawan.[39]

The SW REZ Access Scheme was formally declared by the Minister for Energy under section 24(1) of the Electricity Infrastructure Investment Act 2020 on 12 April 2024.[40] The declaration operationalises the terms and conditions of the Access Scheme, which sets out how generation and storage projects can be granted access rights to planned and new network infrastructure within the South West REZ.

In April 2025, the Minister for Energy and Climate Change announced[41] that four proponents progressing five wind, solar and battery projects (with a combined generation capacity of 3.56 GW) have been granted the right to connect to new power lines in the South West REZ. First generation is expected to come online by 2027.

With the current network configuration in South West NSW, the network's ability to transfer energy is limited by a maximum generation hosting capacity of up to 550 MW. The following transmission projects are needed to achieve the intended network capacity of 2.5 GW:

- EnergyConnect: delivering network capacity with the 330 kV operation (500 kV built) Wagga Wagga to Dinawan section by late 2027
- HumeLink: releasing additional capacity from Wagga Wagga to Bannaby
- Victoria NSW Interconnector West: adding network capacity and alleviating downstream constraints from uprating the eastern section of the Dinawan Gugaa line to 500 kV.
- Further network augmentations will be required near and at Dinawan (including a third transformer) to enable the generator and storage proponents to connect and supply the network.

2.1.4 Future major developments

Wondalga switching station

Additional transfer capacity increase within the Future 500 kV Southern Backbone could be achieved via a new 500 kV switching station at Wondalga. The new Wondalga switching station would cut in at the T-point of the following 500 kV lines:

- 500 kV Line from Gugaa to Bannaby
- 500 kV line from Gugaa to Maragle
- 500 kV line from Maragle to Bannaby

These lines are built under the HumeLink project. The Wondalga switching station would increase the transfer capacity between southern NSW and the major load centres of Sydney, Newcastle and Wollongong (SNW).

Long-term development strategy for the SNW supply network

This strategic planning work is critical because, beyond 2035, when coal is largely retired, new transmission will still be required to meet the massive clean energy demand of our electrified economy. Now many of the new renewable generation locations have been decided, it's time to plan for the infrastructure required to power the SNW economy of the future.

As we do, we are taking into account the likely future surges in metropolitan energy needs. Population growth, sector-wide electrification and the rise of energy-intensive technologies like data-centres are driving up demand (see Section 4.2.2). Our job is to find the best pathways to upgrade energy infrastructure to meet this demand with the least possible community impact and the lowest cost to consumers.

This section explains Transgrid's long-term strategy for network development in the SNW area. It describes how we are actively investigating opportunities for transmission capacity upgrades and making strategic decisions to ensure the NSW metropolitan hubs maintain the supply reliability they enjoy today – 40 years into the future.

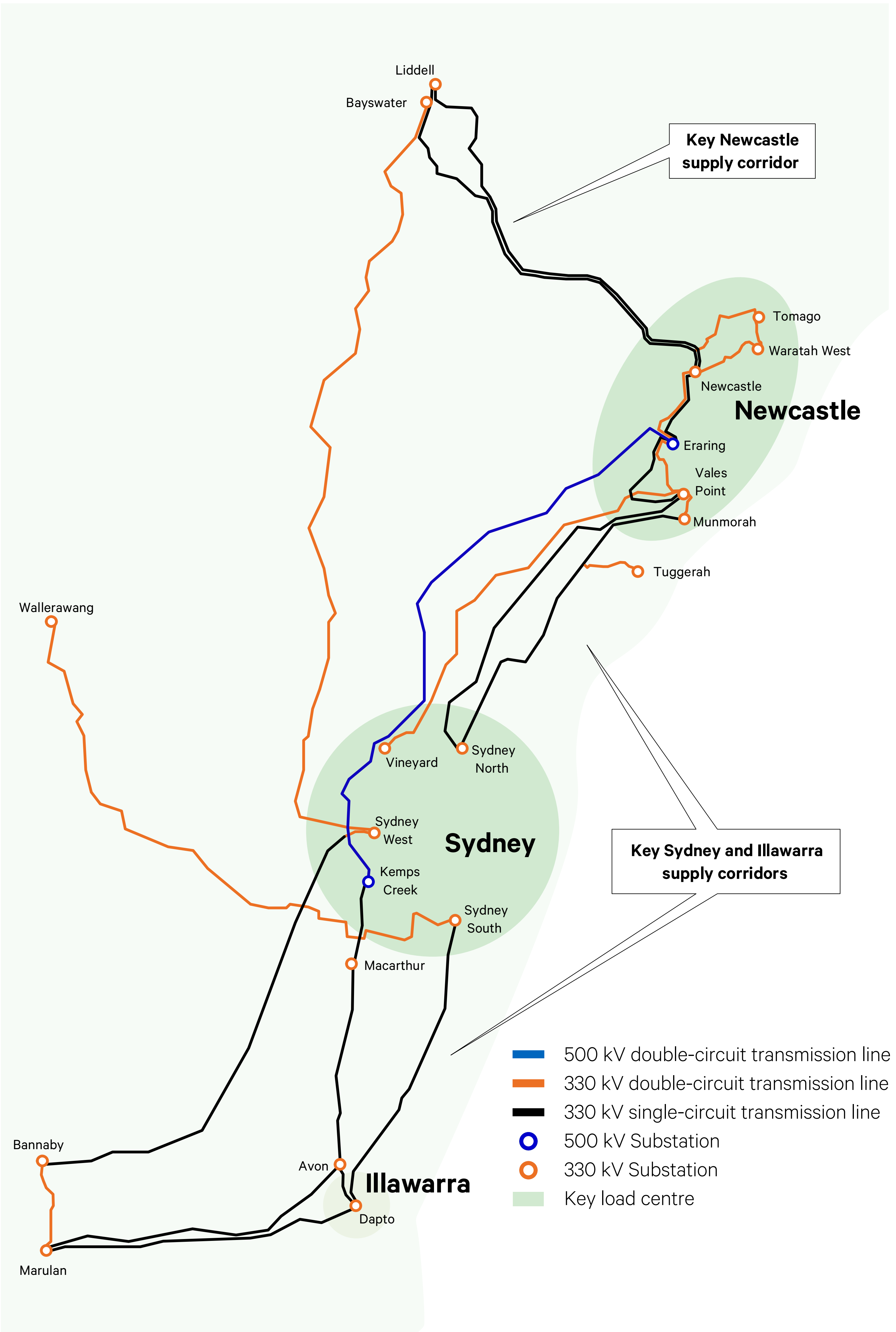
39 Source: Office of Energy and Climate Change, 'South West Renewable Energy Zone Access Scheme', March 2023
40 Government Gazetta No. 126 of Friday 12 April 2024
41 https://www.energyco.nsw.gov.au/industry/access-schemes/south-west-REZ-access-scheme

Evolution of transmission planning in NSW

Our long-term network development strategy builds on decades of transmission planning that have shaped NSW's energy landscape. From the 1950s Snowy Hydro planning using analogue tools, to the construction of a 3,000 km 330 kV backbone in the 1960s, and the strategic shift to 500 kV in the 1970s to minimise new corridors into Sydney, each decision has laid the groundwork for today's projects like the Hunter Transmission Project and Sydney Ring. The 1980s–1990s saw the build-out of 500 kV double-circuit lines, some of which are now being upgraded to support future capacity needs, including industrial decarbonisation in the Illawarra. Strategic land acquisitions in 2007 further secured key sites to close the 500 kV ring and safeguard Sydney's future supply.

The following sections detail how, in the longer term, supply could be brought into Newcastle from the north, into Sydney from Newcastle, into Sydney and Illawarra from the south, and within and around Inner Sydney. The pace of change will depend on the speed and scale of increased energy demand – itself driven by economic growth, and technology development and uptake.

Figure 2.12: Key supply corridors for Sydney, Newcastle and Illawarra



Strategic network developments in the key Newcastle supply corridor

The pattern of power flows into Sydney is changing. Now supply is shifting to remote renewable hubs such as the Central West Orana (CWO) and New England REZs, significant volumes are now expected to flow through the Bayswater region towards Newcastle and Sydney – requiring major reinforcements to this critical transmission corridor.

The two 500 kV circuits connecting Bayswater from the west will soon be utilised by renewable energy supply from the CWO REZ. In addition, four new 500 kV circuits are planned to connect Bayswater from the north, linking to the New England REZ. This northern backbone will also carry through-flows from the future QNI Connect project, further increasing the load on the corridor.

The first of several reinforcements required in this corridor is already progressing. We are engaging with EnergyCo as Infrastructure Planner on the Hunter Transmission Project (HTP) – a new 500 kV double-circuit transmission line between two new switching stations: Bayswater South and Olney. We are also looking beyond HTP to identfy future capacity uplift options.

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Strategic network developments in the key Sydney and Illawarra supply corridors

The first 5–10 years of the planning horizon are critical for delivering urgently needed capacity via the Sydney Ring South project. This new infrastructure will enable the progressive rebuilding of existing single-circuit 330 kV transmission lines that currently supply Sydney, turning them into double-circuit configurations.

Converting single-circuit lines to double-circuits presents a strategic opportunity for capacity uplift with minimal community impact. This approach effectively adds a new circuit without requiring additional easement widths or new line routes.

To maintain reliability of supply during the rebuild process – expected to take at least one year per line – only one single-circuit 330 kV line supplying the Sydney area can be taken out of service at any given time. This constraint necessitates a 10-15 year integrated rebuild strategy, led by Transgrid in collaboration with Endeavour Energy and Ausgrid – subject to Australian Energy Regulator (AER) approval.

The success of this rebuild campaign hinges on the timely delivery of Sydney Ring South, which must be operational well before demand growth erodes the available capacity buffer. If demand accelerates as projected and critical easements are not secured in time, the window of opportunity to execute this strategy may close.

These single-circuit to double-circuit conversions on existing 330 kV lines both north and south of Sydney offer a key strategic opportunity for increasing Sydney supply capacity to meet the economic growth requirements into the future. These developments will build on the projects listed in section 2.3.1.

In the Illawarra region, industrial electrification is expected to drive significant new demand. BlueScope Steel, for example, is investigating direct reduced iron (DRI) technology to replace traditional blast furnace processes. This shift will introduce several hundred megawatts of additional peak load to the NSW network, with natural gas replacing coal as the reductant. A further transition to green hydrogen, produced via electrolysis, would likely increase demand even further. As a result, transmission reinforcements at 500 kV or 330 kV into the Illawarra region are currently under study.

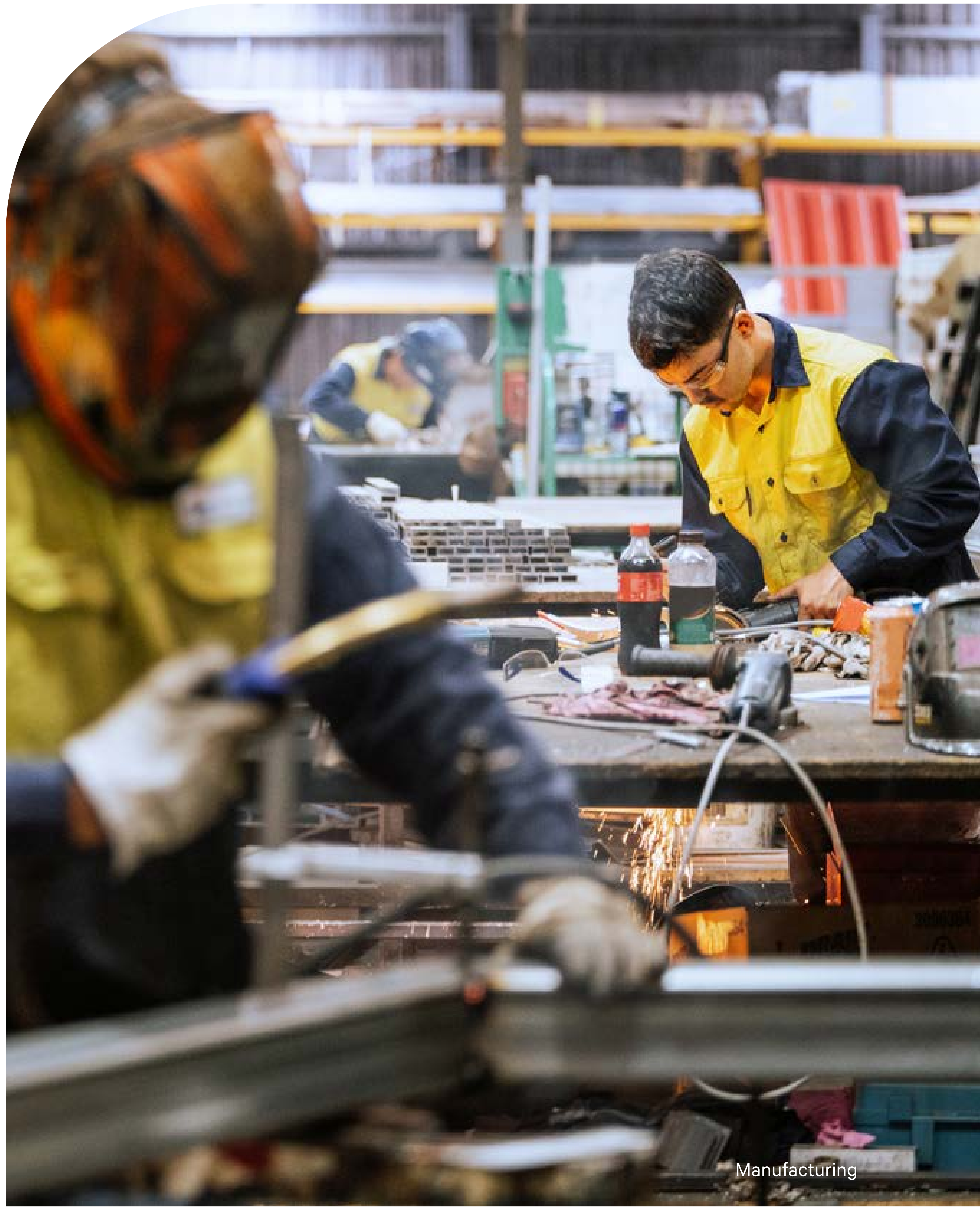
Strategic network developments in Sydney

Developing new high-capacity 330 kV transmission lines in Greater Sydney will require rebuilding existing lines to higher capacity within existing easements, facilitating efficient capacity uplifts while minimising community impact.

A key example is the Sydney West to Holroyd 330 kV transmission line, which was rebuilt on a former 132 kV easement – marginally widened in some locations. This project was strategically designed to:

- Bring a 330 kV supply point closer to Inner Sydney
- Reduce the length of underground 330 kV cables required to serve the city and eastern suburbs.

In collaboration with Ausgrid and Endeavour Energy, we are identifying the future corridor reinforcement needs to meet the growing demand levels underpinning economic growth within Sydney, leading to the following: Sydney West reinforcement and Blacktown supply, Kemps Creek to Line 30 double-circuit line, Luddenham, and Inner Sydney BSPs.



Manufacturing

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Sydney West reinforcement and Blacktown supply

Endeavour Energy's demand forecasts indicate that the Sydney West Bulk Supply Point (BSP) will exceed its firm capacity by 2031. To ensure continued supply reliability, substation upgrades and reinforcement of the transmission network will be necessary.

The Sydney West BSP is expected to reach its maximum buildability with the installation of a sixth 330/132 kV transformer. This creates an urgent need to offload demand from the site.

Currently, approximately 60% of Sydney West's peak load is to supply Endeavour Energy's 132 kV Blacktown STS substation. This presents a strategic opportunity to relieve pressure on Sydney West by redirecting Blacktown STS supply from Sydney West to a new BSP.

Two primary options are under consideration:

- Divert the Blacktown STS supply to a new Mt Druitt BSP
- Establish a new Blacktown 330/132 kV BSP by rebuilding part of the 132 kV network from Sydney West to a site near Prospect Reservoir.

Both options would:

- Support Endeavour Energy's increasing load demands
- Alleviate pressure on the Sydney West BSP
- Strengthen the security of supply to the 330 kV cable network serving Inner Sydney and the eastern suburbs.

Kemps Creek to Line 30 double-circuit line

A new 330 kV double-circuit line from Kemps Creek to Line 30 is proposed, enabling:

- A new Kemps Creek to Sydney West line
- A new Kemps Creek to Liverpool line.

These connections will facilitate increased power transfer from Kemps Creek into Sydney, supporting the transition to higher flows on the 500 kV backbone. Easement acquisitions are underway, with implementation targeted for the early to mid 2030s, aligned with the HTP and Sydney Ring South developments.

Luddenham

We could support data-centre development by establishing a Luddenham 330/132 kV BSP between the Western Sydney Airport and South Creek. This would:

- Reduce pressure on Inner Sydney supply
- Leverage available land and lower residential density.

This development depends on establishing the South Creek substation under the Sydney Ring South project, expected in service by the early/mid-2030s.

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Inner Sydney BSPs

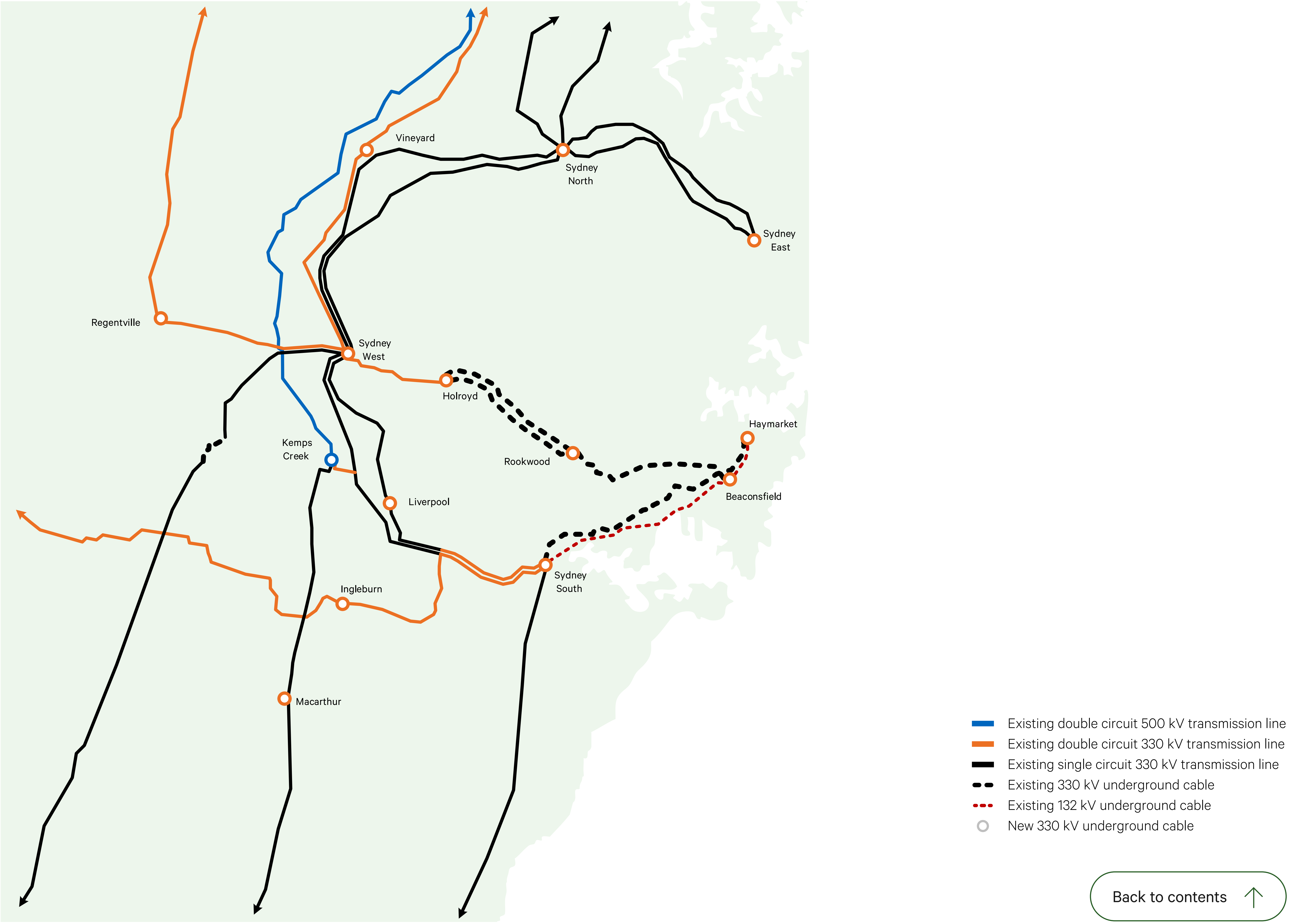
To support long-term demand growth, new 330 kV BSPs are required deeper within Inner Sydney. These will serve as supply points for the Ausgrid distribution network.

Due to the lack of suitable overhead corridors, these 330 kV extensions will likely be cable-installed in tunnels. Joint planning with Ausgrid and Endeavour is underway to identify optimal launching points, including:

- Holroyd
- Sydney North
- Sydney East
- Sydney South
- Rookwood Road.

Within Inner Sydney, the Macquarie Park area has become a strategic focus due to high-density residential growth driven by NSW Government initiatives and increasing electricity demand. The area is also seeing rising interest from data-centre developers and broader electrification trends, contributing to regional load growth. To address transmission constraints, Transgrid and Ausgrid are planning a new 330 kV BSP to support development and improve reliability. Supply for the new BSP will likely be from either Sydney North or Sydney East, and, subject to load growth, may require a single-circuit to double-circuit rebuild of Line 20 and/or Line 14 into Sydney North.

Figure 2.13: Sydney transmission network



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2.2 Forecast of constraints

Transgrid forecasts potential constraints on the network over the next 10-year period. We take into account the network performance requirements in NER Schedule 5.1 or relevant NSW regulations over one, three and five years. We also consider forecast loads, future generation, market network services, and changes in demand.

Our annual planning review also considers the:

- Forecast loads submitted or modified by relevant registered participants in accordance with NER Clause 5.11.1
- Adequacy of existing connection points and relevant parts of the transmission system, and planning proposals for future connection points
- Most recent AEMO system planning updates, including the 2024 Integrated System Plan, 2024 Electricity Statement of Opportunities and issue of reports on system security planning, including the 2024 Network Support and Control Ancillary Services Report, 2024 Inertia Report and 2024 System Strength Report
- Potential for augmentations, or non-network alternatives to augmentations, that are likely to provide a net economic benefit to all those who produce, consume and transport electricity in the market
- Condition of network assets
- Potential to replace network assets, or use non-network options, to provide a net economic benefit to all those who produce, consume and transport electricity in the market
- Operation of, and any known or potential interactions between:
  - any emergency frequency control schemes, or emergency controls in place under NER clause S5.1.8
  - protection systems or control systems of plant connected to the network (including consideration of whether the settings of those systems are fit for purpose for the future operation of the network)
  - where such operation or interactions would be likely to lead to cascading outages or major supply disruptions.

Additional connection point and transmission line data is available at: tapr.transgrid.com.au.

330 kV cable drum

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2.3 Subsystem developments

This section outlines our proposed capital works for subsystems to meet the network performance requirements of NER Schedule 5.1. It includes new projects to address emerging needs, as well as ongoing and recently completed work. We highlight what's driving each project and the estimated work, timing and costs – based on current planning information and requirements. More rooftop solar, data-centres, electric vehicle chargers and electrification mean energy demand is changing fast. Peak demand is growing and minimum demand is falling. As this 'demand envelope' widens, we are upgrading subsystems where these changes are happening to keep the network reliable. These local upgrades won't impact the transmission network or power flows between states.

For each project, we've looked at a range of credible options – network and non-network. These included using interconnectors as well as generation, demand side options, market network service and inter-network options.

Our proposed subsystem developments align with the primary objectives of AEMO's Integrated System Plan and System Security Planning reports:

- Enhancing interconnection capacity between NSW and the other states
- Supporting the development and connection of large-scale renewable energy zones across the NEM
- Improving system strength and security in response to the decline of thermal generation sources and the increase in renewable energy sources, particularly in NSW and Vic.

The information reported in this section meets the requirement of the NER Clause 5.12.2(c)(5) and (6).

Figure 2.14 shows a summary of all planned projects across NSW including the subsystem developments.

Data- centre

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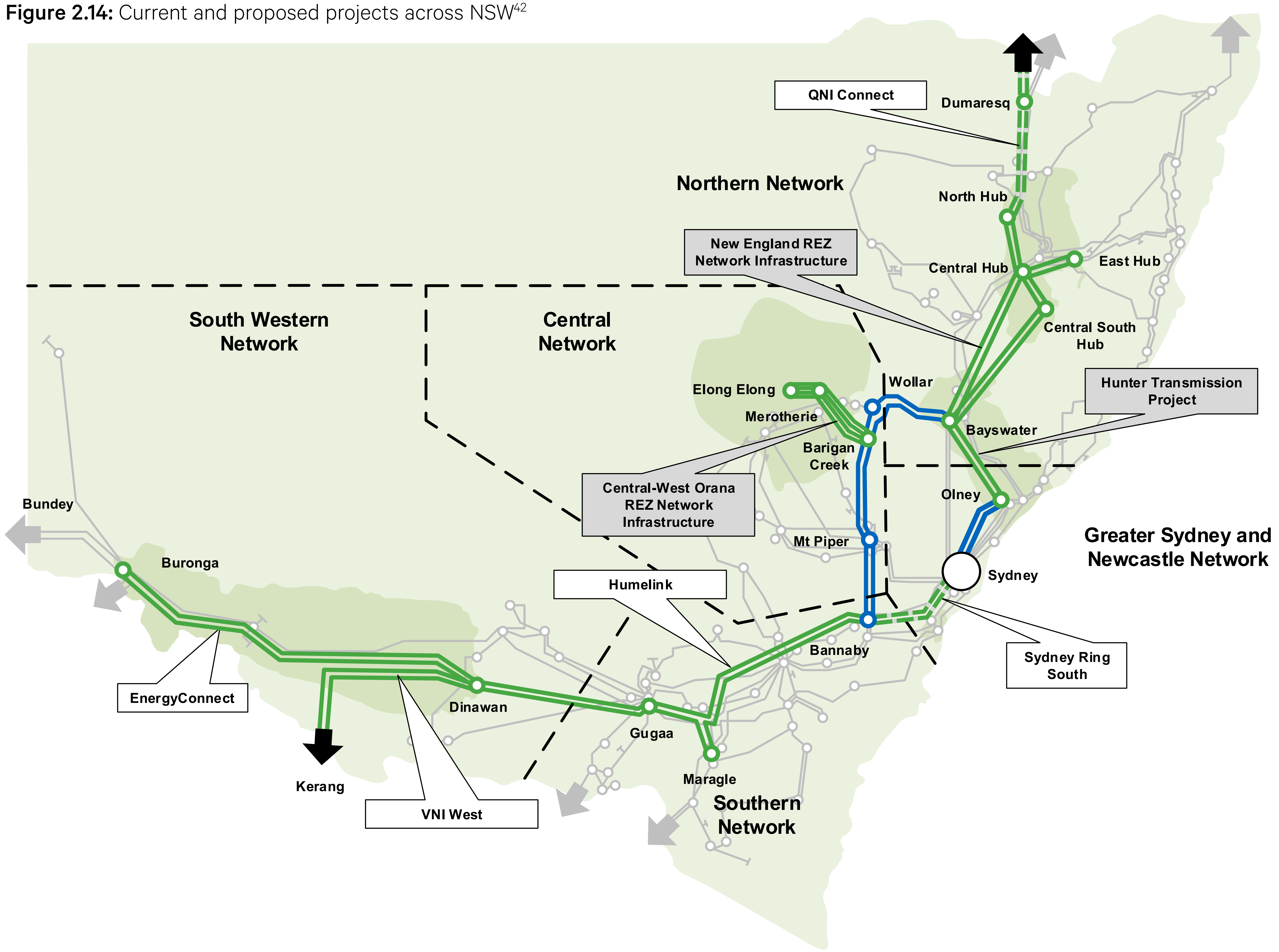
Figure 2.14: Current and proposed projects across NSW[42]



Central NSW

- Increasing capacity for generation in the Molong and Parkes area
- Meeting demand growth in the Parkes area
- Maintaining reliable supply to Bathurst, Orange and Parkes areas – Stage 1
- Maintaining voltage levels in the Beryl area
- Increase capacity for generation from Parkes to Wellington
- Maintaining reliable supply to the Wellington area
- Increase capacity for generation from Wellington to Molong and Orange
- Maintain voltage levels in the Cowra to Forbes area

Southern NSW and ACT

- Increasing capacity between the Yass and Wagga Wagga areas
- Dynamic ratings for Yass 330/132 kV transformers
- Maintaining reliable supply to the Yass area
- Managing increased fault levels in Southern NSW
- Increasing capacity for generation in the Wagga North area
- Increasing capacity for generation in the Wagga Wagga area
- Maintaining reliable supply to the Wagga Wagga area
- Reliability of Supply to ACT

South Western NSW

- Maintaining reliable supply to Deniliquin Coleambally and Finley area
- Maintaining reliability to Broken Hill Area
- Darlington Point 330/220/33 kV Tie Transformer cross tripping scheme
- Relieving X5 voltage stability constraints
- Maintaining a reliable supply to Broken Hill

Greater Sydney and Newcastle

- Maintaining reliable supply to Western Sydney
- Maintaining reliable supply to Vineyard in Northwest Sydney
- Meeting demand growth in the Western Sydney Aerotropolis 'Priority Growth Area
- Maintaining reliable supply to Beaconsfield in the Inner Sydney area
- Maintaining reliable supply to Holroyd in Western Sydney
- Strategic property acquisitions for 330 kV Mt Druitt Substation
- Maintaining reliable supply to Sydney East
- Strategic Easement acquisitions near Kemps Creek
- Establish Mt Druitt 330 kV Substation
- Meeting demand growth at Vineyard in Northwest Sydney
- Powering Sydney's Future Stage II
- Maintain reliable supply to Sydney North

Northern NSW

- Maintaining voltage levels in Northern NSW
- Maintaining reliable supply to the North West Slopes area – Stage 1
- Maintaining voltage levels in the Moree area
- Maintaining reliable supply to the North West Slopes area – Stage 2
- Increase capacity for generation in the North West Slopes area
- Increase capacity from Port Macquarie to Taree
- Maintaining voltage levels in the North Coast
- Increase reliability in Northern NSW

Across NSW

- NSW oscillation monitoring – PMU installations
- Maintaining capacity during climate change
- Meeting system strength requirements in NSW
- Improving voltage control in Southern NSW
- Manage increased fault levels
- Improve the utilisation of lines in NSW

Project status

- Planned projects
- Regulatory consultation in progress
- Projects in Delivery

Future network

- Line
- Substation
- Renewable Energy Zone
- NER Project
- EII Act Project
- ISP Actionable project currently undergoing RIT-T assessment

Present network

- 500 kV Line
- 500 kV Substation
- Line
- Substation

42 Includes transmission projects delivered contestably under the NSW EII Act framework, which will not be constructed, owned or operated by Transgrid

2.3.1 Greater Sydney

The Greater Sydney network consists of a series of Transgrid-owned 330/132 kV and 330/66 kV BSPs that supply two distinct sub-transmission networks, including:

- Ausgrid's Inner Sydney Metropolitan area, comprising a series of 132 kV subtransmission lines and underground cables, owned and operated by Ausgrid, supplied from Beaconsfield, Haymarket, Rookwood Road, Sydney East, Sydney North and Sydney South 330/132 kV substations. The inner Sydney area covers the load centres of the Sydney CBD, inner city, and the suburban area bounded by Hornsby and Dural in the North West, Homebush and Bankstown to the West, and Menai and Heathcote to the South West, and extending eastward to the coast.
- Endeavour Energy's Greater Western Sydney area, comprising a series of 132 kV subtransmsion lines and underground cables (with some 66 kV) owned and operated by Endeavour, supplied from Holroyd, Ingleburn, Liverpool, Macarthur, Regentville, Sydney West, and Vineyard 330/132 kV BSPs. This area covers the load centres of the Parramatta CBD, and the greater west extending from Hawkesbury in the North West, through to the Macarthur area in the South West, and extending westward to the lower Blue Mountains.

The Western Sydney area has grown significantly in the past few years. According to Endeavour Energy's latest DAPR,[43] growth in the Endeavour network is being driven principally by new customer connections arising from greenfield development in Sydney's North West and South West priority growth areas. Significant population increases and the construction of new dwellings and commercial spaces, particularly in greenfield areas and around transportation hubs, are major contributors to load growth. A number of large data-centre (high-volume) loads are also connecting in the Western Sydney network, increase the area's demand forecasts to unprecedented levels. Transgrid is actively identifying and developing solutions in advance to address any potential constraints in the area.

Residential and other industrial or commercial load growth in Inner Sydney remains steady. The summer maximum demand has not changed significantly in the past five years. However, Ausgrid's latest DTAPR[44] shows that the actual and total maximum demand forecasts for both summer and winter are expected to increase over the next 10 years. A significant increase is also projected in the uptake of electrical vehicles. The other potential network impacts are data-centre connections and rooftop solar, with generation across NSW and ACT expected to increase significantly to 10,465 GWh by 2025. Growth in other areas, such as behind-the-meter battery storage, is likely. We will closely monitor these developments and plan appropriately to ensure the network is resilient to cater to the needs of electric vehicles, data-centre loads, rooftop solar and battery storage.

A number of projects are being developed to address the unprecedented load growth in the Greater Sydney area. Some major projects that are being considered are Hunter Transmission Project, Powering Sydney's Future II and Sydney Ring South. A dedicated Sydney Plan is also under review to ensure Greater Sydney network is sufficiently strengthened to meet the region's increasing demand. We are also investigating the development of Riley Street BSP as a GIS breaker and half substation, and extending new cables from Riley street to Beaconsfield and Haymarket.

Greater Sydney

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44 Ausgrid Distribution and Transmission Annual Planning Report 2024

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Planned projects

The table below lists our current and future planned augmentation projects to address forecast load growth and connect new distribution zone substations in the Greater Sydney area. These initiatives are a core component of Transgrid's plan to ensure that Sydney's electricity demand and supply needs are reliably met well into the future. Actionable and future Integrated System Plan projects, such as the Hunter Transmission Project (Sydney Ring North) and Sydney Ring South are detailed in Section 2.1. We are also collaborating with Endeavour Energy, who have identified the need for a new Appin BSP to meet residential demand growth south of Macarthur and in the vicinity of Line 17.

As identified in the 2024 Integrated System Plan and described in Section 2.1.1, with demand increasing in Western and Inner Sydney areas, the commissioning of the Sydney Ring South Project and Hunter Transmission Project project will significantly increase the reliability and security of supply to the area.

As part of the Sydney Plan for a future-ready metropolis, several major energy infrastructure initiatives have been proposed to support the long-term needs of Greater Sydney. These projects are strategically designed to ensure a reliable, secure electricity supply while meeting increasing demand driven by data-centres, electrification, population and economic growth, and to help the region transition to cleaner, more sustainable energy. A summary of some key projects is provided below, with further detail and breakdown of potential projects for Sydney region available in Section 2.1.

Figure 2.15: Existing Greater Sydney network

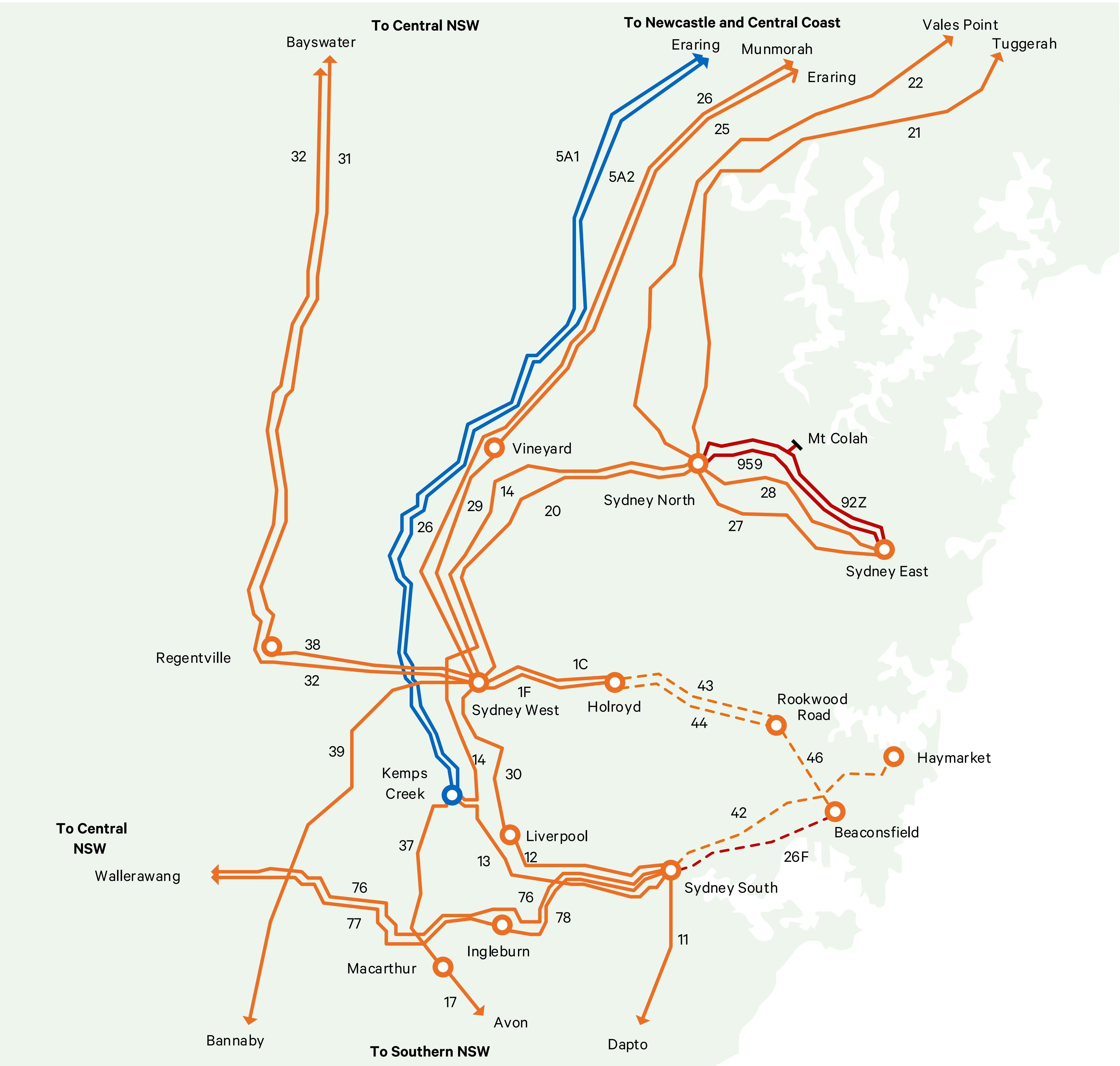

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Table 2.1: Projects in Greater Sydney

Project description	Proposed inservice date	Total cost ($2024/25 million)	Purpose and options	Project justification
Maintaining reliable supply to Western Sydney	2028	27	To address network constraints due to overloading of Sydney West 330/132 kV transformers under N-1 contingency. Installation of an additional transformer to increase the firm capacity at Sydney West.	Load driven
Maintaining reliable supply to Vineyard in Sydney's North West	2028	51	To address voltage stability issues at Vineyard 330/132 kV substation due to the load growth in the North West Sydney region.	Compliance
Meeting demand growth in the Western Sydney Aerotropolis 'Priority Growth Area'	2028	99	Support load growth in the Western Sydney region, including new residential and commercial precincts. Options include a new bulk supply point adjacent to Transgrid's Kemps Creek Substation.	Load driven
Maintaining reliable supply to Beaconsfield in the Inner Sydney area	2029	TBD	To address network constraints due to the retirements of 132 kV cables and contingency of Beaconsfield Transformer.	Reliability
Maintaining reliable supply to Holroyd in Western Sydney	2029	TBD	To address network constraints due to overloading of Holroyd 330/132 kV transformers under N-1 contingency.	Load driven
Strategic property acquisitions for 330 kV Mt Druitt Substation	2029	TBD	To establish new double-circuit lines, construct new lines and establish new 330/132 kV substation. See Section 2.1 for further details.	Strategic property
Maintaining reliable supply to Sydney East	2030	TBD	To address network constraints due to overloading of Sydney East 330/132 kV transformers under N-1 contingency.	Load driven
Strategic Easement acquisitions near Kemps Creek	2030	TBD	Line easement acquisition to re-enforce supply to Western Sydney with additional 330 kV feeders. See Section 2.1 for further details.	Strategic property
Establish Mt Druitt 330 kV Substation	2031	TBD	To maintain reliability of supply to Western Sydney with a new 330/132 kV BSP. See Section 2.1 for further details.	Reliability
Meeting demand growth at Vineyard in Sydney's North West	2033	TBD	To address network constraints due to overloading of Vineyard 330/132 kV transformers under N-1 contingency.	Reliability
Powering Sydney's Future Stage II	2033	TBD	To address network constraints due to the retirements of ageing 132kV cables and reduced supply capacity. See Chapter 2, Section 2.1 for the long-term strategy to reinforce inner CBD.	Reliability
Maintain reliable supply to Sydney North	2035	TBD	To address increasing load supplied from Sydney North. See Section 2.1 for further details.	Load driven

Projects under regulatory consultation

- Meeting demand growth in the Western Sydney Aerotropolis 'Priority Growth Area
- Maintaining reliable supply to North West Sydney (Maintain voltage in the Vineyard area).

Completed projects

The following project was completed after Transmission Annual Planning Report 2024 was published:

- Strategic property acquisition for Western Sydney Priority Growth. Transgrid acquired the land adjacent to Kemps Creek Bulk Supply Point.

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2.3.2 Newcastle and Central Coast

Newcastle and Central Coast areas are served by numerous 330 kV transmission lines and 330/132 kV BSPs. The NSW Government has identified a number of areas in Hunter – Central Coast and Illawarra as REZs, requiring transmission projects to support growth in the region. See Section 2.1.1 for further details.

Planned projects

No prescribed augmentation projects are planned in the Newcastle and Central Coast region.

Completed projects

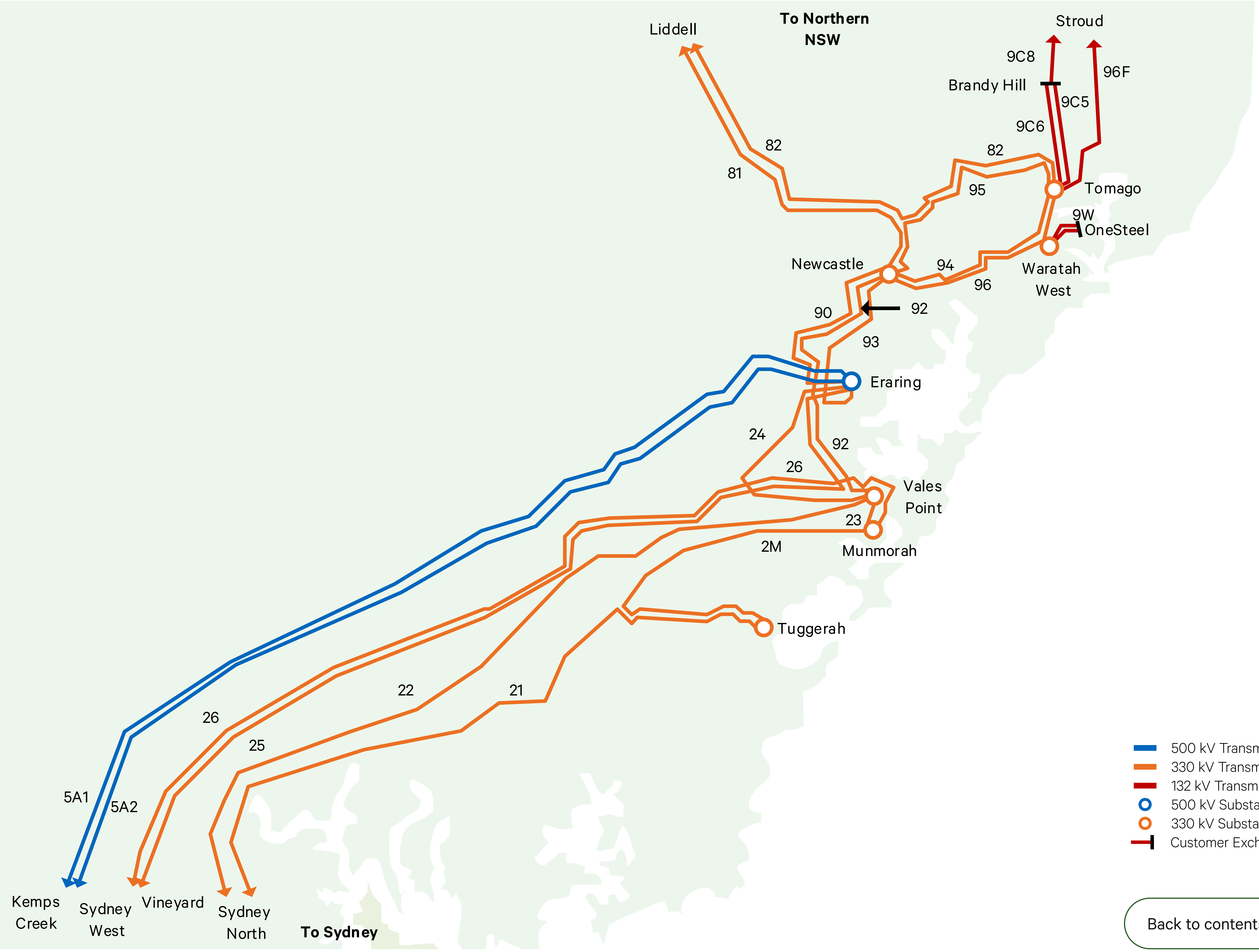
The following project was completed after the publication of Transition Annual Planning Report 2024:

- Maintain Newcastle Substation fault rating.

Future Potential Distribution REZs

HCC REZ stage 2 and 3 – As part of the Hunter-Central Coast Renewable Energy Zone development, Transgrid will be responsible for delivering a range of enabling works. These works may include both minor and major upgrades such as enhancements to communications and protection systems, fault level management, upgrades to the Bulk Supply Point (BSP) and new BSPs.

Figure 2.16: Existing Newcastle and Central Coast network



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2.3.3 Northern NSW

The Northern NSW area extends from Tomago in the Central Coast, up to Lismore in the far northeast, to Moree in the far northwest and back to Tamworth via a network of interconnected 330 kV and 132 kV lines. The network has two electrically and geographically distinct subsystems – northwest and the North Coast – and the main 330 kV corridor linking Qld to the Hunter region of NSW and to Sydney.

QNI Connect and New England REZ Network Infrastructure will be in this network (see Section 2.1).

Planned projects

Planned projects to address improve security of supply to customers, are shown in Table 2.2. Transgrid is also conducting Joint Planning with Essential Energy for load growth projects in the region.

Figure 2.17: Existing Northern NSW network

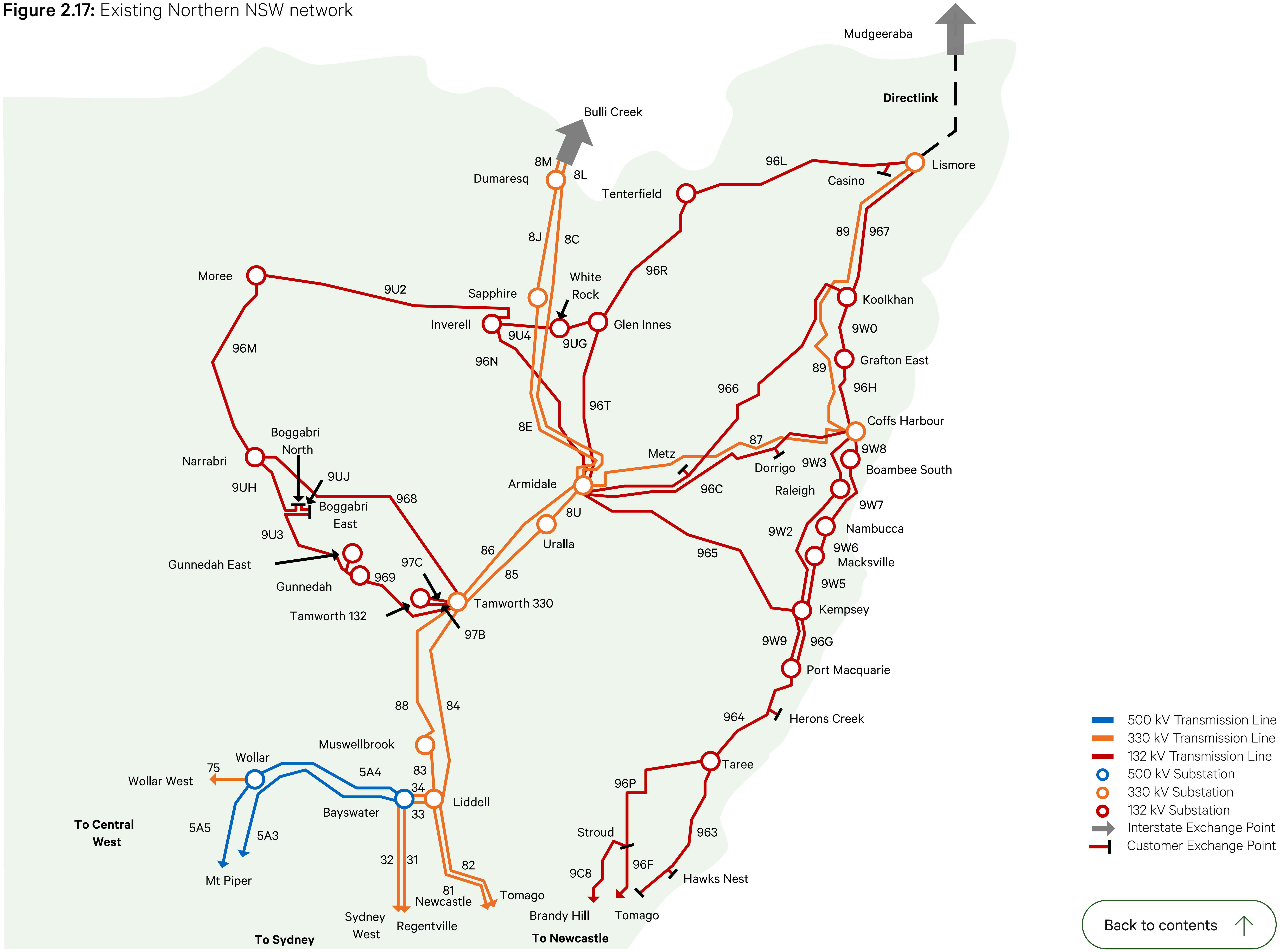

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Table 2.2: Planned projects in Northern NSW

Project description	Expected inservice date	Total cost ($2024/25 million)	Purpose and options	Project justification
Maintaining voltage levels in Northern NSW	Nov-26	14	To address high-voltage issues during low demand in Essential Energy's distribution network. A RIT-T has been completed with the preferred option of a 25 MVAr reactor installation at Inverell Substation.	Compliance
Maintaining reliable supply to the North West Slopes area Stage 1	Dec-26	Non-network solution + 13 for Network solution	To accommodate significant increases in demand in the Narrabri and Gunnedah areas over the next 10 years, mainly due to industrial demand growth in the area. A RIT-T has been completed with the preferred option including both non-network and network components. Stage 1 incorporates a non-network BESS in the region and a third transformer at Narrabri Substation to maintain reliability.	Load driven
Maintaining voltage levels in the Moree area	2030	TBD	To address increasing load growth in the Moree area, which will see voltages dropping, breaching the NER power frequency voltage level requirements.	Compliance
Maintaining reliable supply to the North West Slopes area Stage 2	2032	143	To upgrade transmission lines to mitigate further network constraints as load increases further in the region.	Load driven
Increase capacity for generation in the North West Slopes area	2032	TBD	To reduce constraints on line 969 (Gunnedah to Tamworth).	Market benefit
Increase capacity from Port Macquarie to Taree	2032	TBD	To reduce constraints on line 964 (Port Macquarie to Taree) during a 330 kV line contingency.	Market benefit
Maintaining voltage levels in the North Coast	2033	TBD	To maintain voltages in the North Coast between Coffs Harbour and Taree during maximum and minimum demand.	Compliance
Increase reliability in Northern NSW	2035	TBD	To maintain reliability of supply to the Lismore Area	Reliability

Projects under regulatory consultation

No prescribed augmentation projects have ongoing RIT-Ts in the Northern region.

Completed projects

The following project was completed after the Transmission Annual Planning Report 2024 was published:

- Transposition of 330 kV lines 87 (Coffs Harbour to Armidale) and 8C/8E/8J (Armidale to Dumaresq) to manage negative sequence voltage levels greater than 0.5% within the northern NSW transmission network.

Transgrid

2.3.4 Central NSW

In Central NSW, parts of the 132 kV network face voltage and thermal limitations that restrict new generation or large-load connections. These limits pose significant risks during network outages.

The Orange and Parkes areas are forecast to experience moderate summer and winter maximum demand growth over the next 10 years, mainly due to commercial and mining load demand. Minimum daytime demand, is expected to reduce to negative values within five years.

Due to its abundance of solar and wind resources, this area is also a hive of renewable generation activity.

The network will need to be augmented to unlock low-cost renewable energy, to improve the reliability of supply in the area and to address network constraints associated with demand growth in some parts.

Central West Orana REZ is being developed in Central NSW. Further details are presented in Section 2.1.1.

Planned projects

A summary of the planned projects in the Central NSW region to improve supply reliability are shown in Table 2.3.

Renewable developments in Central NSW include:

- Multiple proposed renewable energy projects in Central West 132 kV network, many of them between Parkes and Panorama
- Strong interest from renewable energy proponents, seeking to connect to the 330 kV transmission network between Wollar, Wellington and Mt Piper.

Figure 2.18: Existing Central NSW network

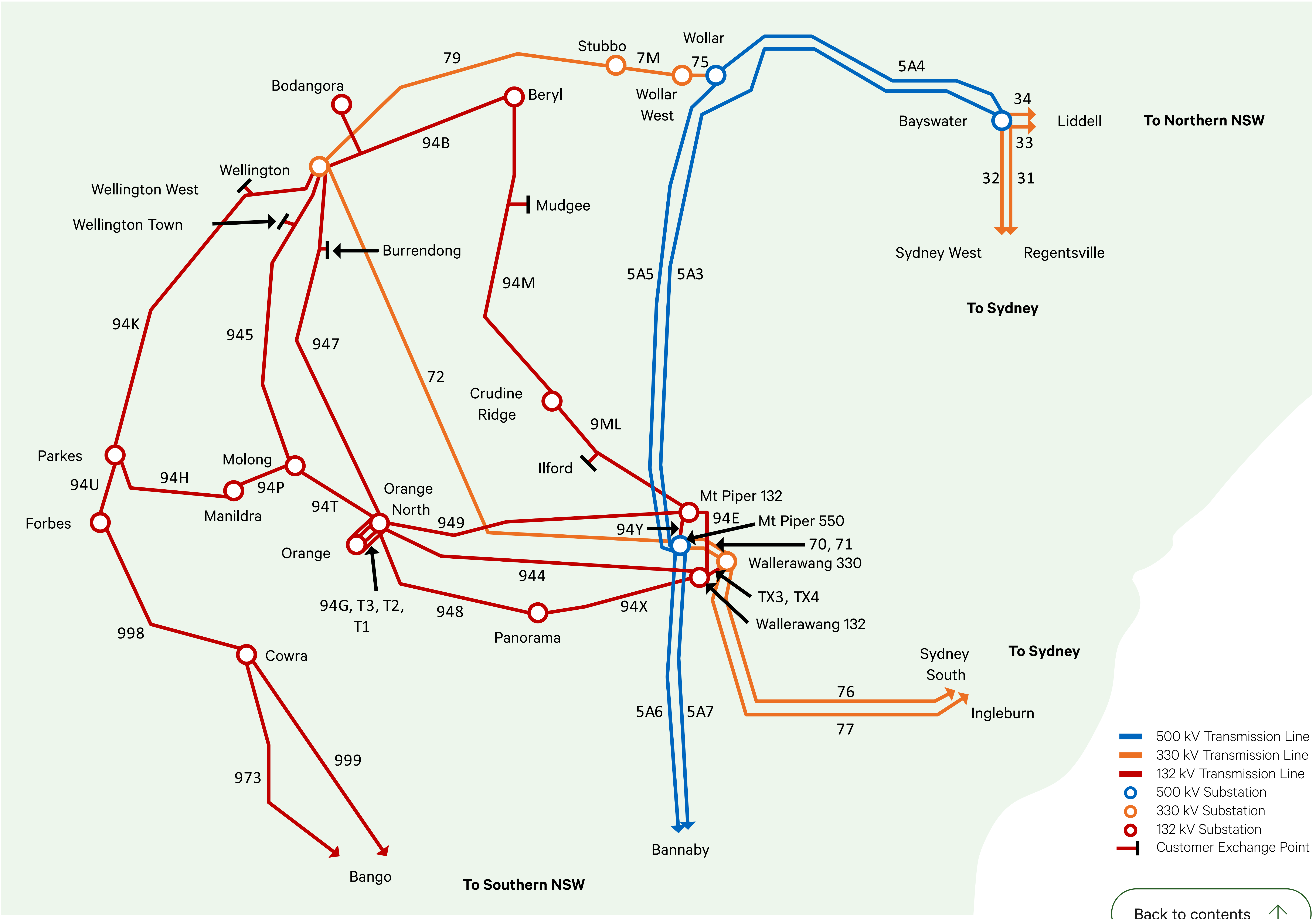

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Table 2.3: Projects in Central NSW

Project description	Proposed inservice date	Total cost ($2024/25 million)	Purpose and options	Project justification
Increasing capacity for generation from Molong to Orange North	Oct-25	0.5	To increase line 94T capacity with dyanamic ratings thus reducing potential curtailment of low-cost renewable generation in the area.	Market benefit
Increasing capacity for generation in the Molong and Parkes area	Dec-26	14	To increase capacity in the network west of Molong Substation, which has many renewable generators in service. The outputs of these generators are being curtailed by the relatively low thermal rating of line 94T. The RIT-T preferred option is to fit line 94T with a higher rating low sag conductor.	Economic benefit
Meeting demand growth in the Parkes area	Jul-26	10	To accommodate the large spot loads proposed in the Parkes area. A new 132 kV bay at Parkes Substation is proposed to connect the Essential Energy switching station from which the load will be supplied.	Load driven
Maintaining reliable supply to Bathurst, Orange and Parkes areas Stage 1	Nov-26	Non-Network Solution	To accommodate significant increases in demand in the Parkes areas over the next 10 years, mainly due to a rise in commercial demand, such as the NSW Government's Parkes Special Activation Precinct and potential mine load growth. This growth is expected to cause voltage constraints in the area. The RIT-T preferred solution for Stage 1 of the project is non-network installation at Parkes.	Compliance
Maintaining voltage levels in the Beryl area	2028	34	To address potential voltage constraints and reactive margin shortfall issues in the Beryl area. Transgrid has identified a range of credible network and non-network options to address these network constraints. The network option is to install a synchronous condenser at Beryl Substation.	Compliance
Increase capacity for generation from Parkes to Wellington	2030	TBD	To reduce thermal constraints on line 94K from Parkes to Wellington.	Market benefit
Maintaining reliable supply to the Wellington area	2030	TBD	To accommodate increasing number of large renewable generators on 330 kV busbar by upgrading the Wellington Substation to a breaker and a half arrangement.	Reliability
Increase capacity for generation from Wellington to Molong and Orange	2030	TBD	To reduce thermal constraints on multiple lines in Central West around Wellington to Molong and Orange area.	Market benefit
Maintain voltage levels in the Cowra to Forbes area	2031	TBD	To address overvoltages from Cowra to Forbes, which appear during a line contingency in the area.	Compliance

Projects under regulatory consideration

- RIT-T for Maintain voltage in Beryl area is in progress (see Section 2.6 for more details)

Completed projects

No projects have been completed in Central region since the Transmission Annual Planning Report 2024 was published.

Future potential distribution REZs

As part of the Dubbo Renewable Energy Zone development, Transgrid will be responsible for delivering a range of enabling works. These works may include both minor and major upgrades such as enhancements to communications and protection systems, fault level management, upgrades to the BSP and transmission lines.

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2.3.5 Southern NSW and ACT

The Southern network plays a crucial role in transmitting electricity both from renewable energy sources to major load centres, and between NSW and Vic. The network connects a mix of generation sources, including gas-fired power plants, wind farms, solar farms, BESS and hydroelectric power. Several projects have been planned in Southern NSW to alleviate thermal congestion and its related constraints. These projects are designed to increase the transfer capacity of the subsystem to facilitate future renewable generation.

HumeLink is being developed in this network. Further details are in Section 2.1.3 of this document.

Planned projects

A summary of the planned projects in the Southern NSW and ACT region is provided in Table 2.4.

Figure 2.19: Existing Southern NSW and ACT network

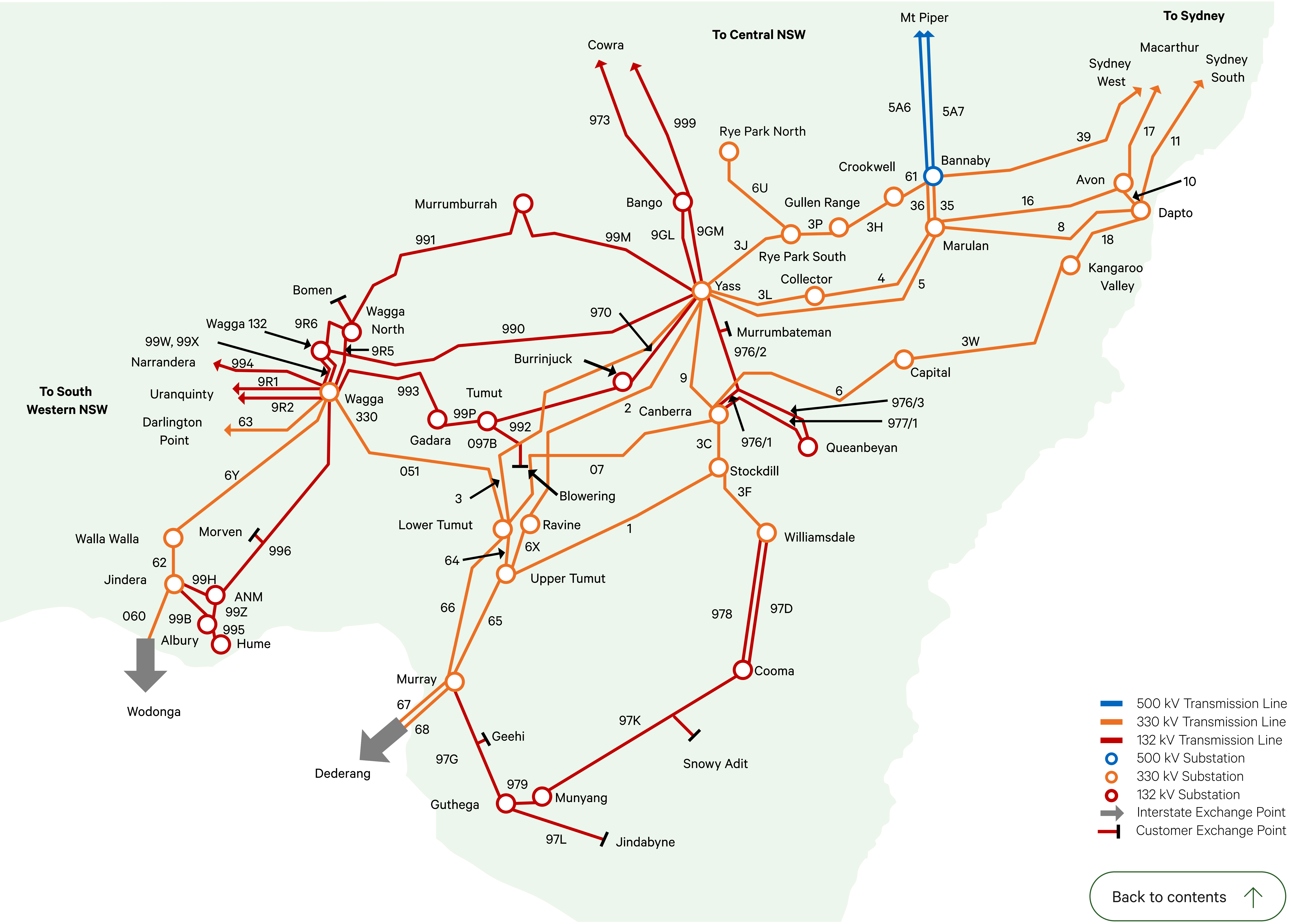

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Table 2.4: Projects in Southern NSW and ACT

Project description	Proposed in-service date	Total cost ($2024/25 million)	Purpose and options	Project justification
Increase capacity between the Yass and Wagga Wagga areas	Dec-25	0.7	To improve the management of the post-contingent overloads of the 132 kV network in the 132 kV subsystem between Yass and Wagga Wagga Feeders in the scheme include 970, 990, 991, 992, 993, 99M, 99P, 9R5, 9R6, 99X and 99W.	Economic benefit
Dynamic ratings for Yass 330/132 kV transformers	Dec-26	1.8	To implement a real-time monitoring system and the required upgrades to facilitate a dynamic rating system for the No.1 and No.2 330/132 kV transformers at Yass 330 kV substation. The dynamic ratings would reduce the constraints on low-cost renewable generation in the Southern area by increasing the transfer capability of these units under contingency conditions.	Economic benefit
Maintaining reliable supply to the Yass area	2028	TBD	To provide 132 kV supply to Essential Energy to maintain a reliable supply to the Yass area and to meet the projected load growth.	Load Driven
Managing increased fault levels in Southern NSW	2028	54	The fault levels in the Southern transmission network will increase due to the EnergyConnect, HumeLink, and VNI West projects. The switchgear at Lower Tumut, Upper Tumut, Wagga Wagga 330 kV and Murray 330 kV substations and the earth grid at Lower Tumut will all be upgraded to meet compliance requirements.	Compliance
Increasing capacity for generation in the Wagga Wagga North area	2028	13	To increase the transfer capacity for renewable generation in the Wagga Wagga North area. Options considered include upgrading the 132 kV lines 9R5 and 9R6.	Economic benefit
Increasing capacity for generation in the Wagga Wagga area	2028	7.4	To upgrade the busbar sections at Wagga Wagga 132 kV substation to remove the thermal constraints at those sites during high renewable generation times and/or outages conditions.	Economic benefit
Maintaining reliable supply to the Wagga Wagga area	2028	3.6	To meet overall network reliability requirements, including upgrading the busbar sections at Wagga Wagga 66 kV substation.	Compliance
Reliability of Supply to ACT	2033	TBD	To meet overall network reliability requirements in the ACT.	Reliability

Projects under regulatory consultation

- Managing increased fault levels in Southern NSW
- RIT for Increasing capacity for generation in the Wagga Wagga North area.

Completed projects

No projects have been completed in Southern region since the Transmission Annual Planning Report 2024 was published.

Future potential distribution REZs

As part of the Marulan and Yass Renewable Energy Zones development, Transgrid will be responsible for delivering increased transformer capacity at BSPs.

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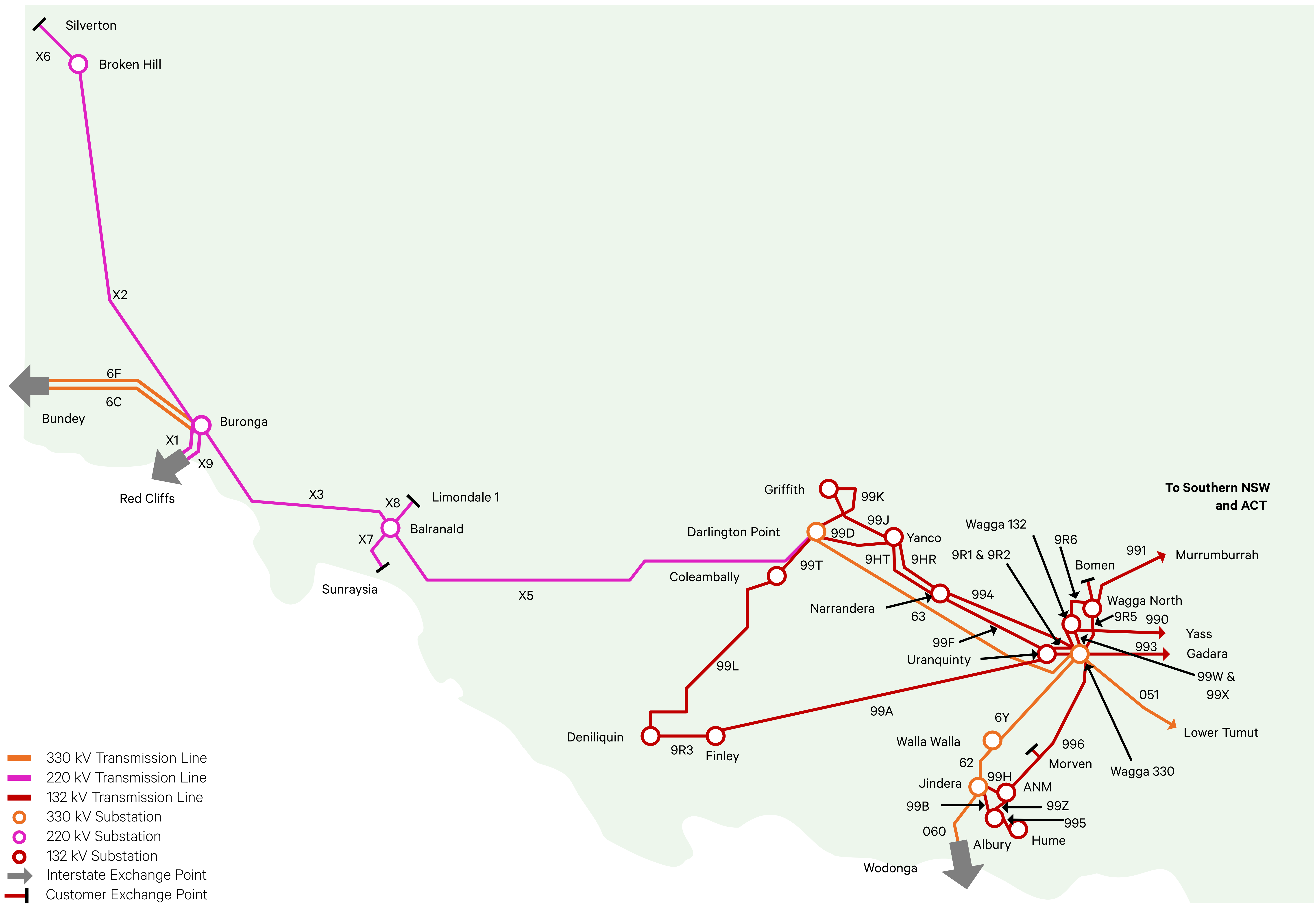
2.3.6 South Western NSW

The transmission network in South Western NSW operates across various voltage levels, with 220 kV lines reaching as far as Broken Hill. Transgrid is implementing expansion and enhancement projects to ensure network security during the energy transition. This includes the NSW section of EnergyConnect; a 330 kV interconnector linking SA to Buronga, which will enhance inter-regional transfer capability, support renewable integration, and improve supply reliability. Transgrid's diesel-fired gas turbines currently provide the backup supply for the Broken Hill area, ensuring compliance with our reliability obligations. We acquired these turbines from Essential Energy in 2022 and are currently planning to phase them out as they approach end of life. A May 2022 RIT-T for Maintaining Reliable Supply for Broken Hill identified Hydrostor's proposed advanced compressed air energy storage (A-CAES) facility, in conjunction with local renewables, as the preferred option (see Section 3.1).

Major projects, including EnergyConnect, South West REZ, and VNI West, are being developed in this network (see Section 2.1.3).

Figure 2.20: Existing South Western NSW network



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Planned projects

A summary of the planned projects in the South Western NSW region is provided in Table 2.5.

Table 2.5: Planned projects in South Western NSW

Project description	Proposed in-service date	Total cost ($2024/25 million)	Purpose and options	Project justification
Maintaining reliable supply to Deniliquin Coleambally and Finley area	Nov-25	11	To address the high-voltage issues during low demand periods by installing two 66 kV 11 MVAr reactors at Deniliquin. The RIT-T has been completed, and the project is currently in progress.	Compliance
Maintain reliability to Broken Hill Area	2025	6.5	To address the need to manage negative operational demand in the Broken Hill region when line X2 is out of service.	Reliability
Darlington Point 330/220/33 kV Tie Transformer cross tripping scheme	Mar-26	0.4	To enable high flows of renewable generation in Far West NSW towards Darlington Point. Currently the dispatch from renewable generation in the Far West is constrained to prevent future overloading of 200 MVA 330/220/33 kV transformers during a trip of the other transformer. This project implements a remedial action scheme to trip the remaining tie transformer, allowing the tie transformers to run at their maximum MVA rating.	Economic benefit
Relieving X5 voltage stability constraints	Apr-26	6.3	To address the very high power flows in the 220 kV network, which are leading to severe under voltages at Balranald and issues with voltage stability limit on Line X5, on a contingent trip of a transmission line in North Western Victoria. This project proposes to install a 220 kV 20 MVAr capacitor bank to provide additional reactive support to relieve the Line X5 stability limit.	Economic benefit
Maintaining a reliable supply to Broken Hill	2028	Non-Network Solution	To provide backup supply when line X2 is out of service, to meet the IPART reliability standard for Broken Hill. The RIT-T identified option is to implement a 200 MW/1,500 MWh advanced compressed air storage system, to be provided by Hydrostor, with a reserve of 250 MWh backup supply for outages. The facility is planned to operate in a mini-grid with other local generation sources. As an interim measure, Transgrid will continue to use the existing diesel-fired gas turbines to provide the backup supply for the Broken Hill area (see Section 3.1).	Reliability

Projects under regulatory consultation

No prescribed augmentation projects have ongoing RIT-Ts in the South Western region.

Completed projects

No projects have been completed in Southern region since the Transmission Annual Planning Report 2024 was published.

2.3.7 Across NSW

Network Support and Control Ancillary Services needs

Network Support and Control Ancillary Services are procured to maintain power system security. Under the NER, AEMO identifies Network Support and Control Ancillary Services needs in NSW, and Transgrid is required to procure the services to address them.

The 2024 Network Support and Control Ancillary Services Report published by AEMO in December 2024 declares that the existing system strength shortfalls at Newcastle and Sydney West have been deferred until FY28, linked with the delayed retirement of Eraring Power Station. No inertia shortfalls, thermal overloading or voltage control gaps have been identified in the report, although several emerging network risks have been identified for supply around Sydney under maximum demand conditions if anticipated generation and network projects do not proceed as planned.

System strength and inertia requirements

As coal-fired generation retires, NSW needs to invest in new system security infrastructure to main system strength. Transgrid is responsible for making sure the grid has enough system strength to stay secure and stable. This includes meeting the basic level needed now, and the additional levels of service required as the projected levels of renewable generation connect to the grid.

Section 5.1 tracks the current and future system strength and inertia shortfalls and discusses options to address them, including synchronous condensers with flywheels, contracting non-base load synchronous machines (generators), “synthetic inertia” from wind generators and Fast Frequency Response from BESS and power electronic-based generators.

Planned projects

A summary of the planned projects across multiple subsystems in NSW is provided in Table 2.6.

Table 2.6: Projects across NSW

Project description	Proposed in-service date	Total cost ($2024/25 million)	Purpose and options	Project justification
NSW oscillation monitoring – PMU installations	Nov-25	13.9	To provide the required data for wide area monitoring, enabling AEMO to detect and respond effectively to rapidly developing power system issues and more accurately model the power system.	Externally driven compliance
Maintaining capacity during climate change	2027	7.4	To implement Dynamic Line Ratings on multiple constrained lines, including lines 96N, 9R3, 99L, 999, 8C, 8E, 8J, 964/1, 964/2, 992, 993 and 99A.	Economic benefit
Meeting system strength requirements in NSW	10 Synchronous condensers from FY29	1,600	To address the system strength shortfall across NSW and meet Transgrid’s responsibility as the System Strength Service Provider in NSW. See Chapter 5 for further details.	System Security
Improving voltage control in Southern NSW	2029	17	To install one 50 MVAr shunt reactor at Kangaroo Valley 330 kV busbar and one 20 MVAr Shunt Reactor at Balranald 220 kV busbar.	Compliance
Manage increased fault levels	2030	TBD	Future transmission augmentation will increase fault levels at various locations in the network. This project will ensure equipment ratings are maintained though the transition.	
Improve the utilisation of lines in NSW	2030	TBD	To implement Dynamic Line Ratings on multiple constrained lines. This project will look at constraints in the network beyond 2028.	

Projects undergoing regulatory consultation

- Meeting system strength requirements in NSW
- Improving voltage control in Southern NSW.

Completed projects

No projects were completed after the Transmission Annual Planning Report 2024 was published.

2.4 Replacement projects

Transgrid renews our ageing assets when needed to keep energy reliable and affordable for our customers. As required by the National Electricity Objective,[45] we use our replacement capex (repex) to:

- Comply with applicable regulatory obligations
- Maintain the quality, reliability and security of supply
- Maintain the safety of the transmission system.

We weigh replacement costs against the risks and rising maintenance costs of keeping existing assets.

Our assets are renewed or retired as they reach the end of their serviceable life. We look at the risk of asset failure and its potential impact in terms of reliability, safety, bushfire and environment. Where needed, the options considered include:

- Do nothing or increase maintenance interventions
- If viable non-network options are available, defer or avoid renewal
- Replace like-for-like
- Refurbish the existing asset
- Replace with an asset of different capacity based on forecast demand
- Reconfigure the network.

Our investment framework makes sure the option chosen delivers measurable customer benefits or meets a statutory obligation.

This section describes Transgrid's capital replacement works, none of which cause any material inter-network impact. The information in this section meets the requirement of the NER Clause 5.12.2(c)(5) and (6).

2.4.1 Transmission lines and cables

Steel tower/pole condition management

We are refurbishing steel structures on transmission lines in Newcastle, Central Coast, Sydney, Illawarra and New England. The program includes refurbishing/replacing rusted steel towers/poles and replacing conductors, earth wires, fittings and insulators at risk of failure. The following table lists our schedule for transmission line refurbishment or replacement.

Table 2.7: Planned steel tower transmission line asset renewal projects

Transmission line project	Scheduled completion	Total estimated cost ($2024/25 million)
Line 23 – Vales Point Munmorah Refurbishment	Jul-25	17.1
Line 24/90 Refurbishment	Jul-25	1.4
Line 12/76 Refurbishment	Aug-25	6.8
Line 90/92 Refurbishment	Dec-25	2.2
Line 95 Refurbishment	Dec-25	3.3
Line 8C/8J Refurbishment	Jan-26	10.0
Line 16 Marulan Avon refurb	Feb-26	10.4
Line 12 Refurbishment	Feb-26	10.1
Line 13 Kemps Creek Sydney South refurbishment	Apr-26	4.7
Line 92/93 Refurbishment	May-26	5.6
Line 8C/8E Refurbishment	Jun-26	22.7
Line 92Z Conductor Replacement	Nov-26	12.1
Line 959 Conductor Replacement	Nov-26	8.7
Line 82/95 Refurbishment	Dec-26	11.5
Line 25/92 Refurbishment	Apr-27	4.4
Line 22 Conductor Replacement	May-27	9.9
Line 21 Conductor Replacement	Oct-27	8.2
Line 11 – Sydney South – Dapto	Feb-28	42.7
Line 9W/96 Refurbishment	Oct-29	1.9

45 The National Electricity Objective: "…to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to: A. price, quality, safety, reliability, and security of supply of electricity; and B. the reliability, safety and security of the national electricity system; and C. the achievement of targets set by a participating jurisdiction. i). for reducing Australia's greenhouse gas emissions; or ii) that are likely to contribute to reducing Australia's greenhouse gas emissions"

Wood pole condition management

Transgrid is replacing wood pole structures in poor condition on 132 kV and 330 kV transmission lines with concrete or steel poles to address deterioration from wood rot, decay and termite attack. Some of these lines also need new conductor fittings and insulators. The following table lists our schedule for wood pole transmission line refurbishment.

Table 2.8: Wood pole replacement projects

Transmission line project	Scheduled completion	Total estimated cost ($2024/25 million)
Line 977/1 Refurbishment	Dec-25	12.9
Line 963 Refurbishment	Feb-26	14.0
Line 966 Refurbishment	Jun-26	14.5
Line 992 Refurbishment	Jun-26	7.6
Line 94M Refurbishment	Sep-26	9.3
Line 94U Refurbishment	Oct-27	23.5
Line 947 Refurbishment	Mar-28	6.6
Line 86 Refurbishment	Mar-28	11.8
Other Wood Pole Replacements	Jun-28	19.0

Remediation of low spans

The industry standard, AS7000, specifies minimum electrical clearances when transmission lines reach their maximum operating temperature (the line design temperature). Transmission lines with low spans at the normal foreseeable operating temperature pose a public safety risk.

To identify priority lines for remediation, we assessed low spans against multiple risk factors, including height and area temperature. We ranked the spans according to their risk to public safety to select remediation options that fulfil the requirements of AS5577 Electricity Network Safety Management Systems and reduce the public safety risk to As Low As Reasonably Practical (ALARP).

Table 2.9: Low Span Projects

Transmission line project	Scheduled completion	Total estimated cost ($2024/25 million)
Low Spans – 132 kV Lines	Jun-27	5.3
Low Spans – Main grid 330 kV Lines	Jun-28	15.0

Public safety

Through our Electricity Network Safety Management System, Transgrid takes all reasonably practicable steps to ensure public safety around our transmission lines, which run through public and private land. Asset inspections have identified ineffective climbing deterrents throughout the network and asbestos paint on certain towers that require modification or remediation.

Table 2.10: Public Safety Projects

Transmission line project	Scheduled completion	Total estimated cost ($2024/25 million)
Public Safety Enhancements – Climbing deterrents	Dec-25	5.2
Transmission Line Tower asbestos paint	Jun-28	20.5

Underground cables

Transgrid's underground cables include self-contained fluid-filled cables where the manufacturer is about to stop making parts. We are purchasing the required spares now to maintain cable reliability over the remainder of their designed service life.

Table 2.11: Planned underground cables asset renewal projects

Transmission line project	Scheduled completion	Total estimated cost ($2024/25 million)
Underground Cables Capital Spares	Dec-26	2.3

Completed projects

The following projects were completed since the Transmission Annual Planning Report 2024 was published:

- X2 Permanent Restoration – replaced towers damaged by a severe weather event in October 2024
- Line 9ML Refurbishment
- Line 99J Refurbishment
- Line 76/78 Refurbishment
- Line 99Z Refurbishment
- Line 99B Refurbishment
- Line 13/78 Refurbishment.

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2.4.2 Substation plant

In substations, to maintain network safety and reliability, we monitor and replace, retire or refurbish larger assets, such as transformers, reactors and capacitor banks, as needed. We also have asset renewal programs for smaller assets in poor condition, such as circuit breakers, instrument transformers, bushings, disconnectors, and gantry steelwork and foundations.

The following table lists our schedule of high-voltage asset renewal or replacement projects/programs.

Table 2.12: Planned substation primary (HV) asset renewal/replacement projects

Project/Program	Area	Scheduled completion	Total estimated cost ($2024/25 million)
Bayswater Reactor Replacement	Central	Jul-25	3.3
Mt Piper Reactor Replacement	Northern	Jul-25	4.1
Marulan No3 Transformer Replacement	Southern	Jul-25	14.8
Kangaroo Valley RMU and Aux Transformer Replacement	Southern	Sep-25	3.9
Broken Hill Gas Turbine Refurbishment	Western	Dec-25	62.4
Haymarket Transformer Cooling System	Sydney	Apr-26	1.9
Buronga Substation HV Asset Replacement	Southern	May-26	8.9
Beryl Capacitor Bank Renewal	Central	Jun-26	9.0
Substation Capital Spares	Across NSW	Aug-26	0.9
Foundation Renewal Program	Across NSW	Sep-26	5.9
Murray Transformer Renewal	Southern	Apr-27	46.8
Molong No1 Transformer Renewal	Central	May-27	7.5
Gunnedah Non-SF6 Circuit Breaker Replacement	Northern	Jun-27	4.4
Sydney South No2 Reactor Replacement	Sydney	Jul-27	10.1
Transformer Compound Wall Renewal	Across NSW	Sep-27	3.5
Sydney East Reactor No1 Renewal	Sydney	Oct-27	5.2
Tamworth Transformer Renewal	Northern	Oct-27	20.3
Condition monitoring for selected high-voltage bushings	Across NSW	Jan-28	6.5
Regentville Transformer Renewal	Sydney	Feb-28	2.1
Buronga X2 Reactor Bund Civil Works	Southern	May-28	0.5
Panorama Transformer Renewal	Central	Jun-28	1.3
Replace Condemned Insulators in Substations	Across NSW	Jun-28	4.3
Narrabri Capacitor Bank Renewal	Northern	Jun-28	5.8
Air Core Reactor Switching Duty	Across NSW	Jun-29	6.0
Inverell Transformer Renewal	Northern	Aug-29	15.5
Tenterfield Transformer Renewal	Northern	Jun-30	13.0
Steelwork Renewal Program	Across NSW	May-31	27.9
Circuit Breaker Renewal Program	Across NSW	Dec-31	52.4
CT Renewal Program	Across NSW	Dec-31	10.4
VT Renewal Program	Across NSW	Dec-31	9.5
Disconnector Renewal Program	Across NSW	Dec-31	22.6
Kempsey Capacitor Bank Renewal	Northern	Jun-32	3.3
Coffs Harbour Capacitor Bank Renewal	Northern	Jun-32	3.3

Completed Projects

The following projects were completed since the publication of the Transmission Annual Planning Report 2024:

- Dapto No3 Transformer Replacement

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2.4.3 Secondary

Secondary systems

Transgrid manages Digital Infrastructure assets, including protection, metering, control and communications technologies. Renewals improve asset visibility and capability, and reduce risks from technological obsolescence where manufacturer support has been withdrawn for certain assets.

The following table lists our planned replacement projects, including secondary system and communications renewals.

Table 2.13: Planned substation secondary asset renewal and replacement projects[46]

Project/Program	Area	Operation date required	Total estimated cost ($2024/25 million)
Murrumburrah Secondary Systems Renewal	Southern	Jul-25	11.6
Ingleburn Secondary System Renewal	Sydney	Aug-25	14.0
Broken Hill Secondary Systems Renewal	Western	Sep-25	31.0
Secondary Asset Capital Spares	Across NSW	Dec-25	1.42
Battery and Charger Renewal	Across NSW	Dec-25	0.7
Metering Comms Implementation	Across NSW	Dec-25	3.0
Substation Security Zone Replacement	Across NSW	Jan-26	1.6
Haymarket Secondary Systems Renewal	Sydney	Jun-26	19.3
Wallerawang Secondary Systems Renewal	Central	Jul-26	13.2
Regentville Secondary Systems Renewal	Sydney	May-27	13.0
Comms Alarm System Renewals	Across NSW	Jul-27	9.5
Alarm Management Philosophy Implementation	Across NSW	Nov-27	2.6
Sydney East Secondary Systems Renewal	Sydney	Dec-27	31.7
Lower Tumut Secondary Systems Renewal	Southern	Jan-28	46.5
Microwave Renewal Program	Across NSW	Feb-28	11.0
Operational Telephone Network Renewal	Across NSW	Mar-28	12.4
Optical Ground Wire – Tenterfield to Lismore	Northern	Jun-28	9.3
Multiplexer B Renewal program	Across NSW	Jun-28	10.2
Cowra substation Secondary Systems Renewal	Central	Aug-29	11.4
Panorama Secondary Systems Renewal	Central	Aug-29	9.8
Narrabri Secondary Systems Renewal	Northern	Jun-30	3.2
Secondary Asset Replacement Programs	Across NSW	Dec-31	38.7

46 Some Secondary System Renewals are being delivered as packaged primary and secondary works. The estimated cost would include the primary scope.

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Cyber and physical security

Transgrid's legislative, regulatory and safety obligations include the NSW Electricity Supply (Safety and Network Management) Regulation 2014, the Work Health and Safety (WHS) Regulation 2011, Security of Critical Infrastructure Act 2018 and the recently ascended Security Legislation Amendment (Critical Infrastructure Protection) Act 2022 (SLACIP Act 2022). These instruments provide minimum requirements for critical infrastructure cyber and physical security and associated risk management programs.

Under the SLACIP Act 2022, Transgrid is subject to enhanced cyber security obligations and a requirement to increase the standing level of cyber maturity. From a physical security perspective, our existing electronic systems across multiple sites have or are expected to reach the end of their serviceable life. Transgrid therefore needs to address increasing asset obsolescence risks and, by extension, security risks to its critical assets as follows.

Table 2.14: Planned cyber and physical security projects and programs

Project/Program	Area	Operation date required	Total estimated cost ($2024/25 million)
OpsWAN ACM and Ticketing Upgrade	Across NSW	May-26	4.3
Cyber Security Upgrade (Operational Technology environments)	Across NSW	Nov-27	5.1
Physical Security Upgrade	Across NSW	Jun-28	37.4

Network property

We monitor the condition of substation property assets to ensure their safe operation and enable us to meet our responsibilities under the WHS Act 2011 and Australian Standards. We have scheduled the following renewals to address safety and operational risks on our network property assets.

Table 2.15: Planned network property programs

Project/Program	Area	Operation date required	Total estimated cost ($2024/25 million)
Fire Systems Renewals	Across NSW	Jul-26	4.8
Palisade Gate Renewals	Across NSW	May-27	5.8

Completed projects

The following projects were completed since the publication of the Transmission Annual Planning Report 2024:

- Multiplexer A Renewal program.

2.5 Asset retirements and deratings

Over the next 10 years, Transgrid is planning to derate and retire some assets in our network that may result in network constraints. The information reported in this section meets the requirement of NER Clause 5.12.2(c)(1A) and (1B).

Derated assets

To ensure compliance with current technical standards, the contingency rating used for market dispatch on some existing 330 kV lines will be reduced (derated) over the next 12 months.

The following lines are affected:

- Line 3L (Yass to Collector)
- Line 4 (Collector to Marulan)
- Line 5 (Yass to Marulan)

The new ratings are required to reduce risks to the public and Transgrid's network and supports the continued safe and reliable operation of these lines as critical components of the NSW transmission system.

Transgrid is evaluating the potential impacts of this change and will engage with market participants prior to the new ratings taking effect.

Retired assets

Yass 330/132 kV Substation is in Transgrid's Southern NSW network. It serves as a major connection point between Transgrid's Central and Southern networks, with the majority of 330 kV and 132 kV transmission lines passing through. Yass substation is also a critical path for interstate power flows, including ACT supply and connection to the Snowy Mountains Scheme.

At almost 60 years old, the Yass No.3 132/66 kV transformer has reached the end of its serviceable life. We have noted signs of deterioration, primarily due to corrosive sulphur and paper insulation moisture, resulting in oil leaks. The No.3 transformer will be retired within the current regulatory period and our partners at Essential Energy will modify their network to supply the load at 132 kV.

Nate Cull – Field Coordinator (TLC)

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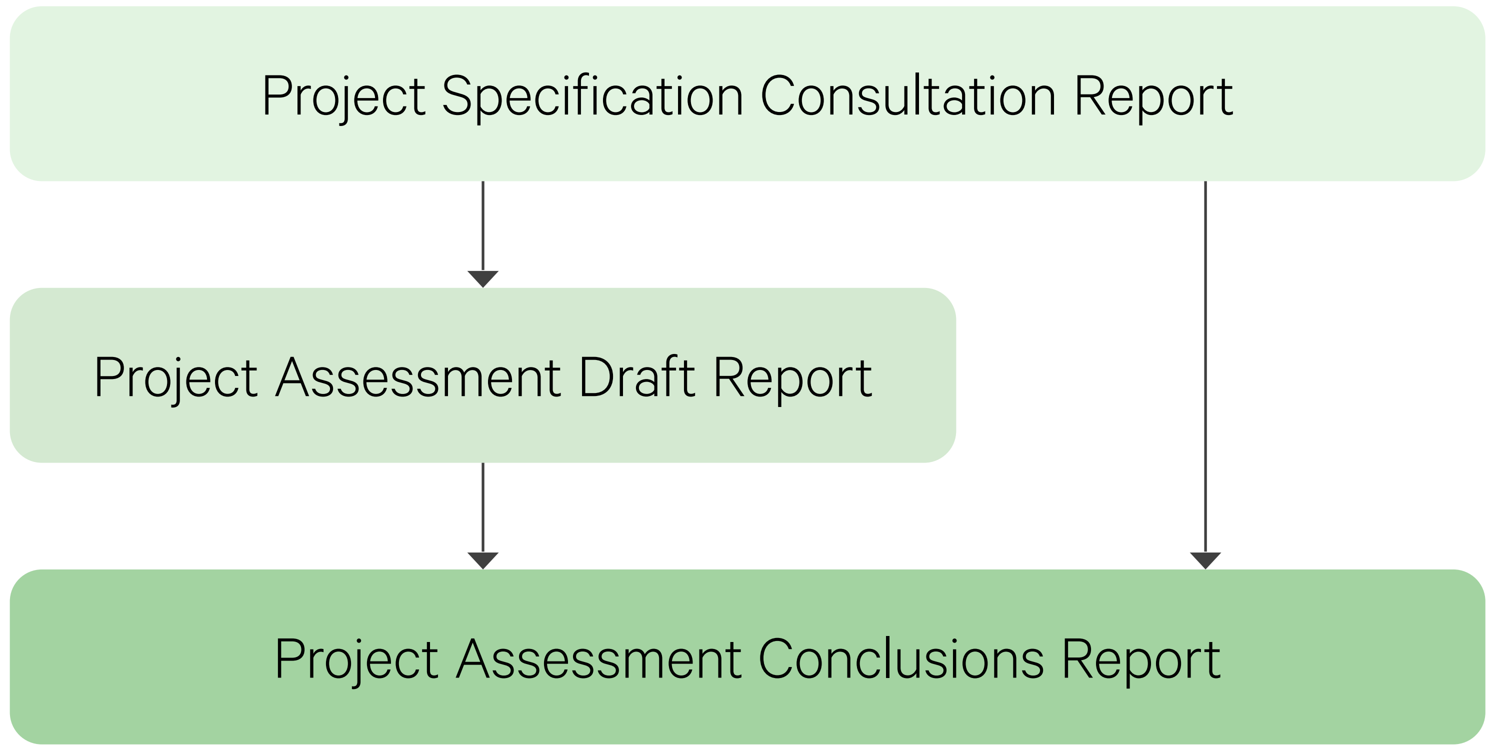
2.6 Regulatory Investment Test for Transmission (RIT-T)

For network investments likely to cost more than $8 million, Transmission Network Service Providers use a public consultation process called the Regulatory Investment Test for Transmission (RIT-T).

The RIT-T normally involves the three reports shown in the diagram, which come at key milestones in the consultation process. After the Project Specification Consultation Report (PSCR) and Project Assessment Draft Report (PADR), Transgrid considers stakeholder submissions received in response to these documents.

In this Report, Transgrid is required to disclose certain information about RIT-Ts in progress, including a brief project description, commissioning date, other reasonable options considered and estimated costs.



2.6.1 RIT-T schedule

The table below shows the start dates for our various RIT-Ts in the calendar year quarter. This includes new RIT-Ts planned for 2025–26 and RIT-Ts that are underway, with final RIT-T documents planned for publication later in the year.

A list of our ongoing RIT-T consultations can be found at: www.transgrid.com.au/about-us/regulatory-framework/regulatory-investment-test-for-transmission-rit-t

Table 2.16: Active and planned RIT-T assessments

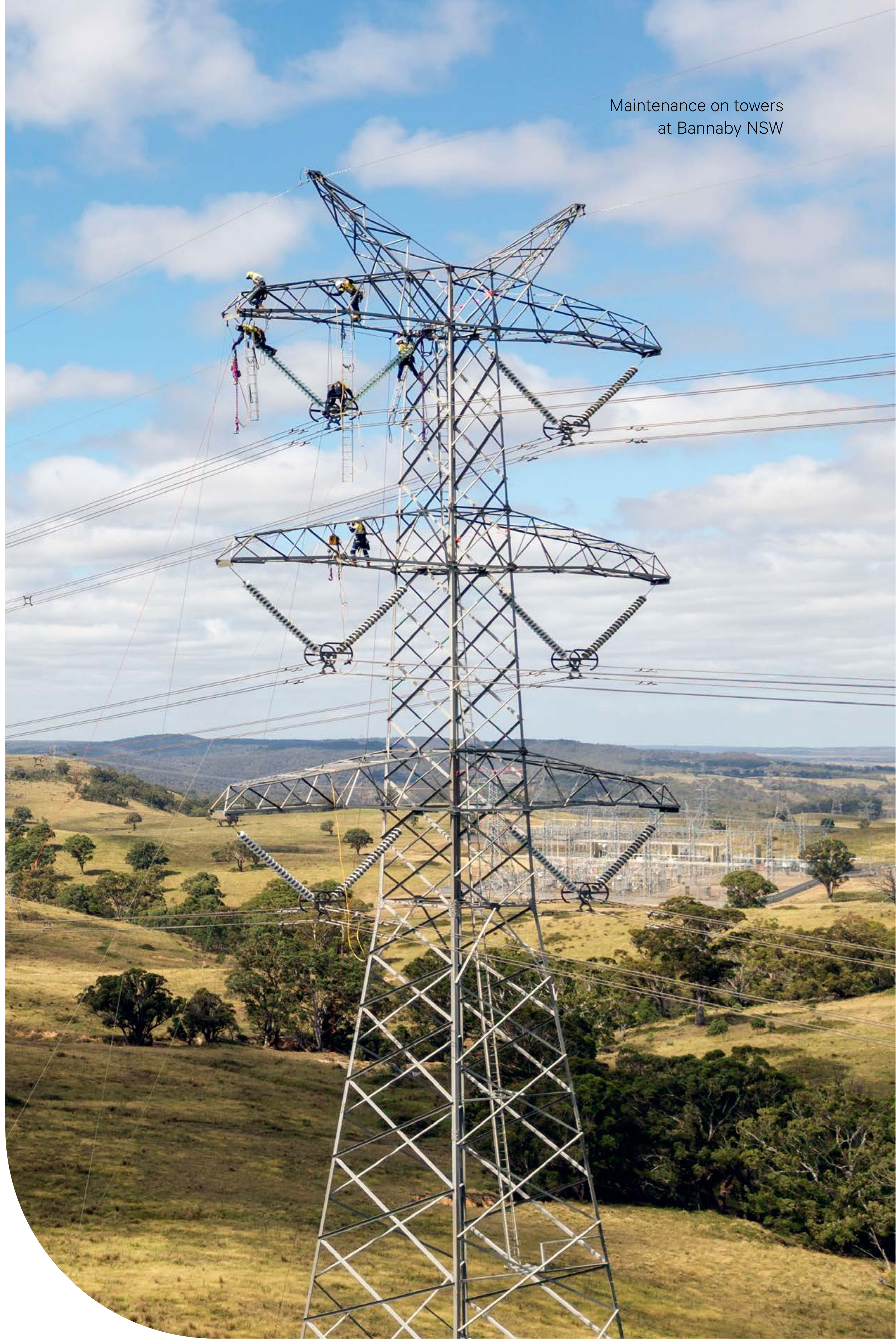
Project description	RIT-T kick off quarter	Type of project
QNI Connect	2026Q2	Major Development
Maintaining compliance with performance standards applicable to Transgrid's communication network	2025Q3	Transmission Line
Maintaining safe and reliable operation of Sydney East substation	2025Q3	Substation
Managing risk on Line 94M (Beryl – Crudine Ridge)	2025Q2*	Transmission Line
Maintaining safe and reliable operation of Sydney East, Wagga Wagga 132 kV, and Dapto substations	2025Q2*	Substation
Sydney Ring South	2026Q2	Major Development
Maintaining safe and reliable operation of Inverell substation	2025Q1*	Substation
System Security Roadmap Operational Technology Upgrades	2024Q4*	Communications and IT
Managing risks on Line 947 (Wellington-Orange North)	TBC	Transmission Line
Managing risks on Line 11 (Sydney South-Dapto)	2025Q2*	Transmission Line
Maintaining compliance with performance standards applicable to Panorama substation secondary systems	2025Q1*	Secondary Systems
Maintaining compliance with performance standards applicable to Cowra substation secondary systems	2025Q1*	Secondary Systems
Maintaining voltage levels in the Beryl area	2024Q4*	Reliability
Maintaining reliable supply to Vineyard in Northwest Sydney	2024Q3*	Reliability
Increasing capacity for generation in the Wagga Wagga North area	2024Q3*	Market Benefits
Improving voltage control in Southern NSW	2024Q3*	Reliability
Meeting demand growth in the Western Sydney Aerotropolis 'Priority Growth Area'	2023Q3*	Reliability
Meeting system strength requirements in NSW	2022Q4*	System Strength
Managing asset risks at Sydney South substation	2018Q3*	Substation

*Active RIT-T, Transgrid anticipates publication of the PADR/PACR during 2025.

Table 2.17: Completed RIT-T assessments

Project description	RIT-T completed date	Type of project
Maintaining safe and reliable operation of Molong substation	July 2024	Substation
Managing risk on Line 94U (Parkes – Forbes)	August 2024	Transmission Line
Maintaining compliance with performance standards applicable to Wallerawang substation secondary systems	August 2024	Secondary Systems
Addressing low spans on Line 1, Line 2, and Line 973/9GL	September 2024	Transmission Line
Managing risk on Line 8C/8J and 8C/8E (Dumaresq – Sapphire – Armidale)	December 2024	Transmission Line
Maintaining reliable supply to Western Sydney	December 2024	Reliability
Maintaining safe and reliable operation of Tamworth substation	January 2025	Substation
Maintaining safe and reliable operation of Buronga substation	January 2025	Substation
Managing risk of disconnector failure	January 2025	Substation
Maintaining compliance with performance standards applicable to Regentville substation secondary systems	February 2025	Secondary Systems
Managing risk on Line 82/95 (Tomago-Seahampton)	February 2025	Transmission Line
Managing increased fault levels in southern NSW*	April 2025	Reliability
Meeting demand growth and reliability requirements in the Parkes area	May 2025	Reliability

*Preparation for Contingent Project Application (CPA) in progress.



Maintenance on towers at Bannaby NSW

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2.7 Changes from the Transmission Annual Planning Report 2024

Updates in this chapter and referenced Appendices since the Transmission Annual Planning Report 2024 include:

- The AER granted Transgrid an extension to the Sydney Ring South Project Assessment Draft Report (PADR) due date to allow additional time to properly identify and analyse potential options to improve the quality of the released PADR. The revised due date is 30 April 2026.[47]
- Following the PADR for managing asset risks at Sydney South substation RIT-T in 2020, further assessment and consideration of the scope was required. Transgrid has not yet been able to determine a conclusion. It is not practicable to publish a Project Assessment Conclusions Report. Consequently, the RIT-T is still active. Transgrid expects to finalise the process in FY26.
- The RIT-T for managing risks on Line 94M (Beryl-Crudine Ridge) has been re-included with the PSCR published in Q2 2025. A revision of scope increased the costs of the technically and commercially feasible options to above the $8 million threshold, requiring a RIT-T.
- The RIT-T for managing increased fault levels in Southern NSW has been completed. Progress is underway to submit the Contingent Project Application, with estimated publication in 2026.
- The RIT-T kick-off quarter for managing risks on Line 947 (Wellington-Orange North) is to be determined after further cost estimations.
- The RIT-Ts for increasing capacity for generation in the Wagga Wagga area and for managing risks on Line 992 (Burrinjuck-Tumut) are no longer required because all technically and commercially feasible options are under the $8 million cost threshold.
- Multiple replacement project changes and updates.

The following projects, described in the Transmission Annual Planning Report 2024, have been removed from the 2025 Report:

- Maintaining reliable supply to Bathurst, Orange and Parkes areas Stage 2 – This project was raised to address further increase in demand in the Orange and Parkes areas. The latest demand forecast does not show additional load increase beyond what has already been addressed for Stage 1.
- Maintaining reliable supply to the Orange area: This project was raised to address demand in Orange area, above firm capacity of Orange substation. However, the increase in demand is not large enough to justify the project.
- Maintaining voltage levels in the Alpine area: This project was raised to address voltage issues due to load growth in the Alpine area. A new proposed connection has deferred the project based on the latest demand forecast.

47 https://www.aer.gov.au/news/articles/communications/project-assessment-draft-report-publication-date-extended-sydney-ring-south-project


Chapter 3

Transgrid Control Room technician

Network innovation and connections

The Transmission Annual Planning Report 2025 showcases Transgrid's use of innovative non-network and emerging technology solutions to address constraints in the NSW transmission network – looking beyond 'poles and wires' – and how we support renewable generators and customers connecting to the grid.

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Network constraints can weaken reliability and affect energy prices. As we enter the second phase of the energy transition, the NSW electricity system is already being constrained by factors like the widening demand envelope and the system security challenges of renewable integration. Our forecasts suggest that new thermal and voltage constraints will appear in additional regions and continue to grow.

Part of the way we ease constraints is to build additional transmission lines – conventional 'poles and wires' infrastructure. But, where possible, Transgrid seeks innovative, faster and lower-cost alternatives – new technologies and 'non-network solutions' – that can help keep energy prices as low as possible for consumers.

These non-network solutions, which include services from energy storage systems, embedded generation or demand management, can remove or defer the need for network capital investment.

This chapter shows our current use of emerging technologies, innovative and non-network solutions to defer or avoid significant network capital costs. It also outlines new opportunities where our planning studies show it may be feasible and cost effective to implement non-network solutions – instead of, or alongside, transmission upgrades. Section 3.3 explores opportunities to further enhance the regulatory framework for non-network solutions. These ideas build on the recent progress made through a March 2025 AEMC rule change that improves the cost recovery arrangements for transmission non-network options.[48]

Finally, Section 3.5 looks at the progress being made in new connections and explains how we are helping generators, storage facilities and large load customers to connect as quickly and efficiently as possible.

Jess Evans – Substation Technician Apprentice
Trent Gillespie – Field Coordinator Substation
Taylor Madden – Substation Technician
Amy Longmuir – Substation Technician Apprentice
Brodie Grant – Substation Technician Apprentice
Christian Johane – Substation Technician

48 AEMC rule change, Improving the regulatory framework for non-network options

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3.1 Innovation projects benefiting consumers

Before we use them, non-network options are typically selected through a Regulatory Investment Test for Transmission (RIT-T) process, which identifies non-network options with the potential to benefit consumers.

Transgrid's innovation projects often make use of non-network solutions and emerging technologies. The following are some recent examples.

Broken Hill and Far West NSW

Backup power supply at Broken Hill has historically been provided by two gas turbines that operate when the single 220 kV transmission line supplying the region is out of service. Transgrid acquired these turbines from Essential Energy in 2022 and is currently planning to phase out their operation as they approach end of life.

October 2024 event

On 16 October 2024, an extreme weather event caused outages that significantly disrupted communities and businesses in Far West NSW.

While the main 220 kV transmission line (X2) was out of service, the Broken Hill Battery Energy Storage System (BESS) was successfully operated in the local system, forming a transmission-scale mini-grid. This was only possible thanks to a collaborative effort between the BESS operator and Transgrid, with the support of AEMO, AER and government.

Long-term solution

Transgrid remains fully committed to providing a resilient and reliable energy supply in Far West NSW. We will continue to work with local communities, governments, regulators and other key stakeholders to develop longer-term solutions to ensure the provision of safe, reliable and affordable energy to Broken Hill and surrounding towns.

The RIT-T for Maintaining Reliable Supply for Broken Hill identified Hydrostor's proposed advanced compressed air energy storage (A-CAES) facility, operating together with local renewables, as the preferred option.

In November 2023, Transgrid entered a Network Support Agreement to procure services from Hydrostor's A-CAES facility to support backup supply arrangements in the region. The Silver City Energy Storage project will have a reserve of 250 MWh backup supply for outages. The facility is planned to operate in a mini-grid with other local generation sources. In 2024 and 2025, Transgrid continued to assess feasibility of the planned mini-grid.

Bathurst, Orange and Parkes

Transgrid is procuring dynamic reactive support services from a hybrid solar and BESS in the Parkes area. This facility will cater for increasing energy demand in the region, providing voltage support and deferring the need for a new transmission line between Wellington and Parkes. The RIT-T for Maintaining Reliable Supply to the Bathurst, Orange and Parkes areas and an amended Project Assessment Conclusions Report (published in January 2023), confirmed BESS facilities at Parkes and Panorama as the preferred option. Based on recent forecasts, only the Parkes solution is required in the near term.

North West Slopes

Transgrid is procuring non-network services at Gunnedah or Narrabri to cater for increased industrial electricity demand in the North West Slopes area, deferring new transmission investment. The RIT-T for Maintaining Reliable Supply to the North West Slopes Area (Stage 1) and an amended Project Assessment Conclusions Report (published in January 2023), confirmed that a new BESS facility at either Gunnedah or Narrabri, together with a new transformer at the Narrabri substation, is the preferred solution. The preferred option also identified transmission line augmentations over the longer term.

Transgrid is continuing to monitor the demand forecasts, supplied by Essential Energy. A Network Support Agreement is planned to align with the updated timing of the need, which will be confirmed through joint planning with Essential Energy.

South West NSW

Transgrid has procured services from existing operating BESS facilities in South West NSW to increase transfer capacity of the network between Darlington Point and Wagga Wagga. The 2022 RIT-T for Improving Stability in South Western NSW concluded that contracting with a committed BESS to provide network support services would unlock substantial market benefits and provide flexibility for future network augmentations in the region, including VNI West and the South West REZ. Transgrid has Network Support Agreements in place with the BESS facilities. These services are increasing power flow limits on the transmission system, reducing constraints on generation in the region.

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Sydney, Newcastle and Wollongong

Transgrid has implemented a System Integrity Protection Scheme that uses up to 700 MW / 1,400 MWh of capacity from a BESS on the Central Coast to increase transmission capacity between regional NSW and key load centres in the Sydney, Newcastle, Wollongong region. The scheme will allow higher line ratings across 36 monitored lines by automating the response to contingency events like lightning strikes and bushfires. The higher line ratings allow electricity consumers in Sydney, Newcastle and Wollongong to access more energy through existing transmission lines. Innovative solutions of this nature, while highly beneficial, increase the complexity associated with system operability, as discussed in Chapter 5.

NSW

As highlighted in Chapter 5, new sources of inertia and fast frequency services will be needed as coal generators retire. Transgrid has trialled a 50 MW/75 MWh lithium-ion battery at Sydney West to provide synthetic inertia services. With support from the NSW and Federal Governments, the large-scale grid battery at Wallgrove began commercial operation in December 2021 and enabled 'Virtual Machine Mode' in November 2022. Since the Transmission Annual Planning Report 2024, Transgrid and Lumea co-published a Flagship Report *Large-scale battery storage as an inertia substitute*, describing the performance of the Wallgrove Grid Battery in responding to grid disturbance with synthetic inertia.[49]

Demand Management Innovation Allowance

Transgrid's Demand Management Innovation Allowance program is funding research and development for demand management projects with the potential to reduce long-term network costs. In 2025, we established an independent panel to evaluate initial projects. In the second half of 2025, we will expand the program to investigate innovative projects capable of exploring and altering network demand usage patterns in the transmission system.

Alarm management project

In early 2025, Transgrid implemented the first phase of its alarm management project, addressing the rapid increase in alarm points due to the growing network complexity. The initiative has already improved situational awareness on the network. Operators can now quickly identify higher priority issues and reassign lower-priority alarms to other teams during business hours. Further enhancements to system operability are being planned through the Regulatory Investment Test process, as discussed in Chapter 1 and Section 5.2.

These projects are just the beginning. As the clean energy transition powers forward, Transgrid will continue to test, trial, prove and implement innovative technologies and non-network solutions that can deliver efficiency, unlock extra transmission capacity on our network and keep costs as low as possible for NSW consumers.

49 Transgrid and Lumea, Wallgrove Grid Battery Knowledge Sharing, Flagship Report

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3.2 Emerging opportunities for non-network solutions

Our planning studies show that non-network solutions can help to maintain voltage stability, support system security and ensure power flows on transmission lines and equipment stay within their ratings.

Table 3.1 presents the emerging constraints and requirements where non-network solutions may be able to usefully support Transgrid's network during the next 10 years. For each project, Transgrid has sought (or will seek) expressions of interest from the market as part of, or alongside, the Project Specification Consultation Report (PSCR) for the specific RIT-T.

Both NER Clause 5.12.2(c)(4) and the Transmission Annual Planning Report Guidelines require Transgrid to report the subset of forecast constraints, identified in Chapter 2, where an estimated reduction in future load would defer a forecast constraint for 12 months. This information is included in Table 3.1.

Table 3.1: Emerging opportunities for non-network solutions

Project	Network need or constraint	Constraint date	RIT-T status	Possible non-network solution/s[50]	Forecast network expenditure ($2024/25)[51]
Maintaining voltage levels in the Beryl area	Voltage constraint	2025	Project Assessment Draft Report to be published 2025	Demand management reduction (up to 30 MW); or Dynamic reactive support up to 50 MVAr (e.g. grid-scale BESS)	Total Augex[52] ~$34 m Annual deferral value ~$1.2 m
Increasing capacity for generation in the Wagga Wagga North area	Thermal constraint	2025	Project Assessment Draft Report to be published in 2025	Demand Management and/or Energy storage as a service	Total Augex ~$13 m
Increase capacity for generation in the North West Slopes area	Thermal constraint	2025	TBD	Energy storage as a service	TBD
Increase capacity from Port Macquarie to Taree	Thermal constraint	2025	TBD	Energy storage as a service	TBD
Increase capacity for generation from Parkes to Wellington	Thermal constraint	2025	TBD	BESS to reduce loading on line from Parkes to Wellington	TBD
Meeting system strength requirements in NSW	System strength (Fault current and/or voltage waveform stability)	2028	Project Assessment Conclusions Report published in mid 2025[53]	Synchronous generation; and/or Synchronous condensers; and/or Re-purposing modification or conversion of existing generation; and/or Emerging technologies such as BESS with grid-forming inverters. Refer to Chapter 5	Refer to Project Assessment Conclusions Report, and Chapter 5
Improving voltage control in Southern NSW (Balranald and Kangaroo Valley areas)	Voltage constraint	2028	Project Assessment Draft Report to be published in 2025	BESS to provide dynamic reactive power support	Total Augex ~$15 m

50 Indicative only, other non-network solutions and technologies may also be suitable.
51 Anticipated network investment in the absence of any non-network solutions
52 This value is indicative for a 30 MVA synchronous condenser.
53 Meeting system strength requirements in NSW

Project	Network need or constraint	Constraint date	RIT-T status	Possible non-network solution/s[54]	Forecast network expenditure ($2024/25)[55]
Increase capacity for generation from Wellington to Molong and Orange	Thermal constraint	2028	TBD	BESS to reduce loading on multiple lines in Central West	TBD
Maintaining reliable supply to Vineyard in Sydney's North West	Voltage constraint (Vineyard)	2029	Project Assessment Conclusions Report to be published in 2025	Demand management (reduction up to 195 MW) Dynamic reactive support (up to 240 MVAr)	Total Augex ~$44 m Annual deferral value ~$2.7 m
Meeting demand growth at Vineyard in Sydney's North West	Transformer thermal constraint	2029	TBD	Demand management reduction	TBD
Maintaining reliable supply to Holroyd in Western Sydney	Transformer thermal constraint	2029	TBD	Demand management reduction	TBD
Maintaining reliable supply to Beaconsfield in the Inner Sydney area	Transformer thermal constraint	2029	TBD	Demand management reduction	TBD
Maintaining voltage levels in the Moree area	Voltage constraint	2030	TBD	Demand management Dynamic reactive support	TBD
Meeting demand growth in the Kemps Creek area	Transformer thermal constraint	2032	TBD	Demand management reduction	TBD
Maintaining voltage levels in the North Coast	Voltage constraint	2033	TBD	Demand management Dynamic reactive support	TBD

54 Indicative only, other non-network solutions and technologies may also be suitable.
55 Anticipated network investment in the absence of any non-network solutions

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3.3 Enhancing the efficient implementation of non-network solutions

In March 2025, following a request from Transgrid, the AEMC changed a rule to significantly improve the cost-recovery arrangements for transmission non-network options. This change marks a substantial step forward in ensuring that non-network cost-recovery processes are more predictable and timely. It also provides a mechanism for TNSPs to obtain greater certainty on cost recovery for non-network solutions before finalising contractual commitments with solution providers.

The rule change includes transitional arrangements for this mechanism, applying a materiality threshold while a new AER guideline is developed. Transgrid will engage with the AER with a view to use the new mechanism and process for as many non-network options as possible.

Transgrid continues to explore additional opportunities for the regulatory framework to encourage non-network solutions that benefit consumers. Issues that could be usefully addressed include:

- **Potential lack of transparency on consumer costs:** The current RIT-T Application Guidelines (published in August 2020) clarify that TNSPs should consider the whole-of-market benefits and costs of non-network solutions rather than the anticipated service contract price, which was the previous industry practice. This reduces the visibility and consideration of costs that consumers will actually incur for these services, and their prominence in assessing the preferred RIT-T option.
- **Lack of reasonable TNSP remuneration for delivering non-network solutions:** Significant TNSP resources are required to plan, develop, negotiate, implement and operate non-network solutions. TNSPs do not receive any incentives for implementing non-network options. Remuneration for negotiating, implementing and managing non-network solutions does not suitably compensate for risks retained on the network and the opportunity cost of intellectual property invested.
- **Potential lack of funding for alternative options if suitable non-network solutions cannot be implemented:** If TNSPs are not able to enter into a suitable Network Support Agreement for the non-network solution, depending on the timing of associated decisions, a regulatory allowance may not be available to deliver an alternative network capital project to meet the identified need. Consumers may miss out on the benefits identified in the RIT-T. For example, Transgrid has no regulatory allowance for network investments as a fall-back or contingent alternative to current non-network solutions for implementation during the 2023–28 revenue period.
- **Definition of non-network**: Given the significant shifts in the energy market since the current regulatory framework was introduced, the definition of what is classified as a non-network option needs to evolve.
- **Materiality thresholds for ex ante reviews:** The AEMC's transitional rules currently include a materiality threshold that annual contract payments must exceed 1% of a TNSP's unsmoothed revenues to be eligible for the AER's ex ante assessment. If this threshold was to be set permanently within the AER's upcoming guideline, a significant proportion of potential non-network options would be excluded from the new framework. This may stifle innovation and increase cost recovery risks for smaller value contracts.

Transgrid is consulting with stakeholders to assess the remaining potential barriers and canvassing options to resolve them either through the existing regulatory framework or via further regulatory reform.

Monitoring power load on the NSW network

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Transgrid

3.4.1 How we support our generation and load customers

Generators, like solar and wind farms, and large-load customers, like data-centres (see Section 4.2.2), require direct connection to the grid. Direct connection gives these customers access to the higher reliability, redundancy and system strength offered by the transmission network.

We encourage generators and large-load customers to engage with Transgrid early so we can plan the network to deliver the best outcomes for the community and maximise plant utilisation.

Collaboration and support every step of the way

Transgrid facilitates the connection of generation and energy storage facilities to the transmission network. Our goal is to support customers to achieve connection as quickly and efficiently as possible. We work with customers to achieve their connections in line with typical average timeframes reported in AEMO's Connections Scorecard.

Transgrid's contestable arm, Lumea, is Australia's most experienced connections provider, with a portfolio of more than 55 projects totalling 14 GW. Lumea plays a key role in accelerating Australia's energy and decarbonisation transition by connecting renewable generators and large energy users to the transmission grid. This includes building, owning, operating and maintaining critical energy and telecommunications infrastructure to keep customers connected and generating power reliably.

We are also contributing to further initiatives for improving the connections process, and opportunities to connect more renewables, including:

- The Connections Reform Initiative
- The Streamlined Connections Process
- NSW Priority Battery Energy Storage System (BESS) Project Program
- Batch processing for connections in REZs
- Transmission expansion options
- Unlocking hosting capacity.

Rich data from the Transgrid Connection Opportunities Portal

Transgrid supports generation and storage proponents with the data they need to make informed investment decisions. Choosing where to connect to the network depends on many factors, including project size, technology type, timing and the strength and capacity of the local transmission system.

To help proponents make their own risk and investment determinations, we've developed the Transgrid Connection Opportunities Portal, powered by Rosetta – an interactive data visualisation and mapping tool that gives proponents direct access to spatial and temporal insights about the NSW transmission network.

The Portal supports connection proponents in their early-stage planning by providing clear, detailed information on transmission infrastructure and system conditions. This includes transmission lines, substations, Renewable Energy Zones and network capacity.

The Portal information, some which can also be found in this document, includes:

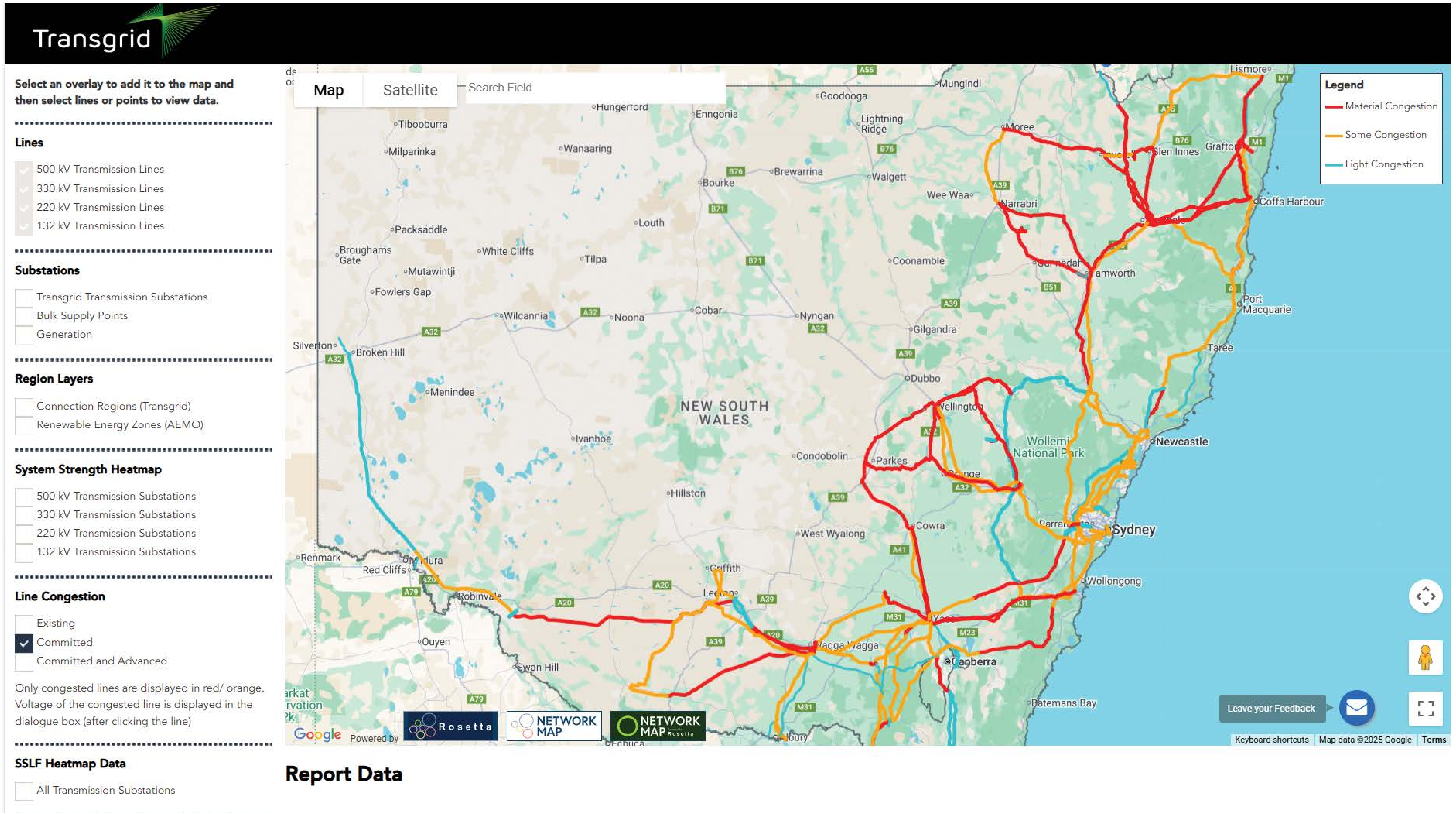
- Map overlays – visualise transmission lines and substations (Section 2), and Bulk Supply Points (Section 4.3)
- System strength heatmaps – understand the robustness of different grid locations (Section 5)
- Line congestion insights – identify network constraints early to avoid delays and optimise connection strategies
- Transmission line load profile – download detailed historical load profiles
- Renewable insights – explore renewable energy integration across the network (Section 3.5.2)
- Network Capacity – view available network capacity information for both generation and load
- Transmission line constraints – identify physical or operational limits on key network corridors to avoid bottlenecks and plan more efficient connection pathways. (Appendix 4)

With this rich data set, proponents can assess risk, compare location options and better justify their investment decisions.

The Portal is part of our broader commitment to transparency and collaboration – helping our customers plan with confidence and contribute to a faster, more coordinated transition to a low-carbon grid.

To obtain project-specific information about what can be connected to Transgrid's network, the formal connection process must be followed, starting with a connection enquiry. We review each enquiry on an individual basis, taking into account the technical specifications of the proposed connection, in accordance with the National Electricity Rules.

Figure 3.1: Existing line congestion visualisation example from the Transgrid Connection Opportunities Portal



Technical advice

All new network connections to Transgrid's transmission line infrastructure are via a purpose built "loop-in loop-out" switching station located as close as possible and not further than 1 km away from the proposed point of "cut-in" on the transmission line infrastructure. Transgrid recommends a direct connection to an existing substation, where the proposed point of "cut-in" on the transmission line infrastructure is within 10 km of that substation. Such a direct connection may present significant benefits compared to the proposed transmission line "cut-in".

3.4.2 Renewable connections summary

Renewable energy interest in connecting to Transgrid's transmission network has increased since the Transmission Annual Planning Report 2024. A high level of connection enquiries and connections are in various stages of development. Importantly, BESS and hybrid installations are opening previously congested areas, enabling more generators to connect to the transmission network.

Battery energy storage enquiries and connections have increased dramatically since the previous year. Hybrid installations, with renewable generation and energy storage sharing a single connection point, have started to increase in frequency and in size.

Since Transmission Annual Planning Report 2024, more renewable generation proponents have signed connection agreements. We have incorporated these agreements in our planning review as committed generation, which now includes:

- 450 MW of solar
- 270 MW of wind
- 1,395 MW of BESS
- 2,000 MW of hydro with doubly fed induction generator and synchronous technology.

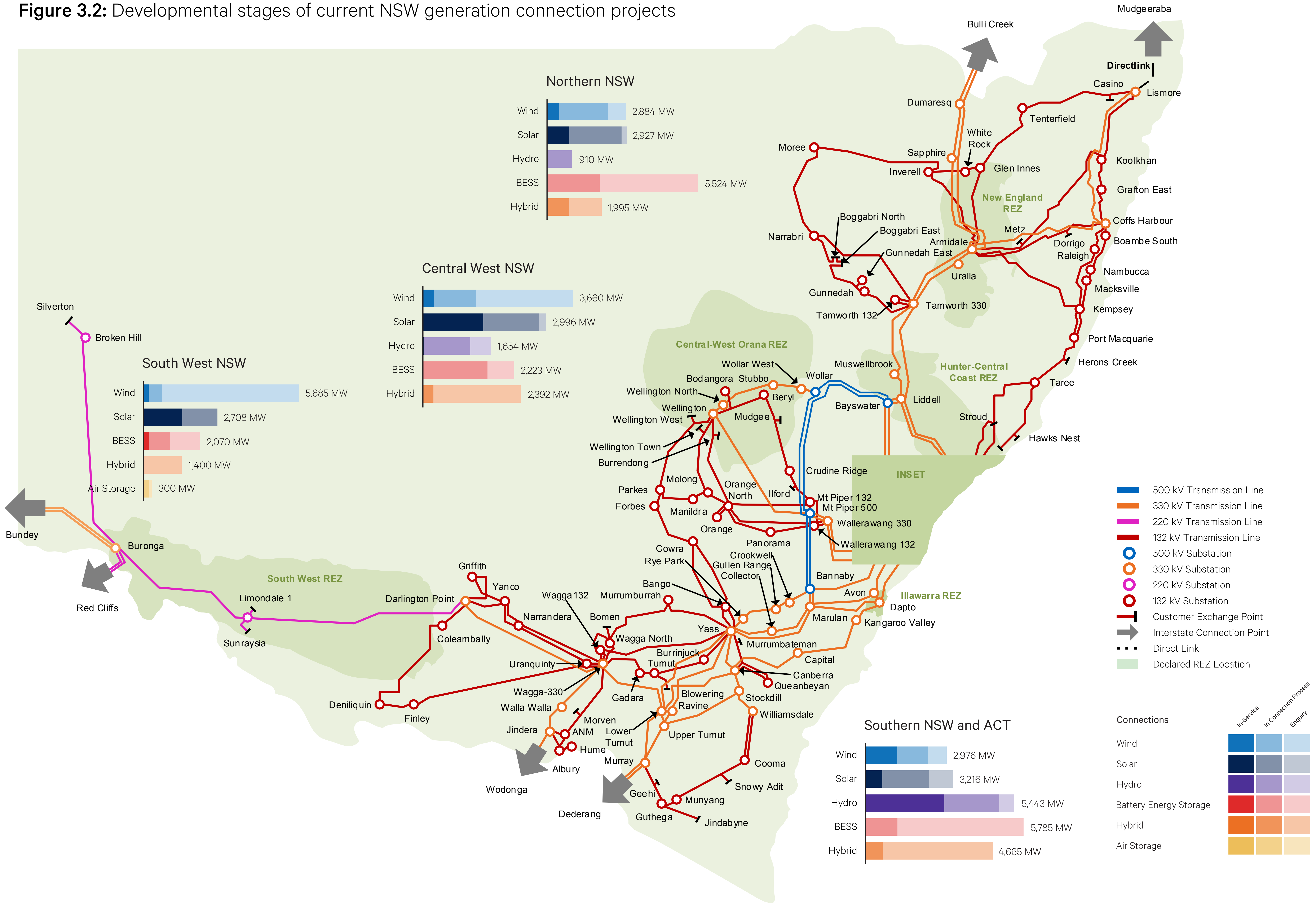
Since Transmission Annual Planning Report 2024, we have had:

- 14 connection applications totalling 2.7 GW
- 6 connection registrations totalling 2 GW
- 5 connections commissioned totalling 1.9 GW.

We expect more solar, wind, battery energy storage and pumped hydro generation proponents to sign connection agreements over the next 12 months, as projects advance through the connection process.

Figure 3.2 shows the developmental stages of current NSW generation connection projects.

Figure 3.2: Developmental stages of current NSW generation connection projects



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3.5 Changes from the Transmission Annual Planning Report 2024

Updates in this chapter and referenced Appendices since the Transmission Annual Planning Report 2024 include:

- Network support opportunities have been updated (see Table 3.1)
- Maintaining reliable supply to the Broken Hill during negative demand project is progressing, with the preferred option to install resistor banks
- Maintaining reliable supply to Western Sydney has concluded the RIT-T with the preferred option to install an additional transformer
- Maintaining voltage levels in the Alpine area (Williamsdale or Cooma areas) has been deferred based on the latest demand forecast and a new proposed connection in the region
- Maintaining reliable supply to Sydney East is no longer required based on the latest demand forecast
- Five new network support opportunities have been included (see Table 3.1)
- Final rule change determination published by the Australian Energy Market Commission for 'Improving the cost recovery arrangements for Transmission non-network options'

Leo Robens – Transmission Line Apprentice
Ryan Bourne – Transmission Line Apprentice
Will Clifton – Transmission Line Technician

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Rod Pomfrett – Substation Technician

Forecast assumptions

What's happening inside our transitioning energy system as we move into an intense new phase.

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Our forecasts in this Report paint a picture of a growing, electrifying NSW economy powered by clean energy. They map what happens as NSW changes how, where and when energy is used and generated, with peak demand growing higher and minimum demand falling faster than previously projected. They also highlight the increasing pressure these factors put on the grid. Greater variability, more complexity and uncertainty all point to a sharper need for coordinated investment to maintain reliability as we move deeper into the energy transition.

This chapter describes our inputs and assumptions, and changes since the 2024 Report. It includes minimum and maximum demand, and energy use projections, based on data from our specialist input forecasters.

The impact of Australia's electrifying economy is projected to increase NSW Region summer maximum demand and energy by 1.4% and 1.9% per annum, respectively, driven by steady economic growth and bolstered by electric vehicle charging and new data-centre connections.

The average price of electricity effectively fell in 2025 due to the Energy Bill Relief Fund. Prices are expected to rise again once this program comes to an end. In the long term, we are not anticipating any significant slowing of electrification due to the cost of electricity.

We are expecting data-centre loads to grow significantly in western Sydney and parts of the Ausgrid network. NSW network service providers are currently considering around 10 GW of connection enquiries from various data-centre projects. Even if a fraction of that capacity goes ahead, it will add significant load to the network.

Other major load sources, including renewable hydrogen production, are now projected to be relatively modest before the mid-2030s. We are following AEMO's revised Integrated System Plan assumptions and allowing for much lower renewable hydrogen production than in previous load forecasts.

Consumer energy resources (rooftop solar and batteries) and electric vehicle (EV) adoption continue to grow rapidly. Increasing rooftop solar capacity, uptake of small batteries and EV charging have the potential to increase demand variability and, if coordinated well, may contribute to demand smoothing.

The growing use of household solar means weather will have a greater effect on network demand. On clear sunny days with low average temperatures, households will need very little energy from the grid. But network demand will increase on cloudy days, or days with extreme temperatures.

For the first time, we are predicting minimum demand will fall to zero by the early 2030s. Network minimum demands are falling rapidly in all seasons, but minimum demand is most likely to occur in late spring.

Line stringing 500 kV towers at Muswellbrook NSW

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4.1 Key highlights

Transgrid

4.1.1 Summary of energy and demand projections

Table 4.1 summarises projected growth in NSW Region energy and demand and compares it to equivalent Transmission Annual Planning Report 2024 projections.

Table 4.1: NSW Region medium-scenario energy and demand (compound average annual growth rates)

	Historical growth*	Projected growth**	2024 TAPR equivalent
Annual energy	-0.5%	1.9%	1.1%
Summer maximum demand (50POE)	-0.3%	1.4%	1.5%
Winter maximum demand (50POE)	0.8%	1.5%	1.7%
Minimum demand (50POE)	-12.7%	High negative growth	Low negative growth

*Historical period 2020 to 2024 (2020/21 to 2024/25 for annual energy and summer maximum demand)
**Projection period 2025 to 2034 (2025/26 to 2034/35 for annual energy, summer maximum demand)

Table 4.2 highlights significant changes between the current projections and those in the Transmission Annual Planning Report 2024.

Table 4.2: Major changes since the Transmission Annual Planning Report 2024

	Difference	Effect
Data-centres will make a large contribution to energy and demand growth	6,723 GWh more by FY35 (compared with 307 GWh due to new data-centres included in major loads in TAPR 2024)	Growth in data-centre loads more than compensates for lower projected hydrogen electrolyser capacity. Since data-centres are assumed to operate at almost constant load, their growth will increase annual energy, and maximum and minimum demands in the network.
Lower **hydrogen** electrolyser capacity expected to be connected later	817 GWh by FY35 (compared to over 5,300 GWh in TAPR 2024)	Renewable hydrogen is assumed to use energy from the grid, boosting annual energy. Because renewable hydrogen production needs to run as much as possible to be cost effective, electrolysers will help reduce midday minimum demand. But they won't fully shut down during peak times, so they may increase summer and winter maximum demands.
Higher **consumer energy resources** (rooftop solar generation, small-scale battery operation and EV charging)	Increases of 5,153 GWh of EV charging and 319 GWh of net small battery charging will be more than offset by an increase of 9,774 GWh in small solar generation by FY35 (all significantly higher than forecast in TAPR 2024)	The net impact will lower grid energy use, slightly reduce peak demand and speed up the fall in minimum demand. Our forecasts assume charging in the late mornings and discharging during evening peaks. However, this depends on the right tariffs and policies being introduced.
The average **price of electricity** effectively fell in 2025 due to the Energy Bill Relief Fund and is generally expected to rise again once this program comes to an end	Annual growth in average real electricity prices of 1.9% per annum to FY35, with most growth in the first year (compared with 0.8% in TAPR 2024)	This rate of increase in the real electricity price would, in isolation, reduce energy consumption by up to 0.9%. However, the price impact will be more than offset by the impact of economic and population growth, growing electrification, and by major load increases (including data-centres) that do not respond to short-run price movements.
Minimum demand is projected to fall more rapidly than in TAPR 2024, largely because of updated modelling using more recent data	Minimum demand is expected to fall faster than in previous forecasts. It will most likely reach zero between 2030 and 2033. Late spring is the most likely time.	Falling minimum demands and rising maximum demands have serious implications for grid management. When demand is very low, or zero, it becomes harder to keep the power system stable. Key challenges include voltage control, system strength and managing excess supply.

4.2 NSW Region projected energy and demand

4.2.1 Introduction

Demand forecasting is critical because it helps us plan the future network. This section shows our 10-year demand projections for NSW under three scenarios: Medium growth (the most likely scenario), High growth and Low growth. We also explain the main findings, sources and assumptions behind the projections.

4.2.2 Inputs and assumptions

Like AEMO's Electricity Statement of Opportunities and Integrated System Plan, our forecasts assume that Australia will put measures in place to achieve its 2030 and 2050 net zero commitments. These measures include the Federal Government's Small-scale Renewable Energy Target and the Large-scale Renewable Energy Target, and state government environmental and energy programs and policies. We expect these policies will result in steady increases in renewable generation and less coal-fired power generation.

This year, our specialist input forecasters are:

- Oxford Economics – providing population and economic forecasts
- Jacobs – providing electricity price, rooftop solar and battery projections
- Energeia – providing projections of EV adoption.

Each forecast is aligned as closely as practical to AEMO's Integrated System Plan scenarios of Step Change (Transgrid Medium), Green Energy Industries (Transgrid High) and Progressive Change (Transgrid Low).

Population and economic growth

Last year's expected interest rate cuts arrived a little later than projected in the Transmission Annual Planning Report 2024, but inflationary pressures have moderated, and dwelling construction is resuming as expected. As a result, and despite the headwinds of potential US tariffs, economic forecasts are similar to those in our 2024 Report.

Given uncertainty around global economic growth, and the expectation that inflation falls within the Reserve Bank's (RBA) target band of 2-3%, we expect the RBA to cut rates through 2025 and into 2026. The result will be a very strong rebound in dwelling construction. Lower inflation and real wage rises, combined with continuing low unemployment, will encourage a gradual pick-up in consumer demand. Growth in business and public investment, tempered by the potential impacts of the trade war, will remain modest. Meanwhile, population growth, which was above 2% in the past two years will slow sharply to 1.3% in FY25 and around 1.2% over the FY26-31 period, reducing the contribution to economic growth from population increments.

Electricity prices

In FY25, the average price of electricity effectively fell by more than 20%. However, this was due to Commonwealth Government subsidies to households and small businesses through the Energy Bill Relief Fund. When this program comes to an end, an abrupt increase in prices is expected. Our consultant Jacobs has advised that prices are expected to continue to increase for the remainder of the projection period, although at a more moderate rate – mainly due to the impact on wholesale prices when coal-fired generators retire. We do not expect higher prices to deter electricity consumption.

Rooftop solar and batteries

Rooftop solar, batteries and EV adoption are growing faster than projected in Transmission Annual Planning Report 2024. EV charging is expected to add nearly as much demand as power-hungry data-centres. The net impact of rooftop solar and battery and vehicle charging will be a reduction in network energy consumption and slight reduction in summer maximum demand, which increasingly occurs in the early evening. In winter, maximum demand will rise a little, as most EV charging will happen outside the evening peak. More solar generation during the middle of the day will continue to push minimum demand lower.

Large industrial and mining loads

In line with projections in our Transmission Annual Planning Report 2024, existing, committed and advanced large industrial and mining loads (i.e., excluding data-centres and renewable hydrogen production) are expected to increase slightly over the next 10 years.

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Renewable hydrogen

We have revised down our expectations for renewable hydrogen growth, based on AEMO's Integrated System Plan draft stage 2 inputs. Slower project progress and unfavourable economics are key factors.

Data-centres[56]

Our data-centre projections are partly drawn from a briefing paper commissioned from Cutler Merz, which looks at global trends in data-centre demand, electricity consumption and the likelihood of individual projects in NSW proceeding.

The paper found that demand for traditional and cloud data-centres is rising fast, driven by cloud adoption and more data-intensive content. Global data use has already nearly tripled since 2019. But now the rise of AI means data-centre demand and energy use are expected to soar.

To date, data-centre energy use has been kept under control by more efficient hardware, smarter cooling systems and better use of computing resources. Between 2010 and 2018, compute instances rose by 550%, while energy use only increased by about 6%. But this is likely to change. AI training workloads require larger, more power-hungry computer chips with cooling requirements beyond the capacity of traditional air-based cooling systems. Also, load patterns for AI-optimised data-centres are likely to be different from those of cloud data-centres.

We don't exactly know how many new data-centres will be built in Australia, or how many will be AI-optimised. Many large projects are targeting Western Sydney. Lower operating costs and strong network connectivity – including the highest number of international submarine internet cables – make Sydney a preferred location.

To forecast data-centre load, we examined data-centre projects that would require network capacity of more 10,000 MW over the next 10 years, considering:

- **The possibility of a single project lodging multiple connection enquiries.** While exploring possible locations and economic options, data-centres are likely to submit multiple network connection enquiries.
- **The likelihood of proceeding, due to long-term AI demand uncertainty.** Demand for AI compatible data-centres has surged, particularly in the US, where major investments are proposed. But long-term demand for AI services remains uncertain due to their high energy use. Also, even if these data-centres begin to appear in Australia, the likelihood of proceeding may be lower than for traditional data-centres.
- **Overestimation of data-centre size.** Based on previous connections, data-centre developers tend to overestimate how quickly the data-centre will be filled. In most cases, it can take over a decade for a data-centre to become fully utilised.

To account for these factors, we adjusted connection enquiry information to:

- Remove dormant enquiries with no communication for more than year and enquiries deemed unlikely to proceed
- Remove likely duplicates from the same developer
- Apply probabilities to projects in progress (85% High, 55% Medium and 30% Low)
- Apply 10% to all other projects at the enquiry stage
- Assume 20% of demand will come online in the first year, with a 20-year ramp rate for the remaining capacity
- Assume a construction timeframe of at least three years

4.2.2.1 Summary of load forecasting inputs and assumptions

Table 4.3 shows per cent changes in model inputs compared to Transmission Annual Planning Report 2024.

Table 4.3: Inputs and assumptions summary (Medium scenario)

Model inputs	2025 TAPR	2024 TAPR
	Average annual % change 2025/26 to 2034/35	
Population	0.8	1.0
State Final Demand	2.3	2.3
Real retail electricity price	1.9	0.8
Real retail gas price	0.1	0.8
Consumer price index	2.7	2.5
Consumer Energy Resources and transport	**Increase 2025/26 to 2034/35**	
Small solar installed MW	7,341	6,632
Small batteries installed MW	2,027	1,542
EV annual charging GWh	5,153	4,615
Specific loads	**Increase 2025/26 to 2034/35**	
Large industrial and mining loads GWh	322	367
Hydrogen production loads GWh	817	5,282
Large data-centre loads GWh	6,723	0#

Note: # Large data-centre loads in 2024 Transmission Annual Planning Report were included in Large industrial and mining loads

56 Just prior to this document going to the publisher, we have had information on a few more data-centre projects signing connection applications with Transgrid. These are, however, not included in the Cutler Merz data-centre forecasts. Hence it is likely that additional data-centres will push our load forecasts upwards towards the latter part of the 10-year forecast horizon. We will continue to monitor the dynamic data-centre environment and, if required, update our load forecasts in due course.

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4.2.3 Annual energy projections

Figure 4.1 and Table 4.4 show recent and projected annual NSW Region energy sent out.

Projected energy growth has increased since AEMO revising down the historical annual energy sent out for recent years. This caused the starting point for our 2025 energy projections to be below that of our 2024 Report, affecting projected growth rates.

Figure 4.1: Actual and projected NSW Region annual energy sent out

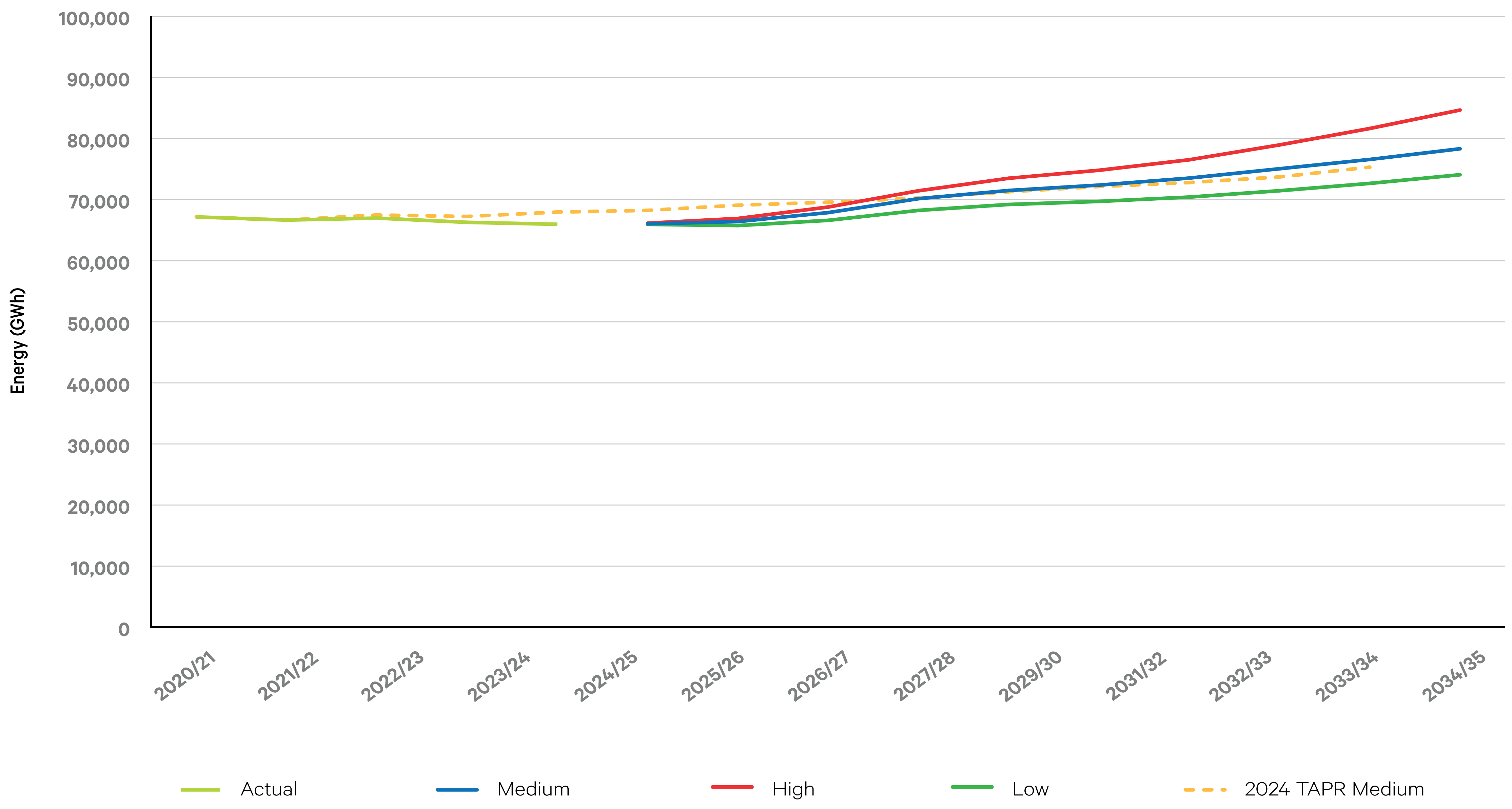

Table 4.4: NSW Region annual energy sent out (GWh)

	Actual	Medium	High	Low
2020/21	67,173			
2021/22	66,658			
2022/23	66,979			
2023/24	66,285			
2024/25	65,970			
2025/26		66,040	66,150	65,950
2026/27		66,410	66,920	65,760
2027/28		67,880	68,790	66,610
2028/29		70,160	71,450	68,240
2029/30		71,500	73,500	69,210
2030/31		72,380	74,810	69,710
2031/32		73,530	76,530	70,420
2032/33		75,060	78,960	71,460
2033/34		76,580	81,650	72,660
2034/35		78,330	84,670	74,080
CAGR: 2025/26 to 2034/35		1.9%	2.8%	1.3%

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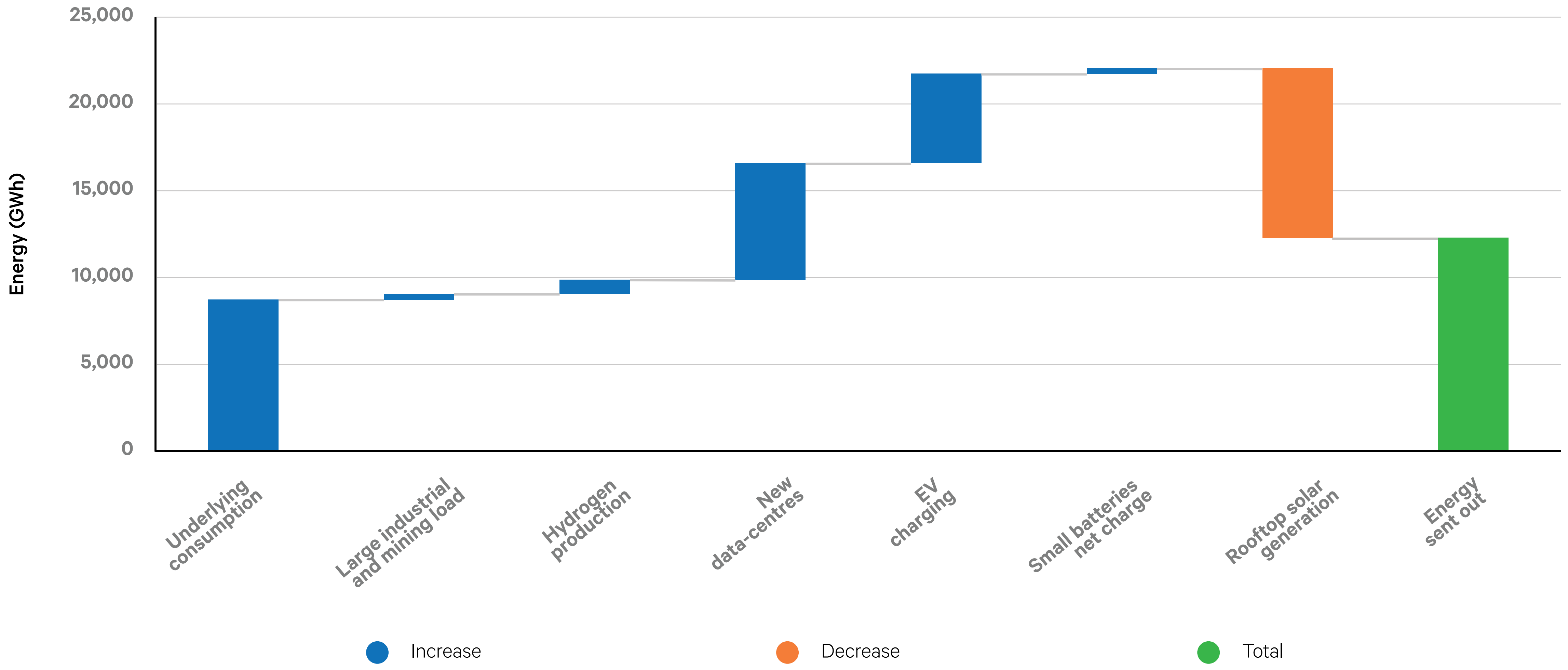
The main drivers of change are:

- Rapidly growing small-scale rooftop solar generation being used instead of network-supplied power
- Growth in household battery adoption
- Underlying intrinsic growth due to increased population and income
- Growing electrification, partially offset by increasing real electricity costs and energy efficiency
- New data-centre loads, with a potential to exceed expected growth in EV charging
- EV charging, with the growing adoption of plug-in battery electric vehicles
- Delayed beginning of Australia's renewable hydrogen industry
- The expansion of traditional mining loads

These changes are illustrated in Figure 4.2.

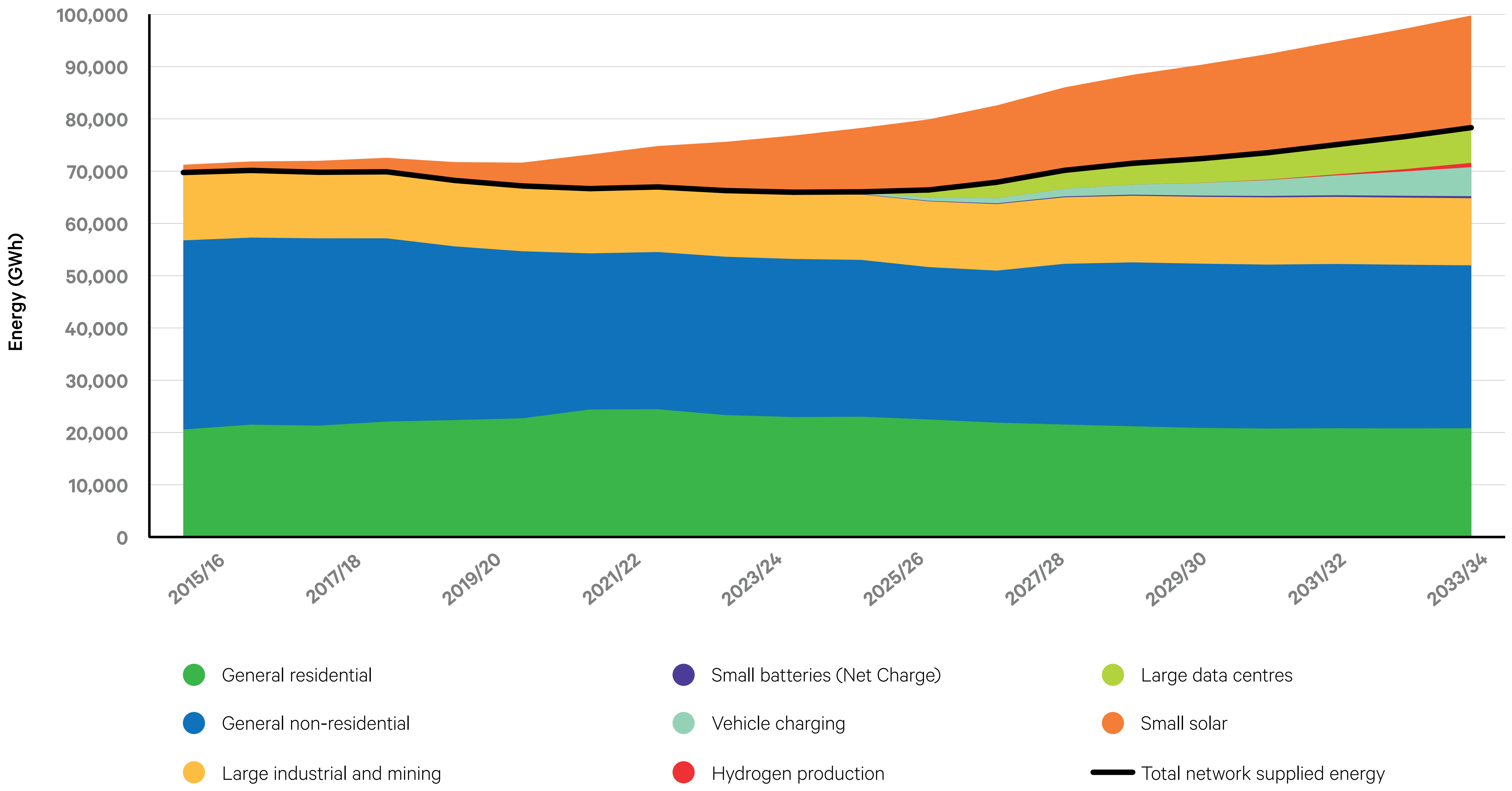
Figure 4.2: Contributions to change in energy sent out FY26 to FY35



Composition of future network energy

Figure 4.3 shows that the recent decline in the proportion of energy used by the residential sector will continue, with the general non-residential load remaining relatively flat. The largest increases will come from new data-centres and EV charging. Without small-scale rooftop solar adoption, NSW Region energy sent out would potentially be 20,000 GWh higher.

Figure 4.3: Composition of NSW Region annual network energy consumption (GWh)



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4.2.4 Summer maximum demand projections

Figure 4.4 and Table 4.5 show recent and projected NSW Region summer as generated maximum demand.

Projected demand is generally lower than in the 2024 Transmission Annual Planning Report but growing at the same average rate.

Figure 4.4: Actual and projected NSW Region 50% probability of exceedance (POE) summer as generated maximum demand

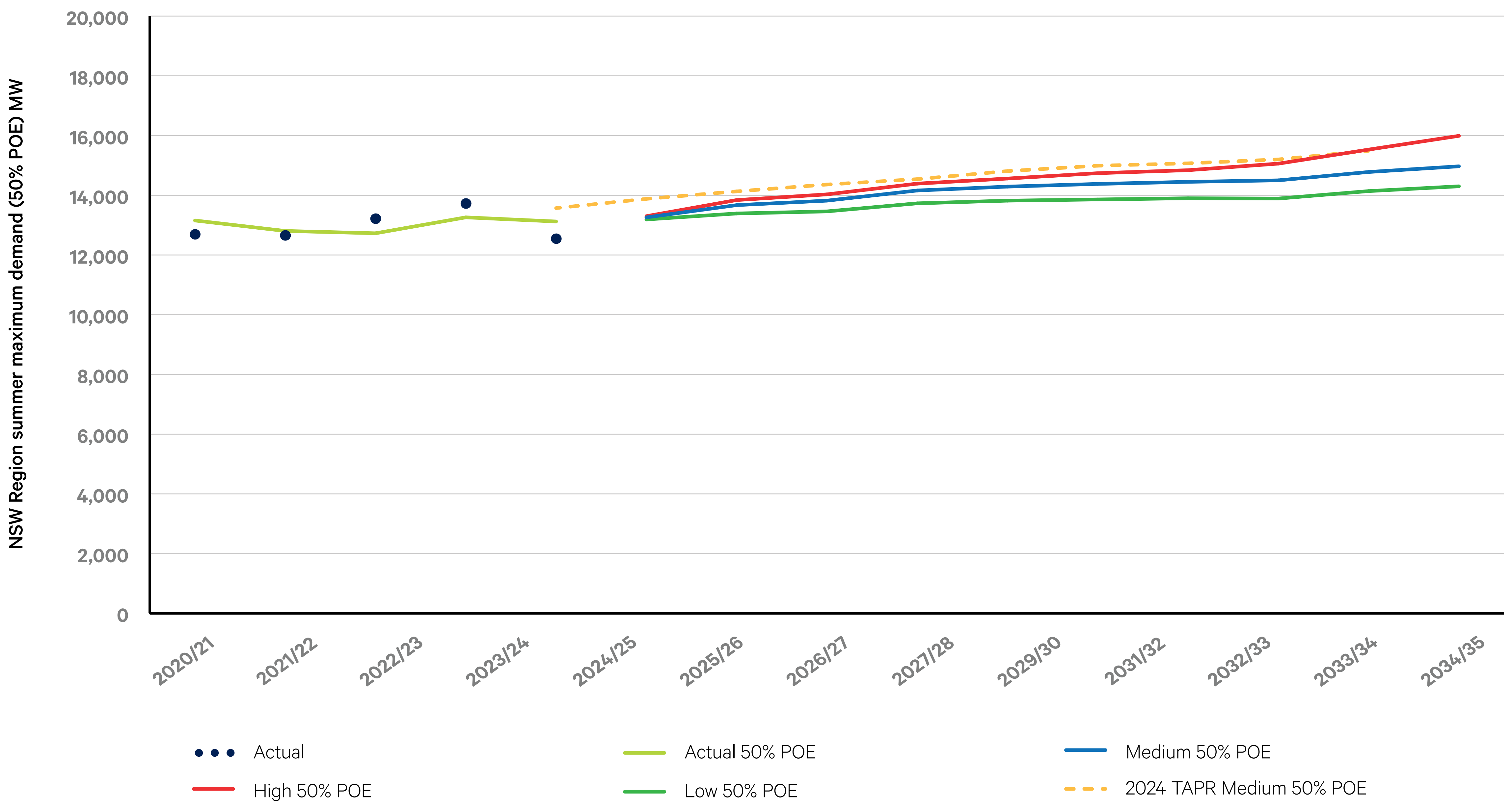

Table 4.5: NSW Region as generated summer maximum demand (MW)

	Actual	Medium			High			Low		
		10% POE	50% POE	90% POE	10% POE	50% POE	90% POE	10% POE	50% POE	90% POE
2020/21	12,692	13,901	13,155	12,499						
2021/22	12,656	13,529	12,805	12,208						
2022/23	13,216	13,371	12,727	12,175						
2023/24	13,723	13,840	13,260	12,663						
2024/25	12,546	13,724	13,122	12,542						
2025/26		13,870	13,260	12,680	13,910	13,300	12,720	13,800	13,190	12,600
2026/27		14,310	13,670	13,100	14,450	13,840	13,270	14,020	13,390	12,780
2027/28		14,540	13,820	13,300	14,730	14,030	13,540	14,230	13,460	12,910
2028/29		14,860	14,160	13,590	15,100	14,390	13,840	14,470	13,730	13,130
2029/30		14,990	14,290	13,580	15,260	14,560	13,890	14,570	13,820	13,110
2030/31		15,160	14,380	13,790	15,490	14,740	14,140	14,650	13,860	13,250
2031/32		15,250	14,450	13,820	15,640	14,840	14,260	14,720	13,900	13,250
2032/33		15,320	14,500	13,900	15,820	15,060	14,490	14,750	13,890	13,260
2033/34		15,580	14,780	14,180	16,310	15,530	14,880	14,950	14,140	13,460
2034/35		15,750	14,970	14,330	16,820	15,990	15,340	15,170	14,300	13,620
CAGR: 2025/26 to 2034/35			1.4%			2.1%			0.9%	

Significant drivers of change are:

- Average demand rising due to population growth and increasing temperatures
- New data-centre, mining and renewable hydrogen loads (later in the forecast period)
- A small amount of rooftop solar generation late in the day, partially offsetting network demand
- Evening peak demand being controlled by incentives to move EV charging to other times
- Stored battery energy powering homes in the early evening, partially offsetting maximum demand.

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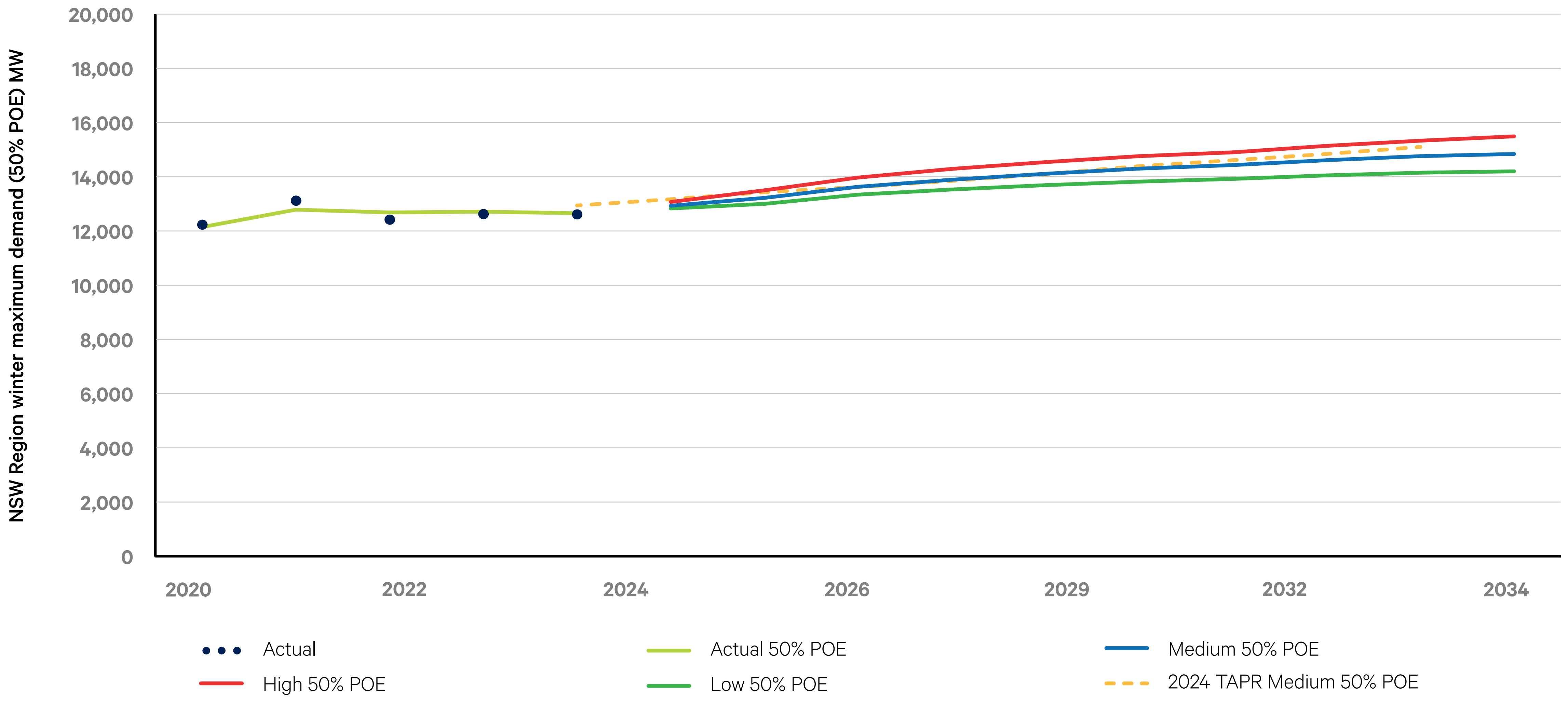
4.2.5 Winter maximum demand projections

Figure 4.5 and Table 4.6 show recent and projected NSW Region winter as generated maximum demand.

Projected demand is generally at a similar level to the 2024 Transmission Annual Planning Report but growing at a slightly lower average rate.

Figure 4.5: Actual and projected NSW Region 50% POE winter as generated maximum demand



The largest drivers of change are:

- Average demand rising due to population growth and increasingly mild temperatures
- New data-centre, mining and renewable hydrogen loads (later in the forecast period)
- Evening peak demand being controlled by incentives to move EV charging to other times
- Stored battery energy powering homes in the early evening, partially offsetting maximum demand.

Table 4.6: NSW Region as generated winter maximum demand (MW)

	Actual	Medium			High			Low		
		10% POE	50% POE	90% POE	10% POE	50% POE	90% POE	10% POE	50% POE	90% POE
2020	12,233	12,447	12,144	11,862						
2021	13,117	13,133	12,785	12,490						
2022	12,418	13,049	12,683	12,381						
2023	12,623	13,020	12,712	12,398						
2024	12,612	12,988	12,653	12,346						
2025		13,260	12,930	12,620	13,410	13,070	12,750	13,150	12,830	12,510
2026		13,540	13,220	12,890	13,830	13,500	13,160	13,320	13,000	12,680
2027		13,960	13,630	13,330	14,310	13,970	13,660	13,660	13,340	13,050
2028		14,240	13,890	13,540	14,650	14,290	13,920	13,870	13,530	13,180
2029		14,470	14,110	13,790	14,910	14,540	14,200	14,040	13,690	13,370
2030		14,640	14,300	13,970	15,120	14,760	14,430	14,160	13,820	13,510
2031		14,790	14,430	14,120	15,280	14,900	14,600	14,260	13,920	13,610
2032		14,960	14,610	14,260	15,510	15,140	14,770	14,380	14,050	13,710
2033		15,110	14,760	14,440	15,710	15,330	14,990	14,490	14,150	13,850
2034		15,200	14,840	14,510	15,870	15,490	15,140	14,540	14,200	13,880
CAGR: 2025 to 2034			1.5%			1.9%			1.1%	

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Maximum demand in All Seasons

Figure 4.6: Actual and projected NSW Region 50% POE maximum demand by season

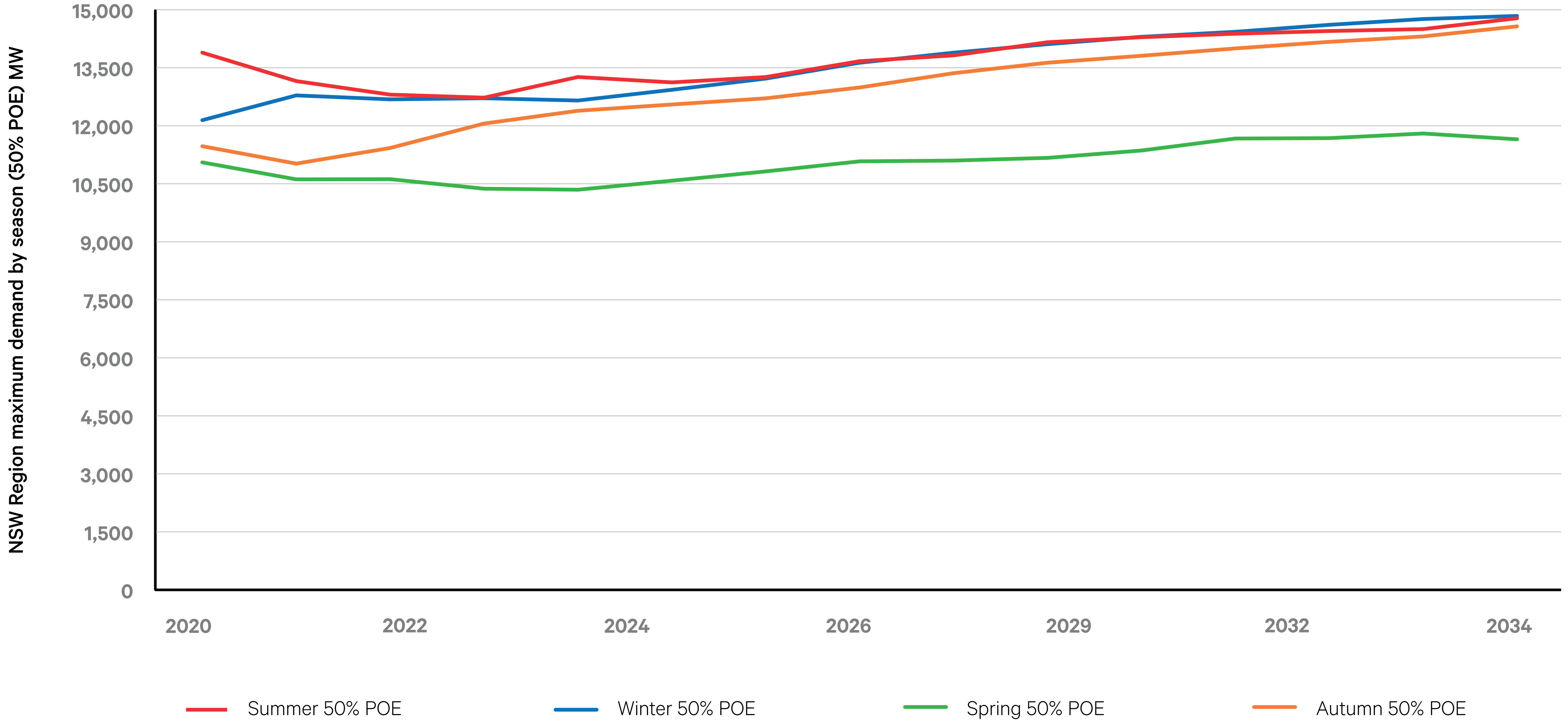

Figure 4.6 shows our projections for 50% POE maximum demand by season. Over time, maximum demands in all seasons (except spring) converge as:

- Summer grid maximum demand moves increasingly towards late evening and is flattened by the proliferation of household batteries
- Winter grid maximum demand grows due to additional data-centre loads but is also offset by battery discharge
- Autumn grid maximum demand grows due to higher average temperatures extending into autumn months and moderate rooftop solar output
- Spring maximum demand is the lowest due to lower average temperatures and very high rooftop solar output

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4.2.6 Minimum demand projections

Projected demand is much lower than in the 2024 Transmission Annual Planning Report, largely due to model revisions using recent rooftop solar and demand data. Minimum network demand is now projected to become negative sometime in the early 2030s. It is unlikely that all NSW power will be exported to other NEM regions and so very low demands may be accommodated – at least in part – by large grid-scale battery charging.

Figure 4.7 and Table 4.7 show recent and projected NSW Region as generated minimum demand.

Figure 4.7: Actual and projected NSW Region 50% POE spring as generated minimum demand

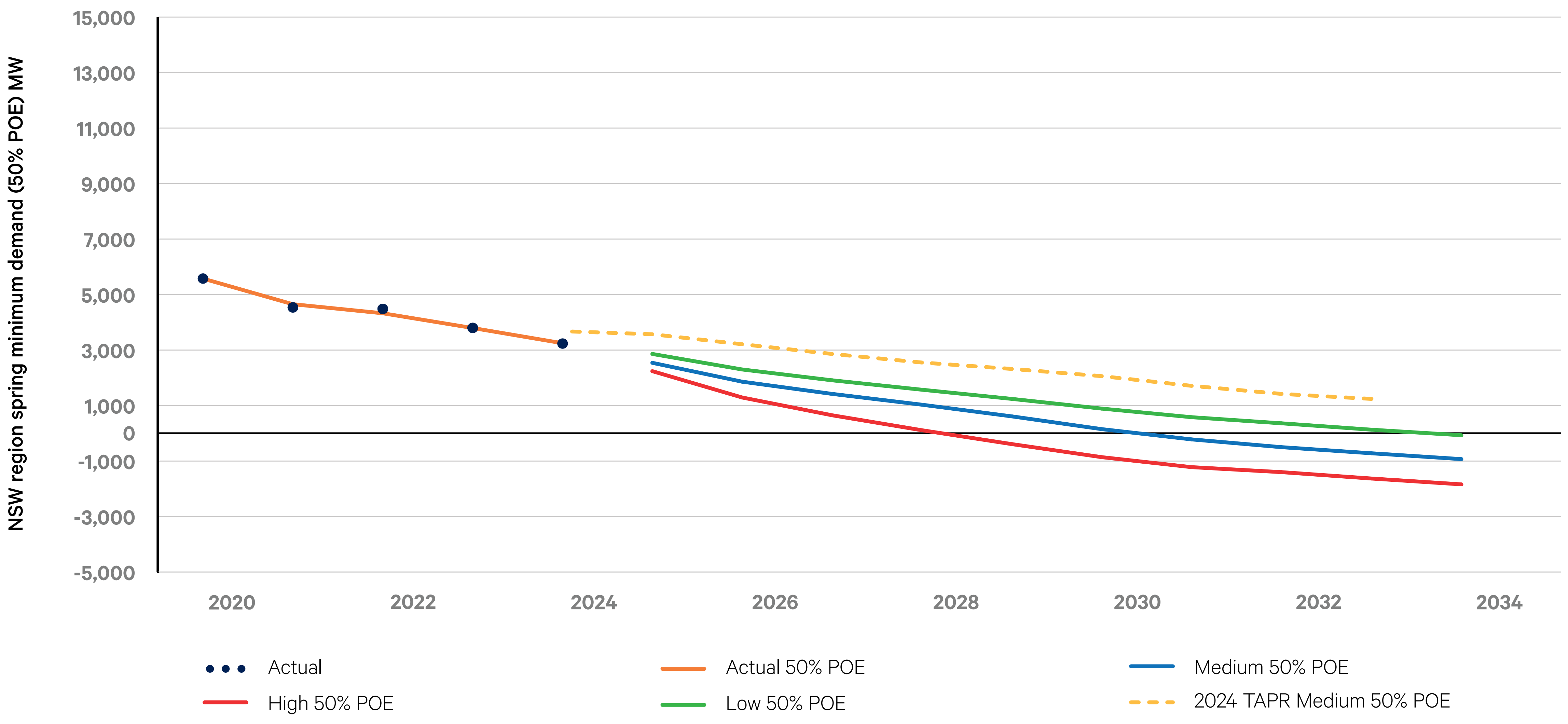

Table 4.7: NSW Region as generated spring minimum demand (MW)

	Actual	Medium			High			Low		
		10% POE	50% POE	90% POE	10% POE	50% POE	90% POE	10% POE	50% POE	90% POE
2020	5,577	5,474	5,577	5,719						
2021	4,537	4,520	4,653	4,818						
2022	4,483	4,139	4,327	4,580						
2023	3,799	3,589	3,796	4,050						
2024	3,234	2,911	3,248	3,593						
2025		2,160	2,540	2,930	1,850	2,240	2,660	2,510	2,860	3,230
2026		1,410	1,860	2,360	810	1,290	1,850	1,890	2,300	2,770
2027		920	1,420	1,940	100	650	1,230	1,450	1,910	2,400
2028		520	1,030	1,560	-470	110	690	1,100	1,570	2,060
2029		10	610	1,180	-1,090	-390	230	690	1,240	1,780
2030		-440	150	840	-1,540	-860	-100	330	890	1,520
2031		-850	-220	450	-1,930	-1,220	-460	20	580	1,190
2032		-1,170	-500	140	-2,180	-1,400	-700	-220	360	950
2033		-1,450	-720	-50	-2,460	-1,630	-890	-500	130	760
2034		-1,650	-930	-170	-2,660	-1,840	-1,010	-700	-70	640

The largest drivers of change are:

- Above all, the rapid uptake of rooftop solar, so households don't need to draw power from the network during the middle of the day
- Not enough EV and household battery charging at this time, so solar generation is exported to the grid
- New data-centre, mining and (later in the forecast period) renewable hydrogen loads partially offset minimum demand.

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Minimum demand occurs in spring

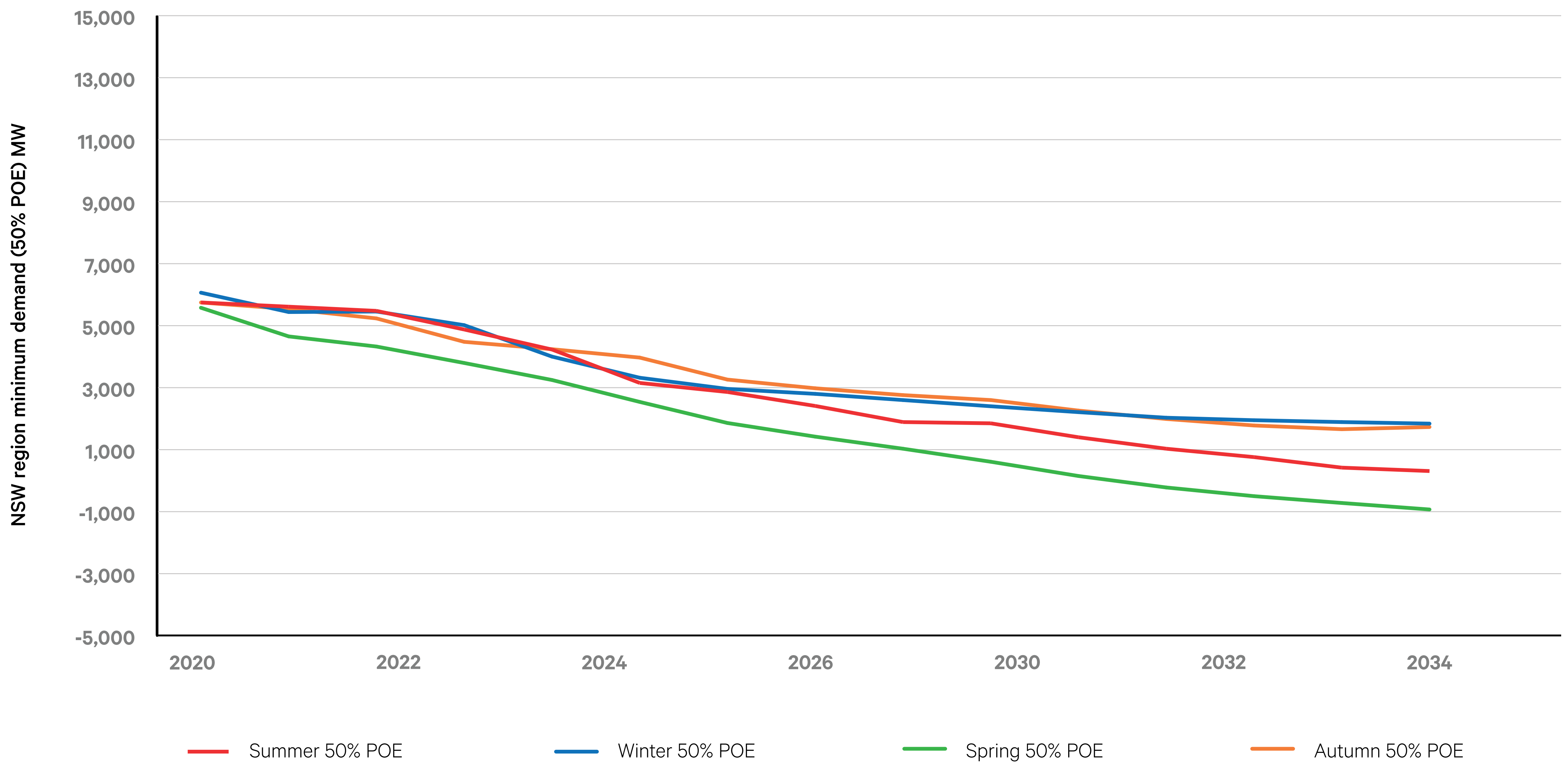
Our projections show minimum demand is most likely to occur in late spring. As shown in Table 4.8, spring and autumn are similar in average temperature, but autumn is wetter. As a result, spring has more solar exposure than autumn and almost as much as summer, but without summer's higher average cooling requirement. Possibly due to the lower temperatures, spring has the lowest average demand level of all seasons. Hence, we expect the calendar year's minimum demand to occur in spring.

Table 4.8: Sydney Airport daily weather summary by load forecasting season January 1990 to March 2025

	Summer	Autumn	Winter	Spring
	Average daily temperature Celsius			
Average	22.9	18.6	13.8	18.3
Maximum	34.6	31.2	23.4	30.3
Minimum	12.2	9.8	8.9	9.3
	Global solar exposure MJ/m^2			
Average	21.7	12.8	10.6	19.1
Maximum	35.0	24.9	18.7	32.0
Minimum	0.3	0.2	0.2	0.2
	Rainfall mm			
Average	3.2	3.5	2.9	2.0
Maximum	216.2	143.4	151.2	115.4
Minimum	0.0	0.0	0.0	0.0

Figure 4.8 shows our projections for 50% POE minimum demand by season, with spring clearly lower than other seasons. However, because demand can vary around 50% POE, it's possible for a 10% POE summer minimum demand to be lower than the following (90% POE) spring minimum.

Figure 4.8: Actual and projected NSW Region 50% POE minimum demand by season



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4.2.7 Load forecasting definitions and conventions

Our forecasts include the outputs that represent transmission network demand:

- Annual energy in GWh
- Summer and winter maximum demand in MW
- Minimum demand in MW.

Network or 'native' demand is the total output of all NEM-connected generators, except scheduled loads like pumped hydro and BESS charging.

Generation output measured at generator terminals is termed 'as generated'. It includes any power used for generator auxiliary load. Generation measured at the point of connection with the network is termed, 'sent out'. In this report, energy (GWh) is measured as sent-out generation, with minimum and maximum demand measured as generated.

Maximum and minimum demands are half-hourly averages that are highly weather dependent. High temperatures during summer afternoons/ evenings and low temperatures during winter evenings typically produce demand peaks.

To account for the imprecise nature of long-range weather forecasting, forecasts are prepared on a probabilistic framework. The probability of exceedance (POE) for maximum demand is the probability that a given maximum demand will be exceeded in a particular year, so 10% POE represents a maximum demand level that has a 10% chance that maximum demand will be above this level in any given year. This can be described as a one in 10-year event. Similarly, 50% POE equates to a 1 in 2-year event and 90% POE as a 9 in 10-year event.

For load forecasting purposes, seasons are defined as follows.

Summer	16 November (previous year) to 15 March (next year)
Autumn	16 March to 31 May
Winter	1 June to 31 August
Spring	1 September to 15 November

About 20% of Transgrid's load comes from large industrial, mining customers. These large users are connected at high-voltages and tend to have stable demand, unaffected by economic conditions, population growth or weather. Because of this, they are excluded from our forecast modelling and added back in separately based on annual reviews and inputs from existing large industrial load customers.

Network demand forecasts are built from top-down models of underlying demand. Consumer energy resources, like rooftop solar, batteries and EVs, are removed first, then added back to estimate total network demand.

Our modelling also takes into account the likely impact of emissions reduction targets, population changes, economic and energy price growth and technology adoption. Assumptions about appliance efficiency are based on existing energy efficiency programs and generally assumed to continue at historical rates.

See Appendix 1 for further information on how the projections were prepared and a review of the previous model and input accuracy.


EV charging

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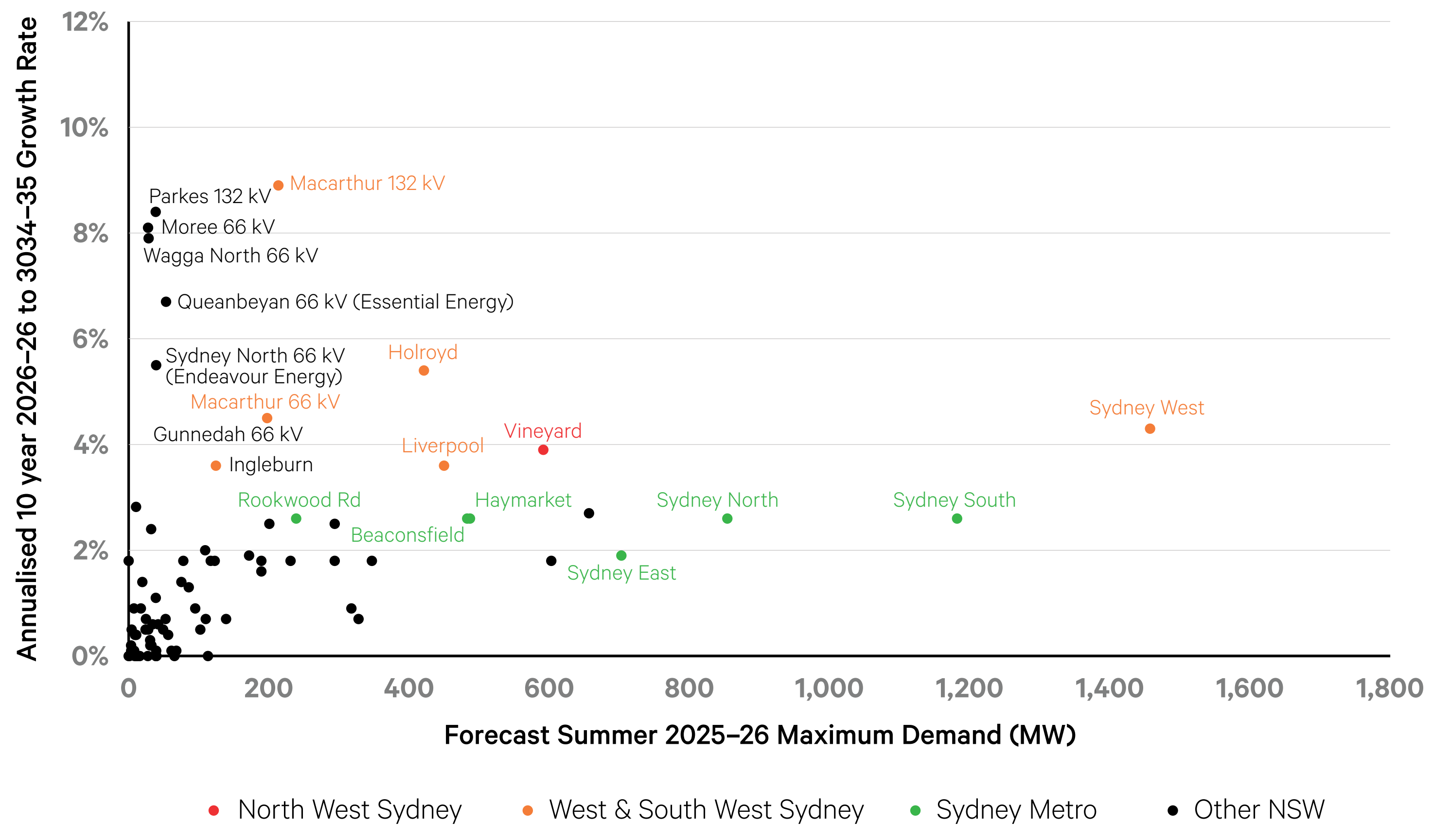
4.3 Bulk supply point forecasts

Bulk supply point (BSP) forecasts, which DNSPs provided to Transgrid in early 2025, incorporate the local knowledge of DNSPs and directly connected customers.[57] Generally, BSPs have gradual load changes. However, our forecasts also include spot loads[58] unlikely to be captured by allowing for general economic growth. This year, these spot loads come from rapid planned development in South West Sydney, data-centre growth, regional Special Activation Precincts and committed mining projects.

Figure 4.9 shows the summer forecast growth rates for BSPs serving the respective DNSPs. See Appendix 2 for detailed year-on-year forecasts of summer and winter maximum demands at the individual BSP level.

The BSPs with the highest growth rates are those serving the following areas:

Figure 4.9: BSP forecast growth rates (Summer)



4.3.1 West and South West Sydney

This area is predominantly within the South West Sector Land Release and Broader Western Sydney Employment Area where a large number of residential lot releases are planned. Load increases are also expected due to the new Western Sydney Airport at Badgerys Creek. The Aerotropolis development is planned as a smart city and will include associated commercial, residential and light industrial/ancillary services growth. Load increases will also likely occur from data-centre expansion and construction.

4.3.2 North West Sydney

The development and operation of North West Rail infrastructure and associated activity in medium/high density residential, commercial and industrial areas will drive load growth in this area.

4.3.3 Sydney Inner Metropolitan area

This area continues to grow at a moderate rate, with real income and population growth forecast to result in higher load growth. The NSW Government is planning a range of projects that will increase electricity loads, including transport infrastructure and a number of precincts or urban developments.

This year, Ausgrid's forecasts also incorporate substantial load increases as a result of new and existing data-centre growth/expansions in and around the Macquarie Park area and in areas closer to population centres.

In future, Beaconsfield and Haymarket will be key BSPs to watch as these are two of our largest exit points supplying the Sydney Inner Metropolitan area.

4.3.4 Other NSW

Other NSW consists of areas in:

Central West – Spot loads in this area primarily relate to two Special Activation Precincts in Parkes and Moree. Load increases will also be required to support rising demand in existing mines at Parkes and Orange.

Northern NSW – Spot loads in this area relate to the expected development of a major gas project.

Southern NSW – Spot load growth, including in areas in the Evoenergy network, will come from mining/industrial developments, new data-centres and increased load from electrifying appliances and transport. The Wagga Wagga Special Activation Precinct will also contribute. Located on the Inland Rail, the precinct houses the Riverina Intermodal Freight and Logistics hub, with overnight access to international ports and 75% of Australia's population.

57 Macroeconomic data is generally not available at a BSP level, so it is generally not possible to develop macroeconomic models for individual BSPs and to produce forecasts for different economic scenarios. In practice, the BSP forecasts are produced in a variety of ways (see respective DNSP annual planning reports), reflecting the amount of data available and the nature of the loads.

58 Spot loads are step (one off) increases in load for a BSP due to new commercial/housing developments or large industrial customer connections. There could be spot load decreases in cases where there are withdrawals of large-load customers from the grid.

4.4 Transgrid's 2025 forecasts remain conservative

Transgrid's forecasts in the Transmission Annual Planning Report 2025 are comparable to those in 2024. They are slightly higher (especially winter forecast) to AEMO's Electricity Statement of Opportunities 2024 and lower than the aggregate DNSP BSP forecast.

4.4.1 Transgrid's 2025 NSW Region forecast vs AEMO's Electricity Statement of Opportunities 2024

The most recent update of AEMO's top-down forecasts for the NSW Region was conducted in August 2024 as part of ESOO 2024.[59] This section compares Transgrid's 2025 topdown summer and winter maximum demand forecasts with those of AEMO (Figure 4.10 and Figure 4.11). Both demand forecasts are presented on a "native as generated" basis.

Figure 4.10: Transgrid's 2025 vs AEMO's Electricity Statement of Opportunities 2024 summer maximum demand forecast for NSW region

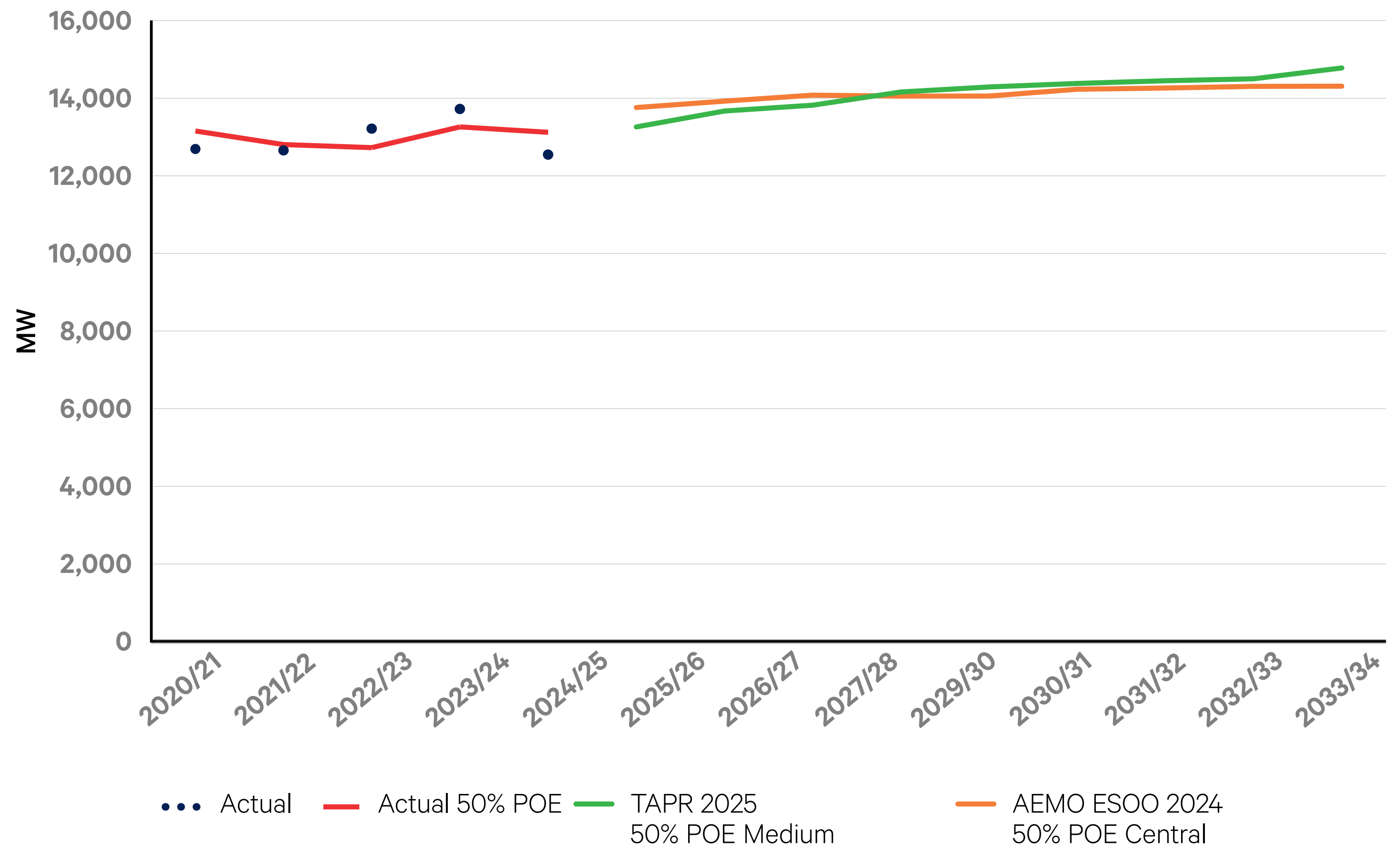
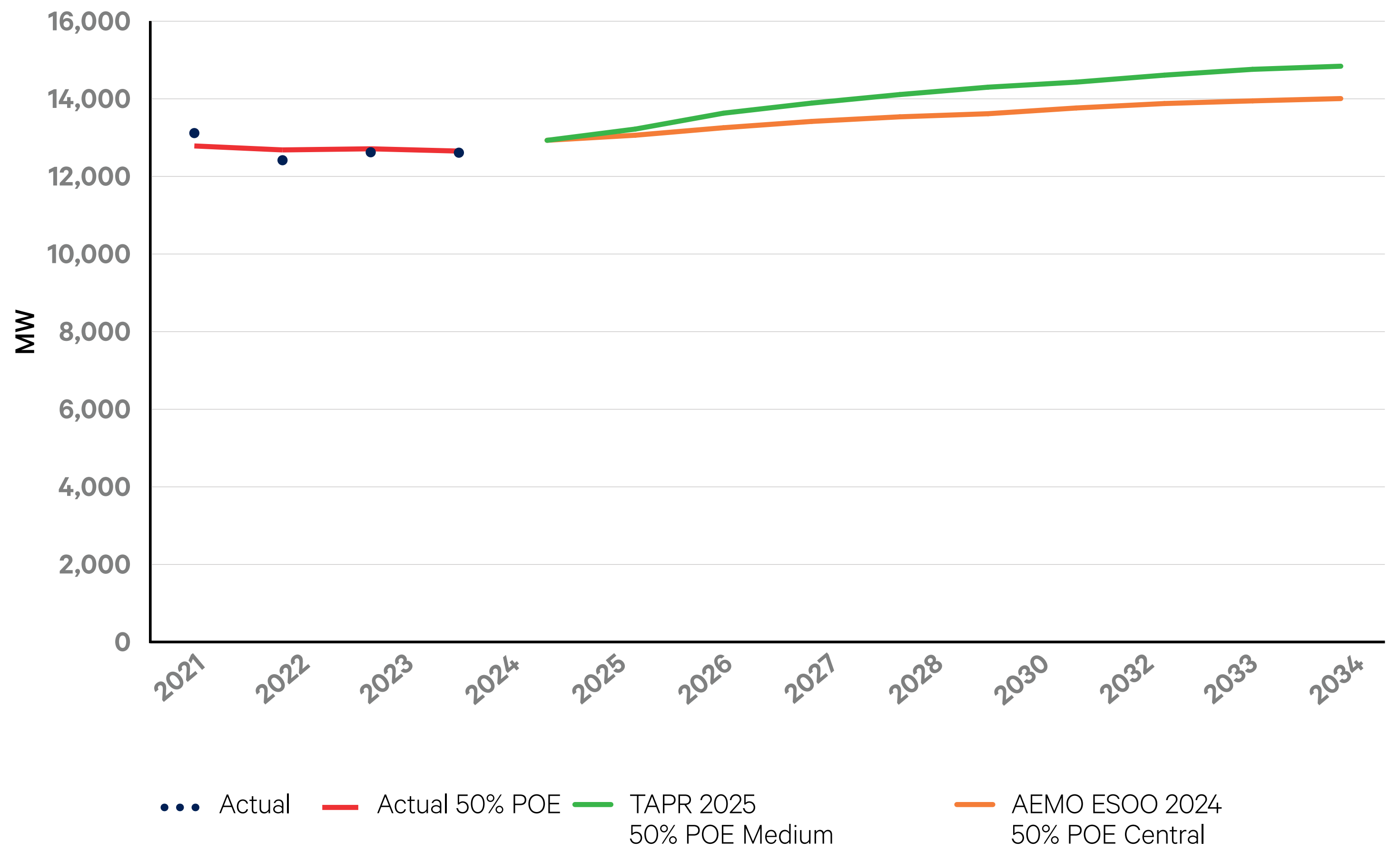


Figure 4.11: Transgrid's 2025 vs. AEMO's ESOO 2024 winter demand forecast for NSW region



4.4.2. Transgrid 2025 NSW Region forecast vs aggregate DNSP BSP forecast

Historical comparisons show that, on average, aggregate BSP forecasts obtained from DNSPs are higher than NSW Region forecasts. This is because DNSP forecasts are not generally based on econometric modelling[60] and include localised spot loads. Also, most DNSP forecasts have little or no adjustments for energy efficiency and rooftop solar unlike NSW Region forecasts.

Unlike Transgrid's NSW Region forecast, none of the BSP loads include transmission network losses or power station auxiliary load. Despite this difference, the individual BSP forecasts for each season can be aggregated to provide a useful comparison with the overall NSW region demand forecast. To achieve this, we consider:

- Diversity of load or timing of maximum demand
- Transmission network losses
- Power station auxiliary load.

We account for the limitations of this process by:

- Using 50% POE forecasts where they are available, and where they are not, by assuming individual BSP projections are based on enough historical data to converge towards an approximate 50% POE forecast
- Diversifying individual BSP forecasts to allow time differences between historical local seasonal maximum demand and NSW maximum demand
- Adding forecast aggregate directly connected industrial loads not included in the BSP forecasts
- Incorporating transmission network losses and power station auxiliary loads, derived from recent historical observations, to express the forecasts in the same 'as generated' basis for comparison with Transgrid's 2025 NSW forecast
- As most BSP forecasts have minimal or negligible adjustments for future rooftop solar and small battery uptakes, we compare the top-down high scenario forecast to aggregate DNSP forecasts for the comparison to become meaningful.

Figure 4.12 and Figure 4.13 show aggregate BSP summer and winter maximum demand forecasts compared with Transgrid's 10% and 50% POE High NSW Region summer and winter maximum demand forecasts respectively for NSW and ACT Region.

59 https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2024/2024-electricity-statement-of-opportunities.pdf?la=en&hash=2B6B6AB803D0C5F626A90CF0D60F6374

60 Econometric data like GSP and HDI are not generally available at a BSP level. Hence DNSP forecasting methodologies tend to rely on time-series forecasting with upward adjustments for future localised spot load developments.

Figure 4.12: Transgrid's top-down forecast vs aggregate BSPs forecast for summer maximum demand

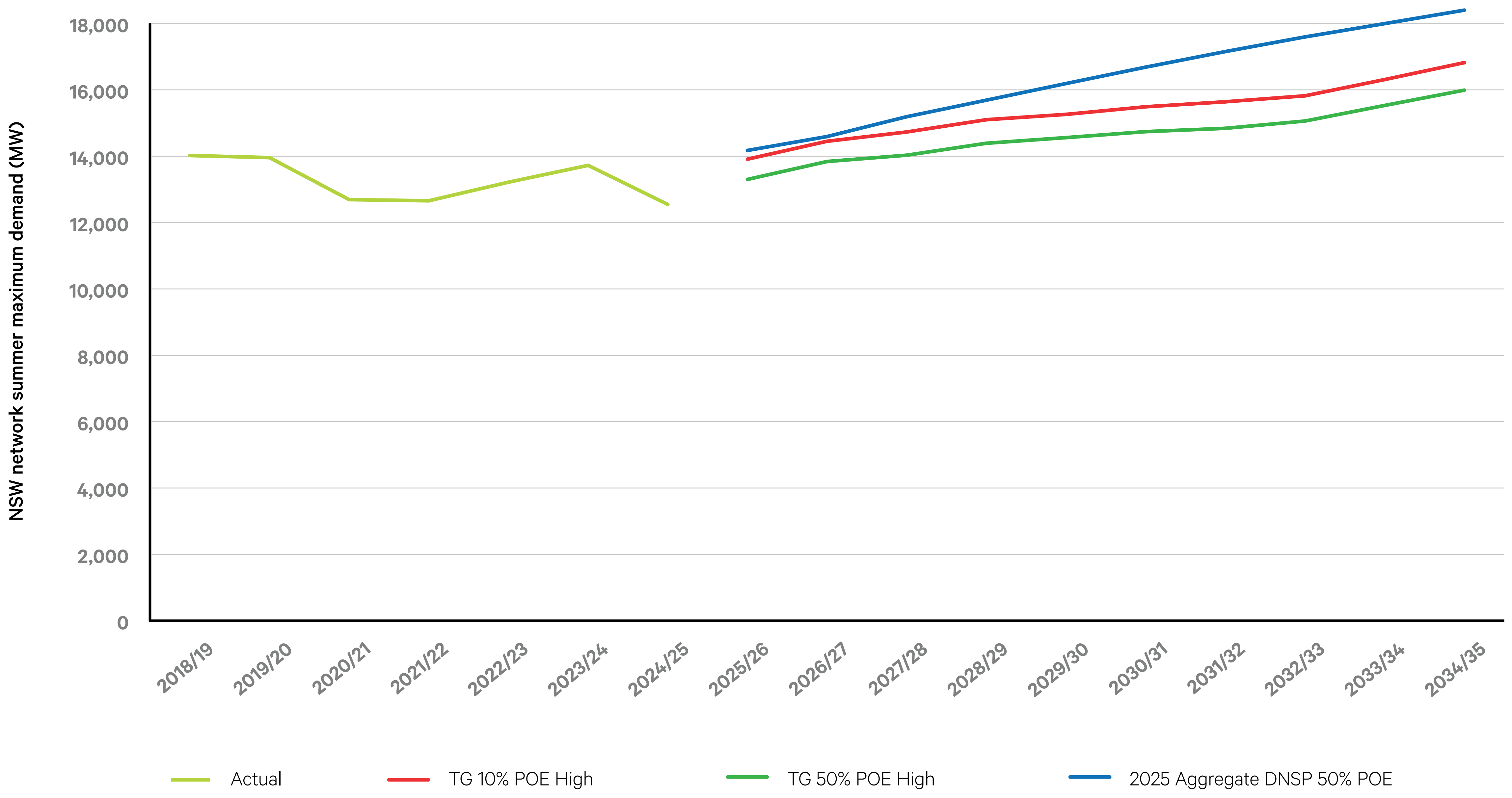
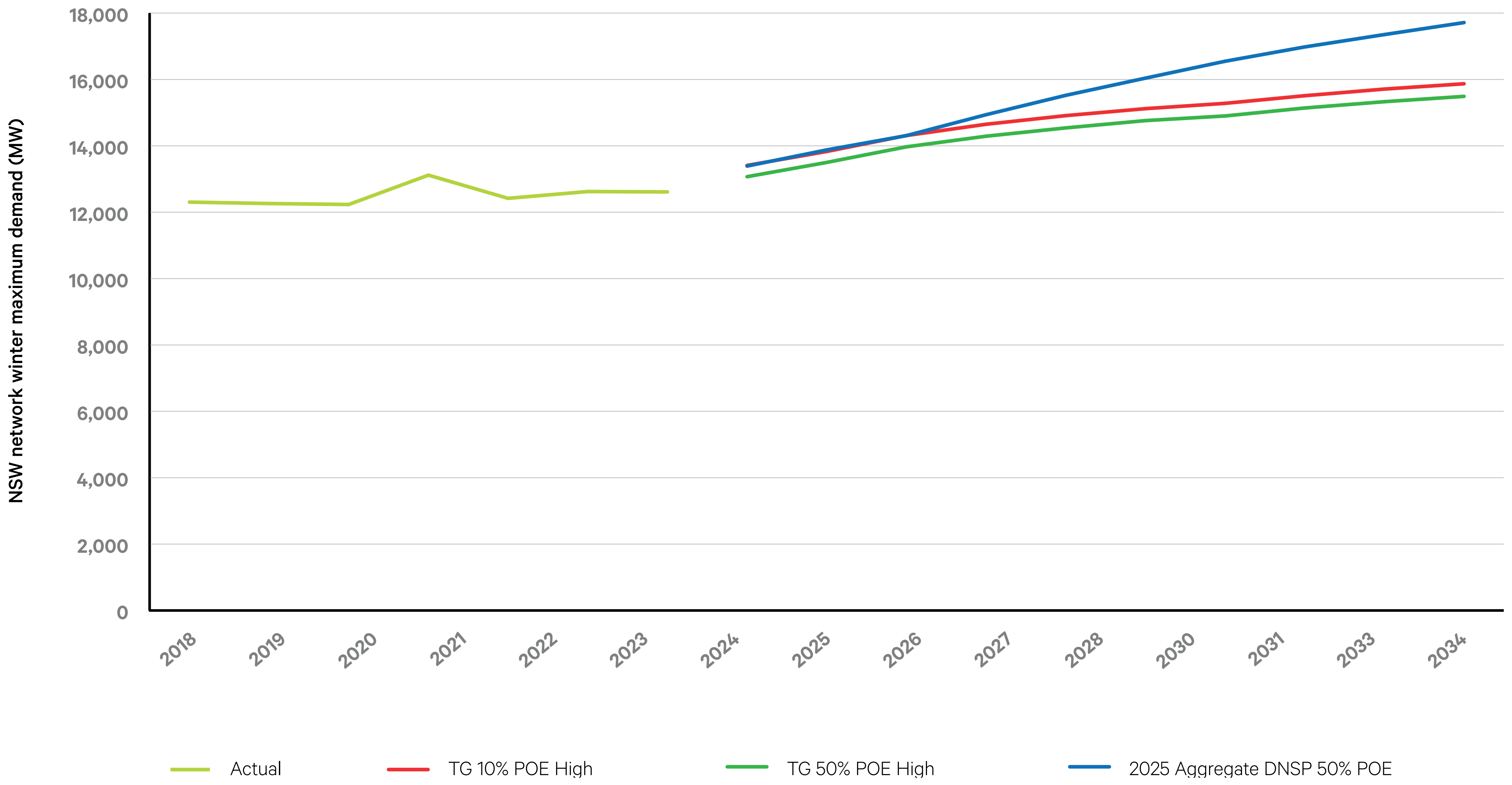


Figure 4.13: Transgrid's top-down forecast vs aggregate BSPs forecast for winter maximum demand



The charts show that DNSP and Transgrid forecasts are similar in initial years but diverge later in the 10-year outlook. This is expected, as they use different methodologies and input assumptions. Comparing them shows high-level differences but does not indicate which forecast is more accurate.

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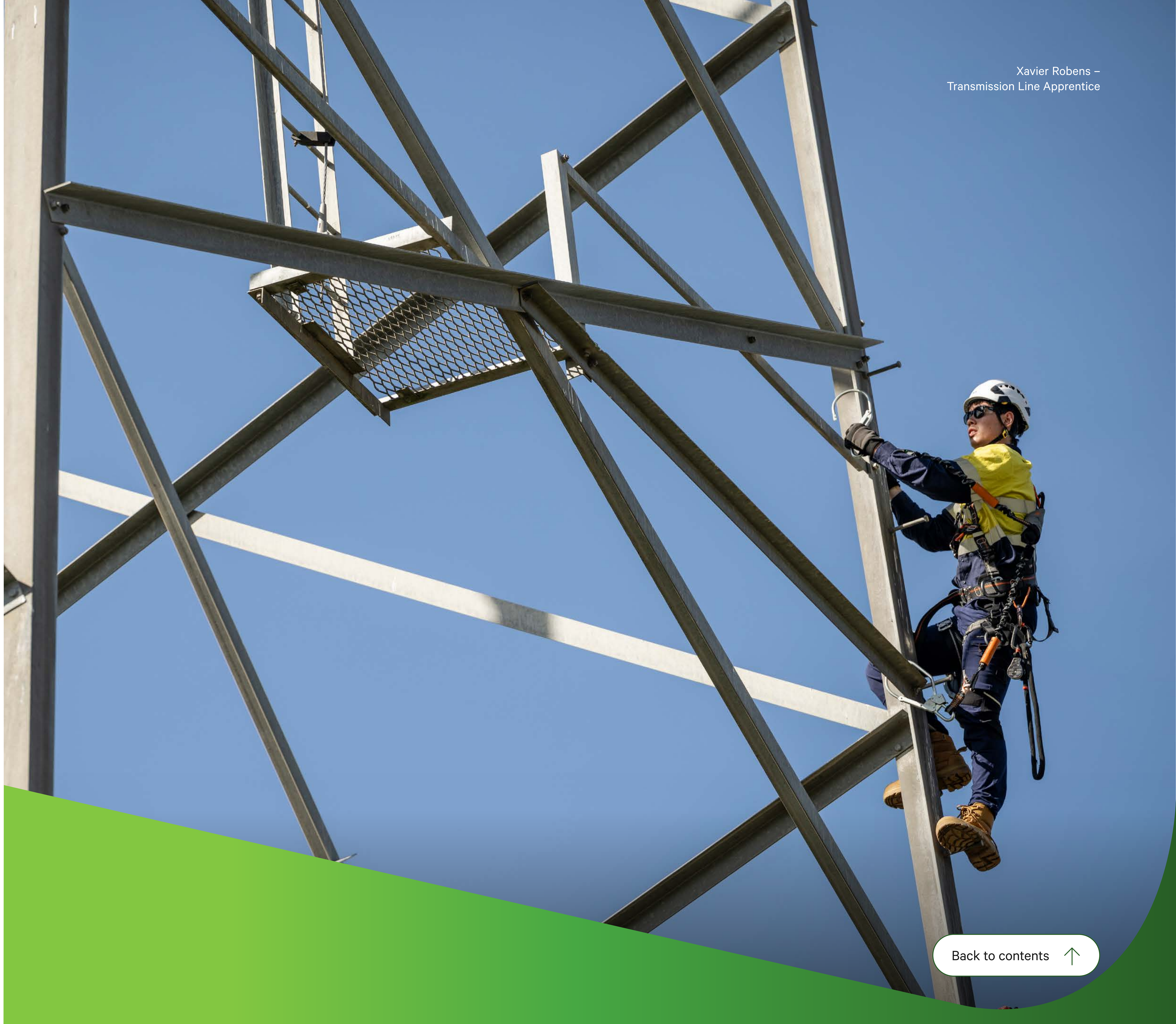
4.5 Changes from the 2024 Report

Compared with the Transmission Annual Planning Report 2024, this chapter:

- Provides a more detailed outlook for NSW energy consumption and maximum demand
- Incorporates new spot loads (including substantially more data-centre loads) in its forecasts
- Uses new forecast methods, including new models, evaluation methods, input variables and scenarios (see Appendix 1)
- Provides a new comparison of annual energy consumption and maximum demand between Transgrid's 2025 forecast and AEMO's 2024 Electricity Statement of Opportunities forecast.

These changes are consistent with the requirements of NER Clause 5.12.2(c)(1), (6A), (9), (10) and (12).



Xavier Robens –
Transmission Line Apprentice

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Chapter 5

Wagga Wagga Substation

System security

Maintaining a safe operating envelope to ensure reliability in a complex grid managing increasingly volatile demand and supply.

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As we advance more deeply into the energy transition, Transgrid is responsible for ensuring sufficient security services – system strength, inertia and voltage control – are available to keep the grid operating within its safe technical envelope. Without adequate system security services, generators may be unable to remain connected during disturbances to the power system, control of the system voltage becomes more and protection systems that ensure safe operation of the network may not operate correctly.

Historically, system security for the NSW electricity system has relied on a minimum combination of coal-generating units being online at all times. Yet in the next decade, around 7 GW of coal generation (more than 80% of NSW coal capacity) is projected to retire and 31 GW of utility-scale wind and solar plants are projected to connect in NSW under a 'step change' scenario.[61] This will create significant gaps in system security that Transgrid and our partners must resolve.

To meet our system security obligations, Transgrid is working with more than 30 market proponents to assemble a diverse portfolio of non-network solutions and new network assets. Based on an extensive RIT-T assessment (see 'Solutions considered to address future system strength needs'), the optimal portfolio of system strength solutions, which will also meet inertia requirements and provide significant voltage support, includes:

- Synchronous condensers that spin freely (with no fuel combustion or power generation), used specifically to provide system security services.
- Grid-forming Battery Energy Storage Systems that can co-optimise energy market outcomes with system strength support, synthetic inertia, fast frequency response and voltage support.
- Services outside the energy market, such as existing synchronous hydro units that may be able to operate in synchronous condenser mode, or generators with units upgraded to operate in synchronous condenser mode.
- Existing and committed synchronous generators dispatched in the energy market, such as hydro and coal and gas, where necessary.

Synchronous condenser Buronga NSW

61 Transgrid analysis of AEMO's 2024 System Strength Report, December 2024

5.1 Assessing power system security

To plan the best way to decouple system-security provision from coal generation, we assess power system security against the criteria that contribute to system stability (Table 5.1).

Table 5.1: Definitions and characteristics of criteria affecting system security

Criteria	Description
Reserve	Extra generation that is readily available by increasing the output of generators already generating in the power system. The power system is normally operated with enough reserve to cover the loss of the largest generator unit.
Maximum demand (or peak demand)	The highest amount of electricity used at any instant in a period of time.
Minimum demand	The lowest amount of electricity used at any instant in a period of time. Low minimum demand can challenge the voltage profile and stability of the power system.
Voltage control	The ability to maintain voltages throughout the power system within stable and safe limits. Voltage control is provided by controlling generators and network assets, such as transformer tap changers, capacitor banks, reactors, Static VAr Compensators and synchronous condensers.
System strength	The power system's ability to maintain and control the voltage waveform at any given location in the network so the network can return to normal operation after a disturbance or fault. System strength is a fundamental service required for the power system to operate in a secure state and to ensure the safe operation of protection devices. It has traditionally been provided by synchronous generators as an intrinsic by-product of producing energy and reserves.
System strength requirements	Transgrid is the System Strength Service Provider for NSW and ACT, responsible for providing both the minimum level of system strength required for power system security, and the additional level of the service required to ensure stable voltage waveforms when hosting new inverter-based resources (the 'efficient' level).
Frequency control	The ability to maintain the frequency of the power system within stable limits. Traditional frequency control acts quickly for small changes in frequency under normal conditions, but slowly for large changes in frequency during disturbances. Therefore, it needs to be complemented by inertia. Fast frequency response (FFR) is a newer approach enabled by high-speed power electronics. Battery storage devices and solar generators use these electronics in their inverters. FFR also has the potential to act quickly during disturbances.
Inertia	The power system's ability to 'ride through' disturbances without significant frequency variation. Inertia measures the physical capability of the power system to resist changes in frequency by means of inertial response from a generating unit, network element or other equipment that is electro-magnetically coupled with the power system and synchronised to the frequency of the power system.

5.1.1 Coal retirement

AEMO's 2024 Integrated System Plan forecasts that coal retirements under the step-change scenario will occur faster than previously projected – and that the annual renewables share of NSW energy generation will exceed 90% by FY32 and 99% by FY39.

The Integrated System Plan notes that, as Australia transitions to a net-zero economy, the lowest cost way to supply electricity is renewable energy connected via transmission and distribution infrastructure, firmed with storage and backed up by gas-powered generation.[62]

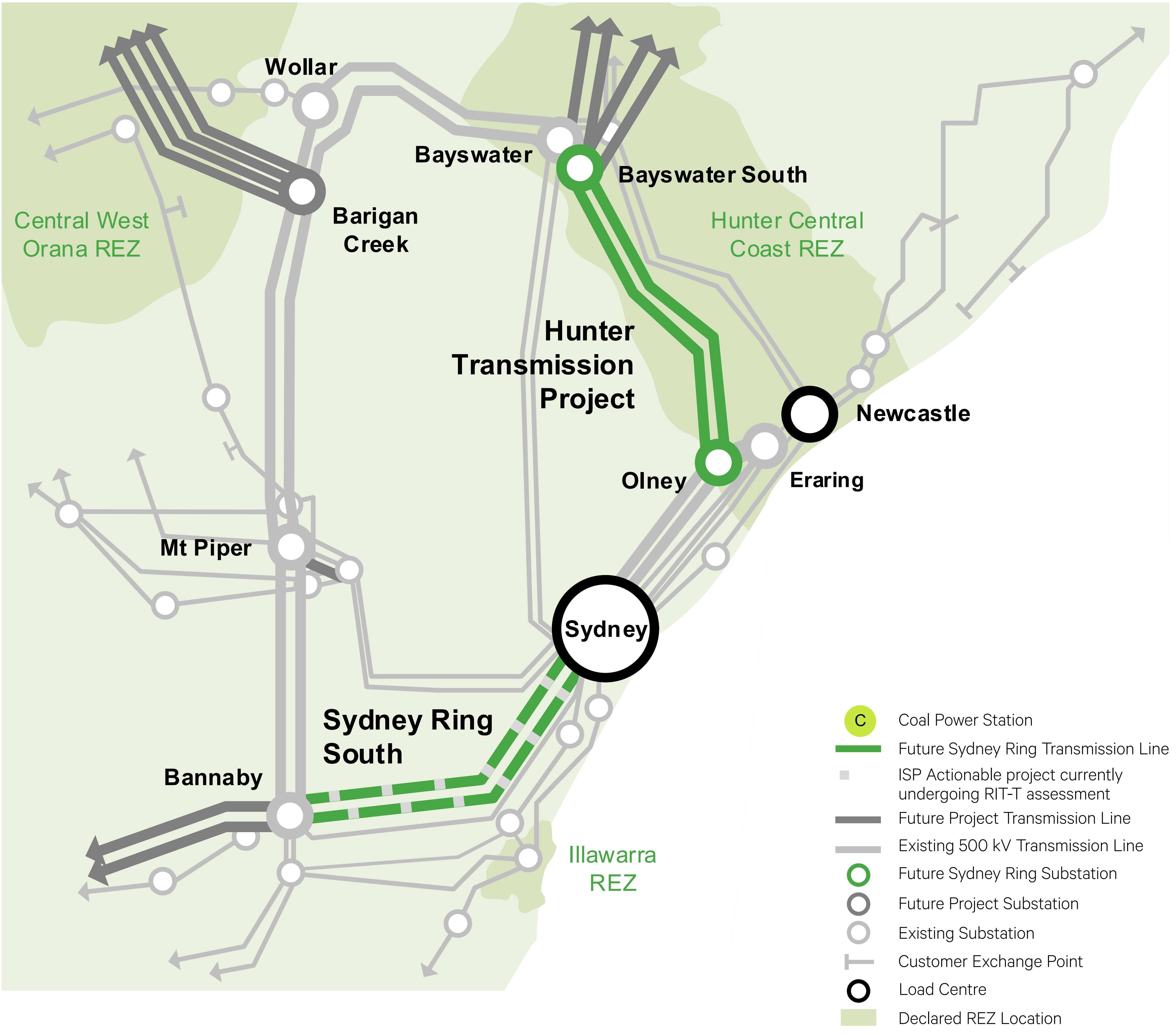
Accelerating coal retirements

The Integrated System Plan forecasts that coal generators, NEM-wide, are likely to retire earlier than owners have currently announced. The coal retirements under the Integrated System Plan Step Change scenarios have been brought forward in 2024 versus 2022 (see Figure 5.2). Up to 90% of the NEM's coalfired power stations are projected to retire before 2035, with the entire fleet expected to be decommissioned before 2040. Operating these plants has become less attractive given their higher operating costs, reduced fuel security, high maintenance costs and increasing competition from renewable energy.

62 AEMO 2024 Integrated System Plan

Figure 5.1: Integrated System Plan Step Change 2024 vs 2022 NSW Coal Retirements

Figure 5.2: Coal generation locations on the Sydney 500 kV ring[63]



In NSW, coal generation is located around the Sydney 500 kV ring (see Figure 5.1), with each plant providing significant energy, system strength, inertia and voltage support to the transmission backbone.

When these generators retire, traditional network flows will change and voltage support across the network will be reduced. During periods of low renewable energy output, NSW will increasingly rely on long-duration dispatchable capacity, in particular from Snowy Hydro units. The southern backbone (HumeLink and Sydney Ring South), with its ability to transfer power from Southern NSW through to Sydney, will therefore be critical to energy reliability in the state.

63 Includes transmission projects delivered contestably under the NSW EII Act framework, which will not be constructed, owned or operated by Transgrid

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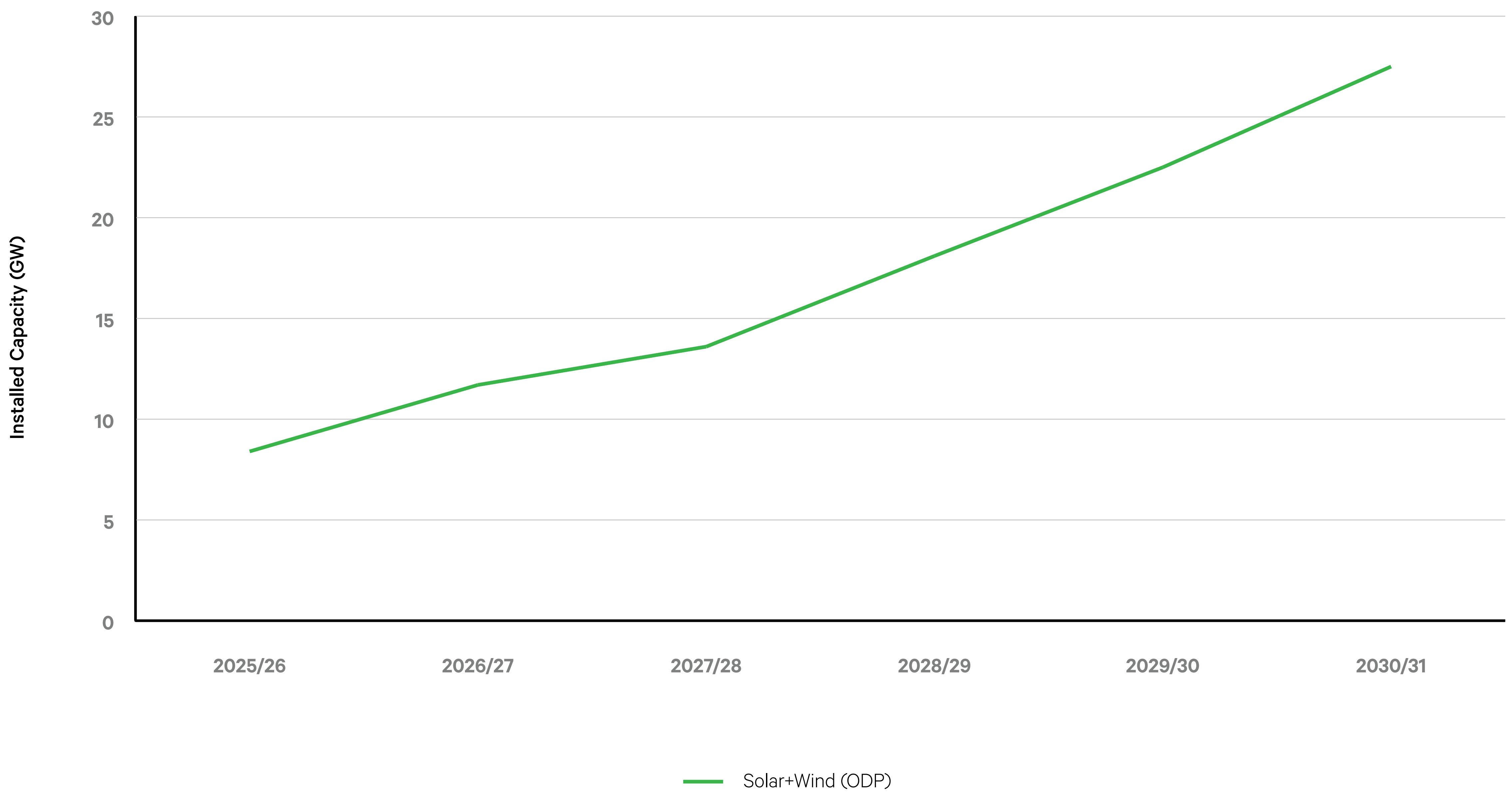
Large uptake of renewable energy technologies

To facilitate the transition towards renewable energy generation, NSW is developing large Renewable Energy Zones (REZs) in Central West Orana, New England, South West NSW, and Hunter Central Coast. Figure 5.3 shows the steady ramp-up of renewables the REZs are expected to deliver over the next six years.

Figure 5.3: 2024 Integrated System Plan Step Change – NSW utility-scale solar and wind capacity (GW)

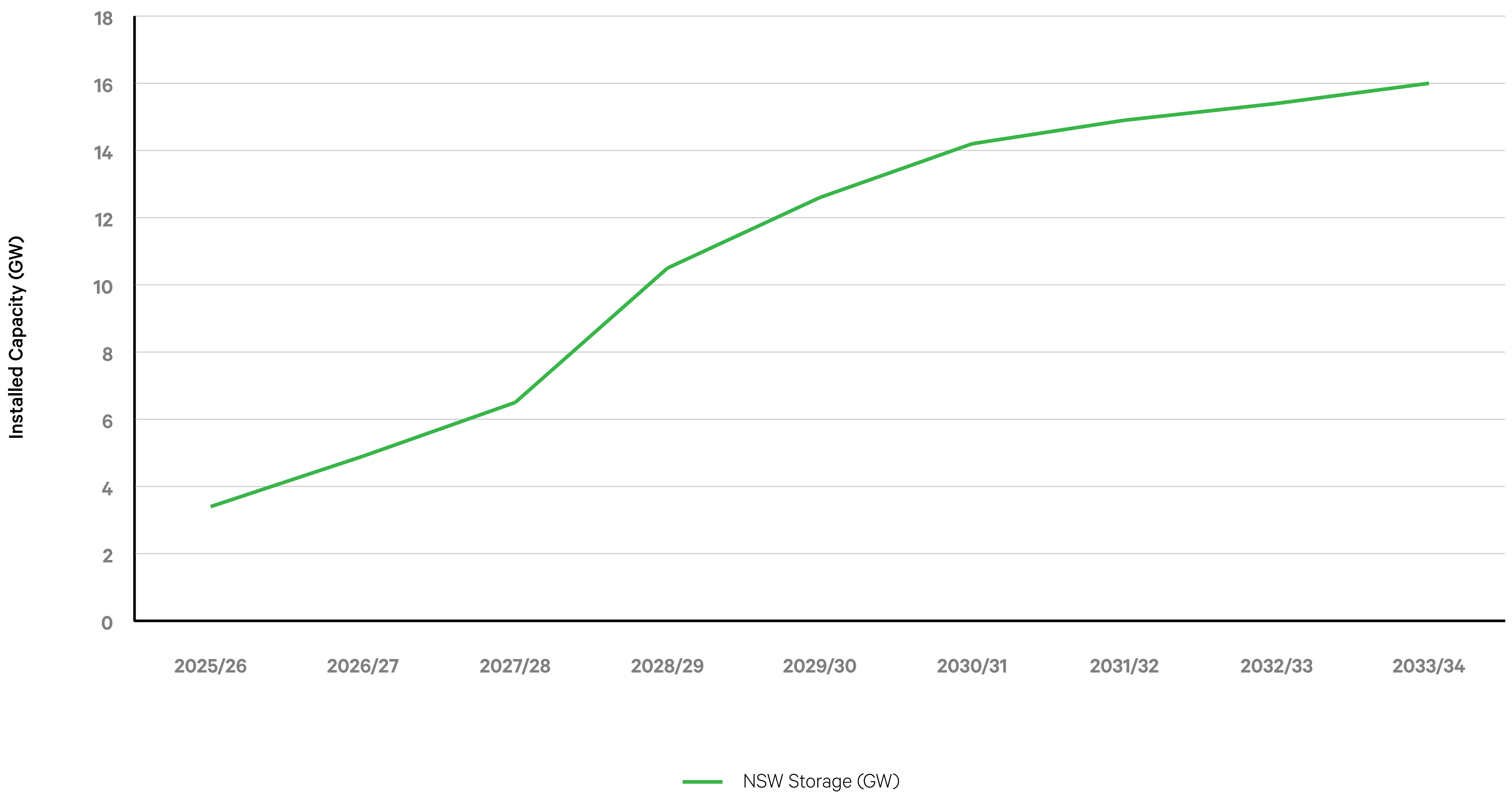


Firmed with storage

In NSW, we will need a large volume of storage capacity to firm a grid powered by renewables. Storage enables the 'time-shifting' of low-cost energy – that is, storing energy when it is cheap and plentiful for use at times of high demand when it would otherwise be more expensive. Storage is also important to provide security of energy supply when renewable resources are scarce.

The new storage will come in a variety of forms, including pumped hydro, deep storage, medium storage, shallow storage and coordinated and passive consumer energy resources. The combined installed capacity of the new storage is planned to increase over 10 years to 16 GW in FY34 (see Figure 5.4). By FY34, Snowy 2.0 will be the dominant form of long-duration storage, representing 350 GWh of the total 420 GWh stored electricity capacity.

Figure 5.4: 2024 Integrated System Plan Step Change – NSW total combined new storage (GW)

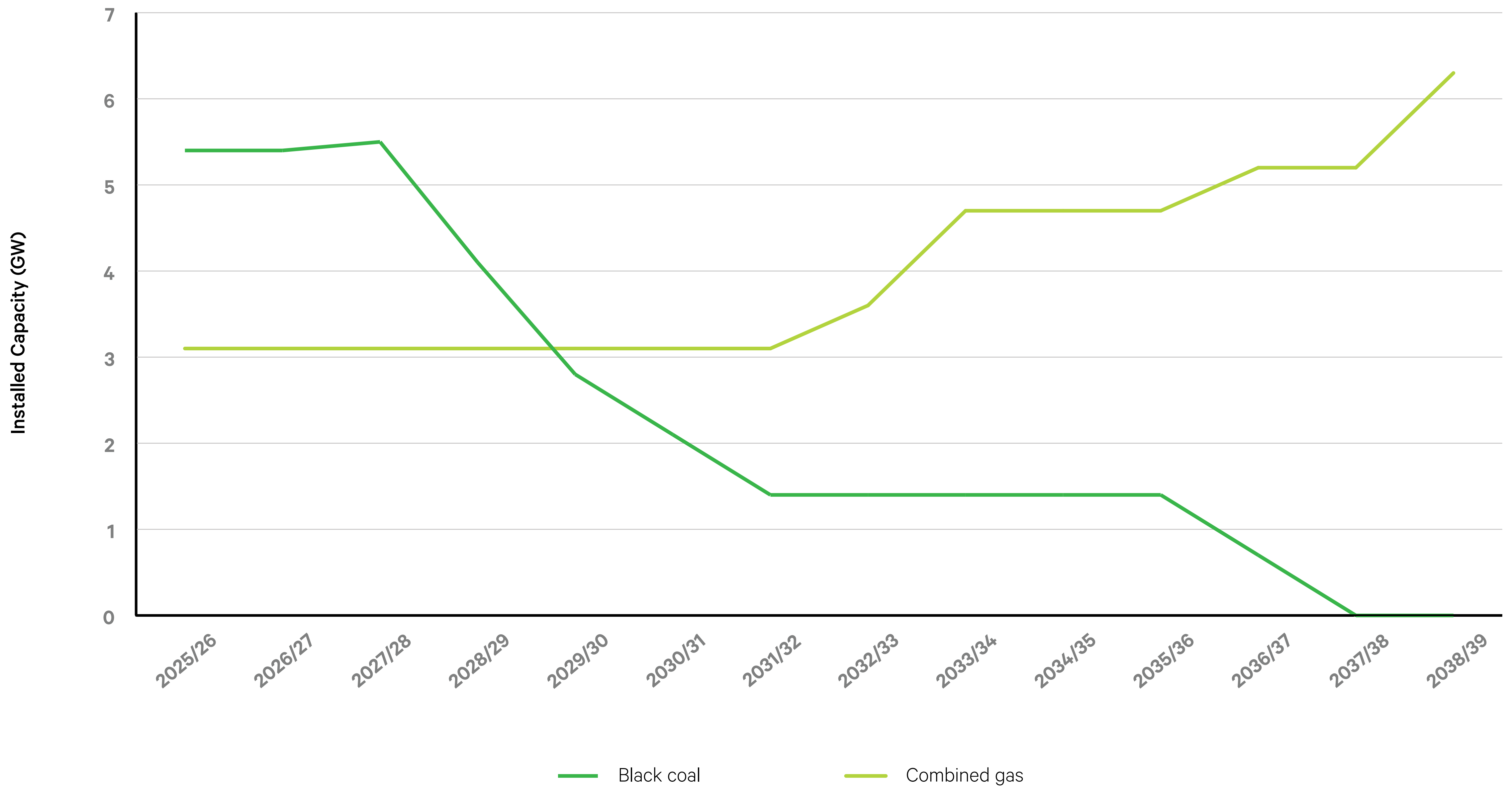


Backed up by gas-powered generation

Figure 5.5 shows how, over the next 15 years, coal retirement in NSW is planned to coincide with an increase in the installed capacity of gas-powered generation in NSW from 3.1 GW to 6.3 GW. This gas-powered generation will be a valuable back-up during renewable energy droughts and times of peak demand.

Gas power plants will need to be located strategically to ensure sufficient gas pipeline capacity and adequate electricity transmission capacity without being constrained under peaking conditions. The bulk of electricity produced from gas-powered generators is projected to come from mid-merit units.

Figure 5.5: 2024 Integrated System Plan Step Change – NSW gas and coal installed capacity (GW)



5.1.2 Reserve and generation adequacy

The power system is built and operated with a level of reserve to maintain system reliability. AEMO informs the market of Lack of Reserve (LOR) conditions to encourage a response from market participants to provide more capacity into the market. The LOR in NSW is defined as:[64]

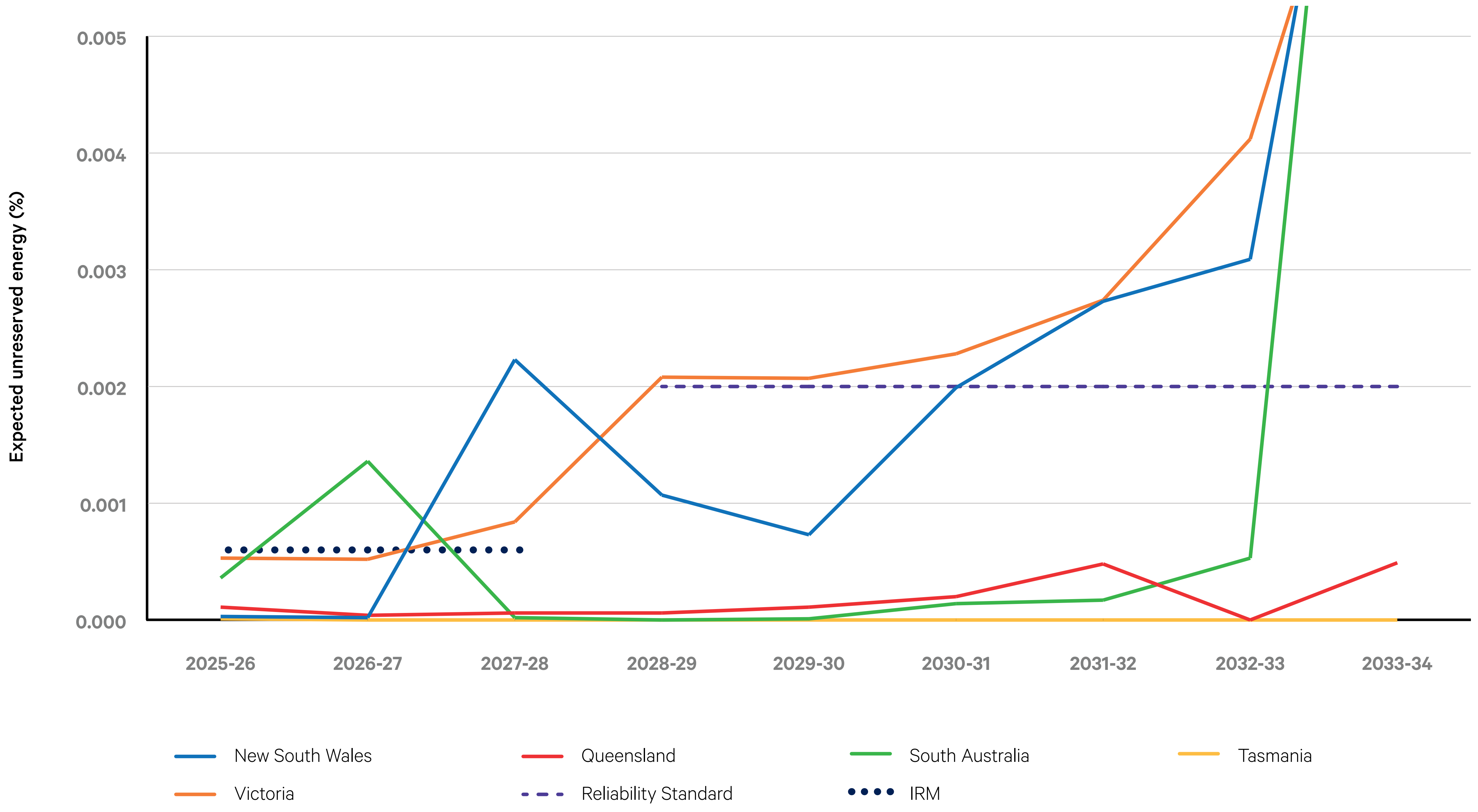
- LOR1: the total reserve in NSW is lower than the two largest supply resources
- LOR2: the total reserve in NSW is lower than the single largest supply resources
- LOR3: the total available electricity supply is equal or less than the operational demand, which is likely to result in unserved energy, or unmet demand for energy, if no action is taken after the event is declared.

As coal generators retire, projected shortfalls in reserve will be mitigated by new scheduled generation connections, energy storage and network augmentation projects to increase network capacity (see Chapter 2).

AEMO has forecast reliability gaps in NSW, where 'expected unserved energy' (i.e. shortfalls in available energy supply to meet demand levels) is projected to exceed standards set by the AEMC Reliability Panel. This occurs in FY28 against the interim reliability measure and beyond FY31 against the reliability standard (see Figure 5.6)[3]. In other words, if further investment beyond current committed and anticipated projects is delayed or does not materialise, reliability will increasingly become an issue in NSW.

64 Lack of Reserve (LOR) notices Factsheet December 2022

Figure 5.6: 2024 ESOO Committed and Anticipated Investments sensitivity for all regions, from FY26 to FY34 in expected unserved energy (%)[65]



The growth in rooftop solar, now installed on one in three Australia homes, is moving 'peak' grid demand to later in the day. Since this peak is shifting into the evening, very little large-scale solar will be available to support these periods. This issue has been observed in both summer and winter maximum demand periods (see Section 4.2).

Battery Energy Storage Systems (BESS) can help store and shift renewable generation to be used later in the day. These new batteries can be located near generators, in REZs or close to loads (which would be limited by fewer constraints). To this end, AusEnergy Services (previously AEMO Sevices) has already released several competitive tenders for firming infrastructure and demand response in NSW.

Transgrid has assessed system adequacy for the years from FY26 until FY33, based on in-service and committed generators. Unlike AEMO's Electricity Statement of Opportunities report, which is based on market simulations and quantifies potential issues as 'expected unserved energy', Transgrid's studies consider potential snapshot scenarios, representing periods when high system demand coincides with relatively low renewable availability, and also provide reserve levels when one additional large-scale unit is out of service to reflect scenarios when there are planned or unplanned outages of large-scale coal-fired units. Specifically, the assessment assumes that at peak demand times:

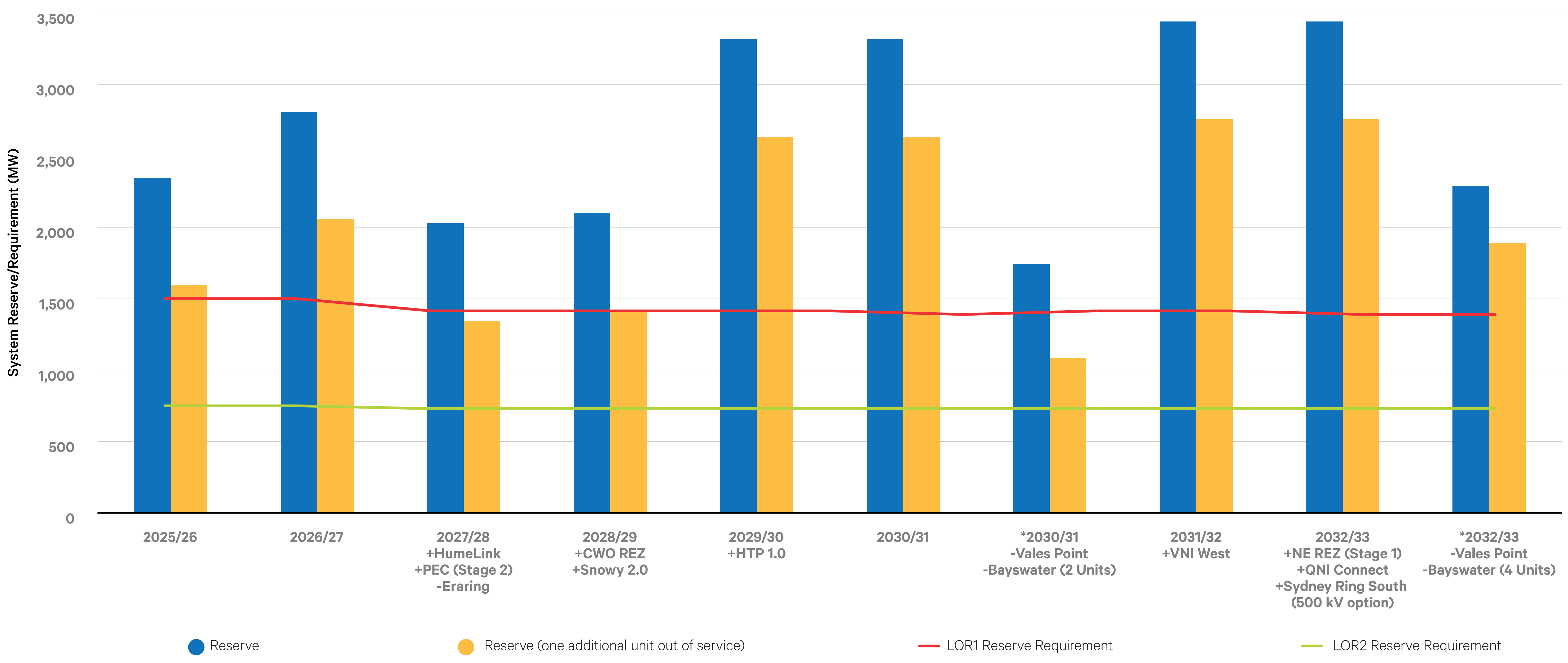
- Solar farms, wind farms and batteries will be generating at 5%, 20% and 100% of their rated active powers, respectively
- The capacity for each of the synchronous generators will be 100% available if they are not retired in the study year in the study case
- The system demand is assumed to be 10% POE Maximum Demand forecasted in summer.

The assessment also considers the locational factor of a generator in contributing to the reserve, noting that one megawatt of system reserve at a specific location, may not be equivalent to the same amount of reserve at another. As a result, noting that the Sydney-Newcastle-Wollongong (SNW) region is the NSW load centre, our assessment defines the reserve in NSW as the total headroom of available dispatchable generation from BESS, coal and gas generators within or close to the SNW region.

Our system generation adequacy results are presented in Figure 5.7.

65 p.8, Committed and Anticipated Investments sensitivity, AEMO 2024 ESOO

Figure 5.7: Transgrid System Adequacy Assessment results from FY26 to FY33[66]



The numbers in Figure 5.7 are indicative only, noting that:

- The deliverable reserves may be different due to network constraints and how generators are dispatched by the the National Electricity Market Dispatch Engine (NEMDE) despatch engine when operating the whole system. For example, if the reserve far away from the SNW region can be delivered when a generator trips, the true reserve is expected to be higher than the calculated values
- Similarly, if the reserve in or near the SNW region cannot be fully delivered when a generator trips, the true reserve is expected to lower than the calculated values
- The study only considers committed generators defined by Transgrid, which means reserve levels are expected to be higher when more generators, either connected to the Transgrid backbone network or via REZs, become committed, thereby being able to address or alleviate potential system adequacy issues.

As Figure 5.7 shows, although the expected reserves are sufficient when all generating units are in service, with one additional large-scale unit out of service, the system may be at risk of LOR1 conditions in FY28, when the Eraring coal-fired generator has retired and the HTP 1.0 has not yet been commissioned. It should be noted that any planned or unplanned outages of the remaining large generating units or critical transmission lines will further increase the generation adequacy gap and could result in unserved energy.

Our analysis shows that the network transfer capability from southern NSW, Vic and SA to the SNW region is limited by the Southern NSW network constraints. As such, either additional dispatchable generating units must be added closer to the SNW region or current network constraints must be alleviated. Transgrid is considering multiple options to relieve these constraints.

Figure 5.7 also shows system reserves under scenarios involving the early retirement of large coal-fired units, indicated by columns marked with an asterisk (*) before the study years. For example, if Vales Point and two Bayswater units retire in FY31, earlier than their projected retirement year of FY34 in AEMO's 2024 Electricity Statement of Opportunities, the generation adequacy gap could widen. In contrast, if the NE REZ (Stage 1) and the Sydney Ring South (500 kV option)[67] are commissioned, system reserves are expected to remain sufficient even with the early retirement of Vales Point and all four Bayswater units. This highlights the critical role and timely delivery of network augmentations in addressing system adequacy challenges.

66 In the study, Eraring Coal-fired generators are assumed to be retired in FY28. The HTP 1.0 and Sydney Southern Ring (500 kV double-circuits) respectively are assumed to be in service from FY29 and FY32, which, however, are subject to further changes depending on project design and development. Moreover, the studies do not consider QNI Connect and New England REZ, which can potentially help alleviate the system adequacy issues when they are in service.

67 The study assumes the Sydney Ring South (500 kV option) will be commissioned in FY33. However, potential options and their timings are still under investigation by Transgrid through the RIT-T process.

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5.1.3 Voltage control

Over the next 10 years, NSW will see increasing voltage control issues for both peak demand and low demand periods in the transmission network. During peak demand, voltage stability issues are already occurring at the Bulk Supply Points (BSPs) in the Western Sydney and Central West areas. Additionally, low voltage issues have been identified in the Southern, Northern, Western Sydney and Central West areas. Projects to remediate these issues are discussed in Chapter 2.

Currently, at times of high renewable generation in the South West NSW network around Darlington Point, under-voltages can occur following the trip of the Darlington Point to Wagga Wagga 330 kV transmission line. Transgrid has procured services from existing operating BESS facilities in South West NSW to increase transfer capacity on the existing network between Darlington Point and Wagga Wagga. The RIT-T for Improving Stability in South Western NSW concluded that contracting with a committed BESS to provide network support services would unlock substantial market benefits and provide flexibility for future network augmentations in the region, including VNI West and the South West REZ. Accordingly, Transgrid executed a network support agreement, for services which commenced from September 2024.

Equally, in the daytime, when rooftop solar is feeding back into the network, high-voltages are occurring more frequently in the BSPs. High voltage issues have been identified in the Greater Sydney, Tamworth, South Coast and South West networks during minimum demand scenarios. Projects to remediate these issues are discussed in Chapter 2.

As the system moves through the energy transition, we will reach periods of high renewable generation coupled with low demand, with minimal synchronous machines online. At this point, our analysis indicates that the NSW power system will experience significant high-voltage issues, particularly in demand centres like the Sydney Region. These voltage issues will need to be mitigated well before the grid approaches 100% instantaneous renewables to keep the system within its secure operating envelope.

5.1.4 System strength

System strength can be likened to the 'heartbeat' of the power system' – necessary to maintain the secure operating envelope of the grid and enable the flow of electricity around NSW. More technically, it's the power system's ability to maintain and control the voltage waveform anywhere on the grid – even after a disturbance. Without adequate system strength, our power system is at risk of instability and supply interruptions to consumers.

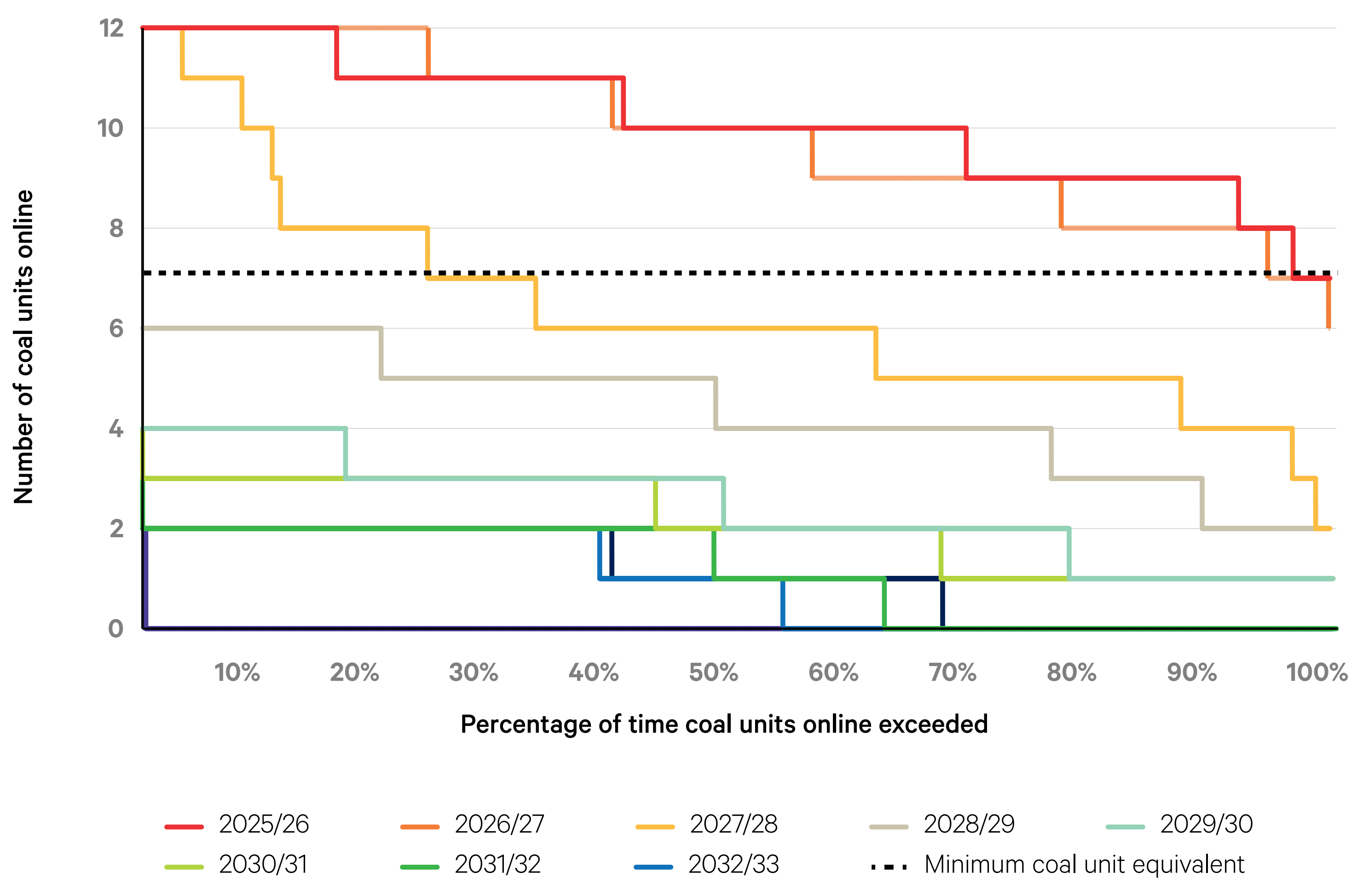
The changing landscape of system strength in NSW

System strength has traditionally been provided by synchronous machines, such as coal, gas and hydro generators. Because these units are electro-magnetically coupled to the grid, they absorb or respond to shockwaves that result from unexpected events or disruptions to the network.

In contrast, wind and solar generators, which connect via grid-following inverters, require a strong voltage waveform (or heartbeat) from the grid to lock onto and follow.[68] If the grid's voltage waveform wavers due to a disturbance, rather than absorbing the shock, renewables may become unstable and disconnect. These technologies need a strong source of system security to operate in a stable manner.

With more than 80% of NSW's coal capacity projected to retire within the next 10 years, we will see increasing periods when we do not have enough synchronous units online to keep the NSW power system secure. As Figure 5.8 shows, this is projected to occur for approximately 6% of the year in FY27, approximately 75% of the time in FY28 and 100% of the time by FY29. During these periods, alternate sources of system strength will be required to maintain the system within the secure technical operating envelope.

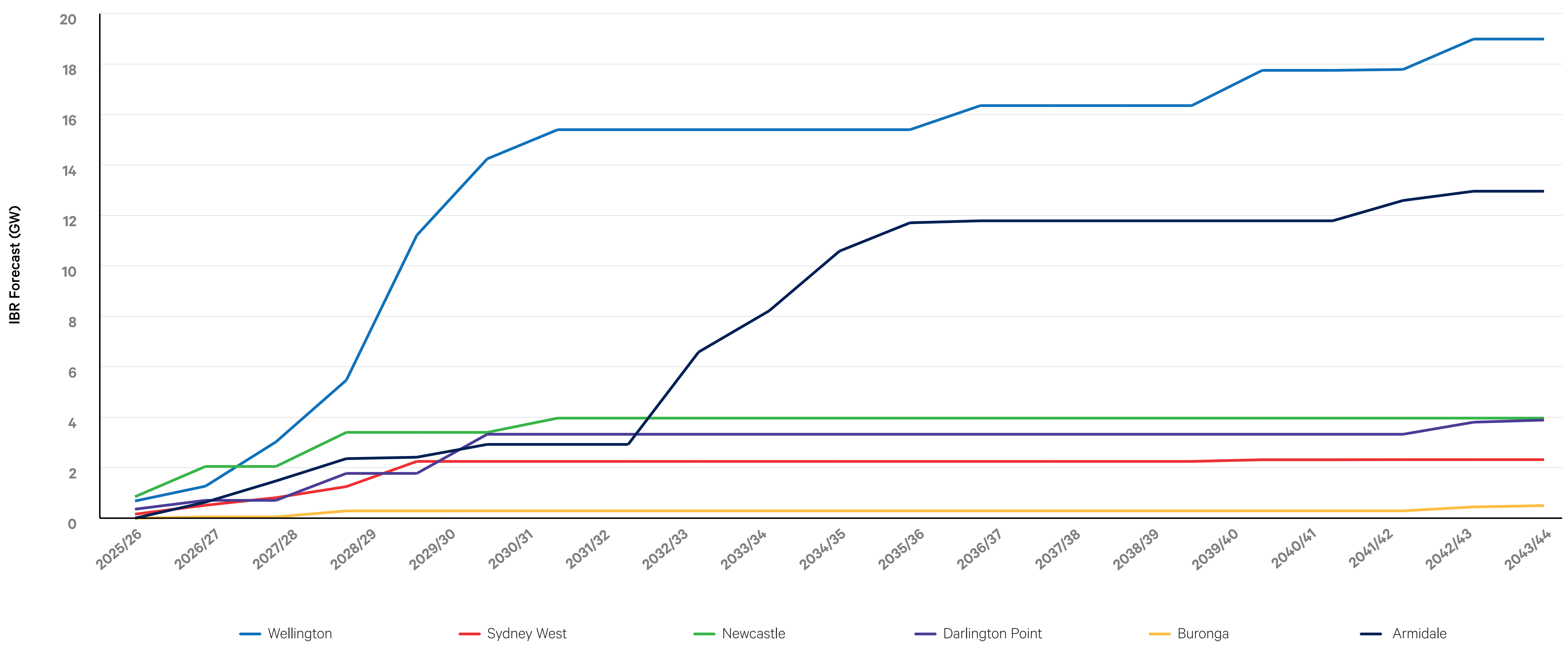
Figure 5.8: Number of coal units projected online in the next decade in NSW during typical market operation[69]



As we connect more inverter-based resources (IBR) to the grid, this must be matched by new system strength services. By FY35, approximately 42 GW of utility-scale wind plants, solar plants and battery energy storage systems are projected to be connected in NSW. Figure 5.9 shows this forecast IBR growth at each of the six system strength nodes in NSW.

68 This is distinct from 'grid-forming' technology, which mimic the ability of synchronous machines to form their own strong voltage reference. Grid-forming batteries are becoming much more common, though their technical capabilities are still maturing.
69 Market modelling results from Transgrid's system strength PACR, https://www.transgrid.com.au/projects-innovation/meeting-system-strength-requirements-in-nsw/

Figure 5.9: Forecast of inverter-based resources projected to connect surrounding system strength nodes in NSW[70]



Transgrid's system strength obligations

Under new AEMC rules,[71] Transgrid, as the NSW System Strength Service Provider, is responsible for planning to ensure sufficient system strength is available to meet the standards required by AEMO's annual System Strength Report.

Our job is to establish a portfolio of solutions to ensure minimum system strength requirements are met in full at all times. We are also required to maintain system strength above minimum level requirements to facilitate the stable connection and operation of new IBR as they come online in NSW.

In planning for this, Transgrid has adjusted AEMO's IBR forecast in the 2024 System Strength Report to include more recent available information (in particular the delay to the New England REZ infrastructure Project). This is consistent with the AER's 2024 guidance[72] which states "the SSSP should complete a holistic assessment using AEMO's forecast as a starting point".

70 From Transgrid's PACR market modelling. The IBR forecast developed follows AEMO's Integrated System Plan methodology and adopts AEMO's Final 2023 Inputs and Assumptions and Final 2024 Integrated System Plan Step Change outcomes, with updates to reflect more recent available information.
71 AEMC, 2021, Efficient management of system strength on the power system, Final determination, 21 Oct 2021, https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system
72 AER – Efficient Management of System Strength Framework – Guidance note, December 2024, pg 15

Figure 5.10: Summary of the types of solutions considered within the RIT-T

Synchronous condensers

- Network synchronous condenser
- Non-network synchronous condenser

Synchronous generation

- Existing, committed and anticipated units without synchronised condenser mode *(coal, gas, hydro)*
- Existing, committed and anticipated units with synchronised condenser mode *(hydro, compressed air)*
- Proposed synchronous generation *(gas, biomass, pumped hydro)*

Grid-forming batteries

- Existing, committed and anticipated grid-forming battery
- Conversion of grid-following battery to grid-forming
- Proposed grid-forming battery
- ISP-modelled battery, converted to grid-forming *(generic option)*
- 'Targeted' grid-forming battery *(generic option)*

Solutions considered to address future system strength needs

Transgrid assessed the economic and technical feasibility of more than 100 network and non-network solutions through its 'Meeting system strength requirements in NSW' RIT-T with the Project Assessment Conclusions Report (PACR) published in July 2025. This included submissions from 30 non-network proponents who responded to Transgrid's system strength Expression of Interest, covering more than 60 individual technology solutions. We also assessed 46 unique network solutions where Transgrid would manage and operate the asset. Technology types considered in the RIT-T assessment are outlined in Figure 5.10.

In assessing potential technologies, we took into account AEMO's 2024 Transition Plan for System Security,[73] which noted, "minimum levels of system strength must be provided by protection quality fault current, which grid-forming inverters have not yet demonstrated capability to provide". This is also consistent with AEMO's position in the May 2024 update to the 2023 Electricity Statement of Opportunities.[74]

Transgrid also engaged Aurecon to assess the maturity of grid-forming BESS to provide system strength support.[75] Aurecon concluded that there is insufficient evidence to rely on grid-forming BESS to support minimum fault level requirements (until FY33) but that grid-forming BESS are sufficiently mature to provide stable voltage waveform support to new connecting IBRs.

73 AEMO, 2024 Transition Plan for System Security, December 2024, p. 44
74 AEMO, Update to the 2023 Electricity Statement of Opportunities, May 2024, p. 43
75 Aurecon, Advice on the maturity of grid-forming inverter solutions for system strength, April 2024.

Optimal portfolio of system strength solutions

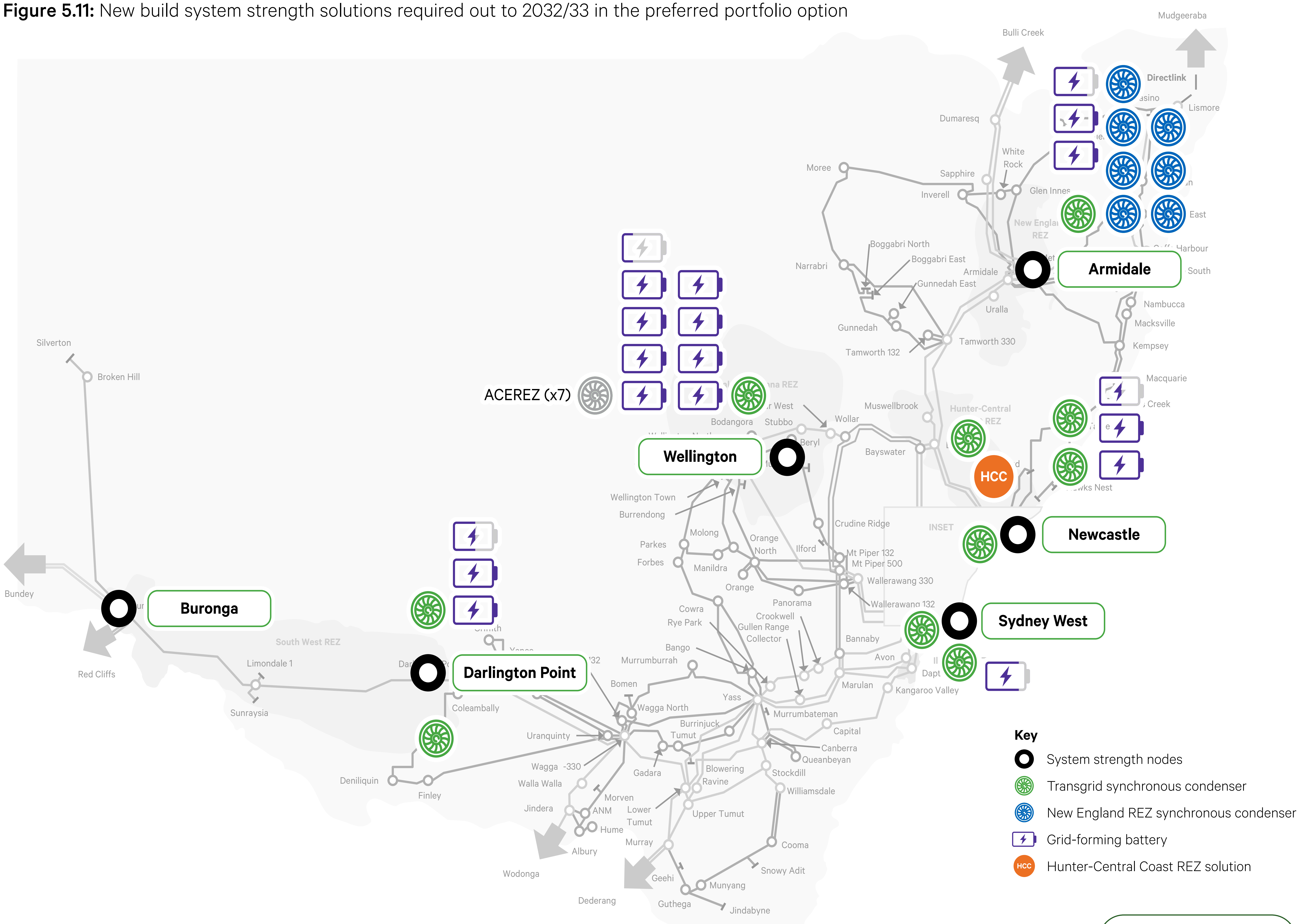
Our modelling identified a diverse portfolio of existing and new build system strength solutions to meet system strength requirements into the future. The preferred portfolio option identified in the RIT-T,[76] blends network and non-network solutions, including:

- 10 network (Transgrid) synchronous condensers required by FY30, each providing 1,050 MVA fault current
- 7 New England REZ synchronous condensers by FY33, each providing 1,050 MVA fault current
- four smaller synchronous condensers (each providing 275 MVA fault current) or 200 MW of grid-forming BESS in FY28 for Hunter-Central Coast REZ
- 650 MW of synchronous generation to be modified to enable synchronous condenser mode
- 5 GW of new build grid-forming BESS by FY33[77]
- Redispatch[78] of synchronous generation to fill gaps in system strength.

Since synchronous condensers will be a critical component, the timing of their delivery will have a significant impact on net market benefits and forecast system strength gaps.

Figure 5.11 shows the location of the new-build system strength solutions required by FY33.

Figure 5.11: New build system strength solutions required out to 2032/33 in the preferred portfolio option



76 Meeting system strength requirements in NSW RIT-T Project Assessment Conclusions Report (PACR)
77 While the portfolio of grid-forming batteries is aggregated by nameplate capacity for ease of communication, their stable voltage waveform provision is heavily influenced by the design and tuning of the inverter. Detailed power system studies during the procurement of grid-forming batteries will be used to identify the optimal configuration and size to meet the need.
78 The words 're-dispatched' or 're-dispatching' represent system strength solutions (typically existing or future synchronous generators) which are 'enabled' or 'scheduled-on' by AEMO to provide system strength services.

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Table 5.2: Summary of the composition of new build assets in the preferred credible portfolio option

	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	By 2044/45
Transgrid network synchronous condensers[79] Cumulative number of units (each providing 1,050 MVA fault current)[80]	-	-	-	3	10	10	10	10	10
New England REZ synchronous condensers Cumulative number of units (each providing 1,050 MVA fault current)	-	-	-	-	-	-	5	7	7
Hunter-Central Coast REZ system strength solutions	-	-	Either four 275 MVA fault current contribution synchronous condensers or 200 MW of grid-forming BESS[81]						
Upgrades to synchronous machine to allow synchronous condenser mode (existing and new units) – cumulative capacity (MW)	50	50	300	650	650	650	650	650	650
Grid-forming BESS – cumulative capacity (MW)	-	1,350	3,250	3,650	4,150	4,800	4,800	4,950	8,150

Expected cost of addressing system strength obligations

Given the magnitude of the portfolio, significant costs are associated with meeting system strength needs. In undiscounted FY24 dollars, we estimate total costs between now and the end of the next regulatory control period (i.e. FY33) of:[82]

- $1,608 million capital costs and $157 million operating costs for new network (Transgrid) synchronous condensers
- $1,258 million capital costs and $107 million operating costs for New England REZ synchronous condensers
- $18 million capital costs and no incremental operating costs for synchronous unit upgrades to allow synchronous condenser mode operation; and
- $2,644 million capital costs and $476 million operating costs for grid-forming BESS including new build and upgrades of committed/anticipated and ISP-modelled solutions to enable grid-forming capability.

The portfolio offers substantial benefits by avoiding gaps in system strength from FY29 through to FY45.

Reliance on additional operation of synchronous generators

Running synchronous generators more often than their typical energy market operation (termed as ‘re-dispatch’) is an important short-term solution to meet minimums level systems strength requirements in the early years before new synchronous condensers are available.

79 This is the earliest identified credible timing under the standard regulatory process. Transgrid is actively pursuing all pathways to enable the earliest procurement and installation of synchronous condensers to minimise power system security risks and maximise net market benefits. If successful, synchronous condensers could be delivered earlier, from FY28.
80 If synchronous condensers with a fault level contribution of <950MVA are selected through Transgrid's procurement process (calculated using unsaturated reactance), an additional one synchronous condenser is required in FY30 in the Sydney West or Newcastle region.
81 Network studies have identified these solutions meet the efficient level requirement in Hunter-Central Coast REZ and the cost of each are within a margin of error. Transgrid have opted to identify the preferred system strength solution through a procurement process.
82 These costs do not map directly to the costs Transgrid expects to recover via the regulatory control process (e.g., the unit upgrades to allow synchronous condenser mode operation and new grid-forming BESS build would be incurred by proponents of these solutions who would then charge Transgrid an operating fee). We have presented costs over this period here since investment decisions regarding the number of network synchronous condensers required by the end of next regulatory control period are expected to be made as a result of the outcomes of this RIT-T.

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Risks of system strength gaps from FY28 to FY30

A risk of gaps in the minimum level of system strength are projected to occur before sufficient synchronous condensers come online.

The largest risks will be during periods of co-incident generation maintenance or forced outages. Risk will increase during 'critical planned outages'. This is when transmission lines are taken out of service for maintenance or, for example, to connect new REZ transmission infrastructure.

The earliest possible delivery of synchronous condensers under the regulatory process is expected between March 2029 and February 2030. Under this delivery timeline, gaps to the minimum level system strength requirements are expected to occur up to:

- 2% of the time in FY28
- 1.5% of the time in FY29 at all NSW system strength nodes except Armidale. At Armidale, gap durations are projected to occur approximately 10% of time if critical planned transmission line outages occur as modelled.
- 5% of the time in FY30 at all NSW system strength nodes except Armidale, which could see gaps exceeding 20% if critical planned transmission line outages occur as modelled.

These system strength gaps have been identified based on a set of modelled assumptions consistent with the 2024 Integrated System Plan Step Change scenario, in accordance with the RIT-T guidelines.

If procurement of synchrononous condensers can commence ahead of the conclusion of the regulatory process, their earlier deployment would eliminate the modelled risk of system strength gaps in FY29 and FY30.

Transgrid is actively pursuing all pathways to install synchronous condensers as early as possible.

Transgrid will support AEMO and other relevant parties to manage the risks of insufficient system strength in the operational timeframe, for example through the scheduling of critical planned outages of transmission lines.

Delivering network and non-network solutions

We have now published the PACR, the final stage in the RIT-T process. We will begin procurement and regulatory processes for individual network and non-network solutions required as part of the preferred portfolio of system strength solutions, including:

- Network solutions (synchronous condensers): The Efficient management of system strength final determination deems a system strength project proposed to be undertaken by a system strength service provider in its current regulatory period (2023–2028 for Transgrid) to be a contingent project for the purposes of its revenue determination for that period. A key next step is to submit a contingent project application to the AER once all triggers have been met.
- Non-network solutions: The final portfolio of solutions in the PACR determine which non-network proponents or types of non-network solutions are eligible to participate in the Request for Tender process.[83] Following tender negotiations, for eligible contracts Transgrid will seek a determination from the Australian Energy Regulator on whether Transgrid's proposed expenditure on non-network options meets criteria indicating efficient and prudent expenditure. If successful, this will be followed by the execution of Non-Network System Security Service Agreements between Transgrid and proponents.

Under the Improving Security Frameworks rule change, AEMO will enable synchronous machines in the operational timeframe to seek to close forecasted gaps in system strength.

5.1.5 System strength information provision

Under clause 5.20C.3[84] of the NER, Transgrid must publish information in this Report relating to activities, methodologies, assumptions, results and forecasts associated with providing system strength at system strength nodes in NSW. This section constitutes Transgrid's response and should be read in conjunction with Transgrid's system strength PACR.[85]

Activities undertaken or planned to satisfy system strength obligations[86]

The activities described in Table 5.3 to satisfy system strength obligations under clause S5.1.14 have been undertaken or are planned. See Appendix 3 (Section A3.18) for modelling methodologies, assumptions and results used by Transgrid in planning the activities referred to in the table.

83 If you are interested in tendering for these contracts, but have not previously submitted an EOI for your project(s), or there have been material changes to your project since your EOI, you may submit a new or updated EOI at any time using the documentation on Transgrid's website (Key documents and Information for non-network proponents)
84 NER Clause 5.20C.3
85 Transgrid, Meeting system strength requirements in NSW
86 NER Clause S5.1.14

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Table 5.3: Summary of key activities undertaken or planned to satisfy system strength obligations

Milestone	Date	Activity undertaken
Project Specification Consultation Report **(PSCR)**	December 2022	Published a PSCR for the 'meeting system strength requirements in NSW' RIT-T, which includes a system strength shortfall at Newcastle and Sydney West fault level nodes from July 2025 and obligations to provide the minimum and efficient level of system strength in full at all nodes in NSW from 2 December 2025. Transgrid engaged stakeholders through a 12-week consultation period where five submissions were received.
Expression of Interest (EOI) for non-network solutions	December 2022	Engaged with non-network system strength proponents to accurately reflect their solutions in the PADR modelling process. Transgrid received EOI submissions from 25 parties, covering more than 60 individual solutions, including more than 10 GW of existing or conversions of existing synchronous generators, a pipeline of more than 10 GW of innovative grid-forming batteries, and more than 5 GW of other new generation and energy storage projects, including pumped hydro and gas.
System Strength Unit Prices **2024/25**	May 2024	Published System Strength Unit Prices FY25 on our website[87] and added an explainer on the System Strength Charge for new connecting parties on our website[88]
Project Assessment Draft Report **(PADR)**	June 2024	Published a PADR for the 'meeting system strength requirements in NSW' RIT-T, which conducted a techno-economic assessment to identify a preferred portfolio of system strength solutions to meet the minimum and efficient level at all nodes in NSW from 2 December 2025. Transgrid engaged stakeholders through a 12-week consultation period where two submissions were received. Additional documents were published via Transgrid's website providing information on modelling, technical performance of synchronous machines and grid-forming BESS and non-network proponent guidance.
PADR Market Modelling Report	June 2024	Produced by Baringa Partners who undertook the market modelling for Transgrid's PADR, that outlines how system strength solutions were co-optimised in a market model to identify a preferred portfolio of system strength solutions. This report included an explanation of key modelling assumptions and the PLEXOS and PSS®E validation process.
Non-network solution EOI re-engagement and re-opening for new solutions	June 2024	Engaged with new and existing and non-network system strength proponents to accurately reflect their solutions in the PACR modelling process. Submissions for non-network solutions were received from 30 parties, covering more than 60 individual potential solutions.
Industry engagement of technical requirements for non-network solutions	June 2024	Two public industry briefings were held to provide guidance for proponents of non-network solutions.
Non-network solution commercial EOI	August 2024	All proponents of EOI non-network solutions were requested to return a commercial component to the EOI containing indicative pricing information.
Supplementary Report to the PADR	October 2024	Published a supplementary report to the PADR to incorporate developments since completion of the PADR and provide opportunity for stakeholder consultation ahead of the PACR being prepared. Submissions were requested over a 4-week consultation period and one submission was received.
Project Assessment Conclusion Report (PACR)	July 2025	Published the final stage of the 'meeting system strength requirements in NSW' RIT-T, which conducted a techno-economic assessment to identify a preferred portfolio of system strength solutions to meet the minimum and efficient level at all nodes in NSW from 2 December 2025. The system strength shortfall from July 2025 previously declared by AEMO has been deferred until FY28.

87 Transgrid, System Strength Unit prices – 2024/25
88 Transgrid, System strength for network connections

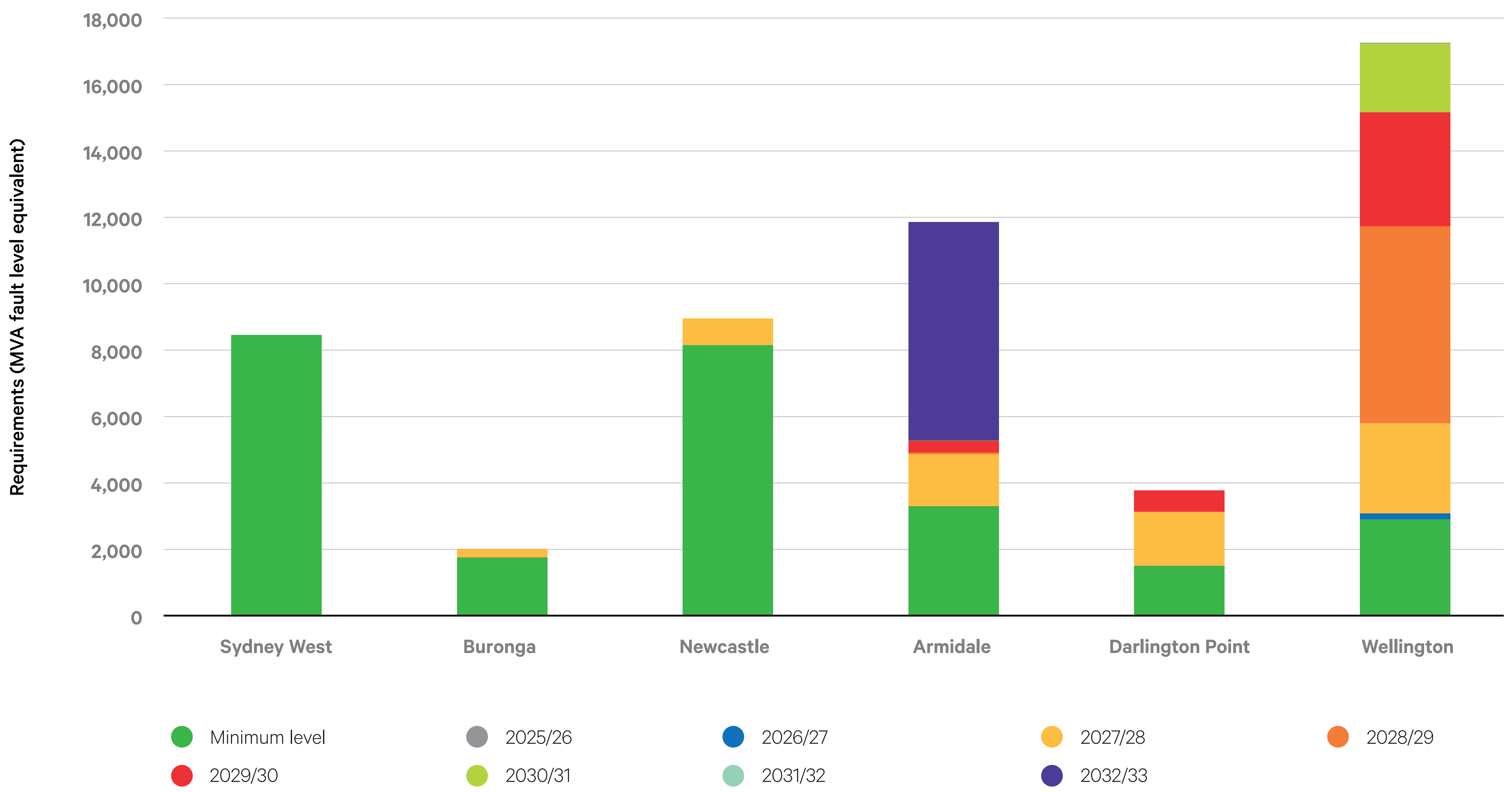
Forecast of available fault level at each system strength node

Under the new system strength framework, Transgrid must make sufficient system strength services available to AEMO to achieve stable voltage waveforms for the IBRs and market network service facilities projected in steady state conditions and following any credible contingency or protected event.[89]

Figure 5.12 and Table 5.4 below document minimum and 'efficient' fault level projections to FY33.

As part of the system strength RIT-T, we undertook (and published)[90] an assessment of stable voltage waveform remediation required using the Available Fault Level proxy method versus detailed PSCAD™ studies. We concluded that the AFL method is a useful long-term planning proxy for stable voltage waveform requirements, with PSCAD™ studies providing more accurate results. However, for the system strength RIT-T and ongoing assessment of stable voltage waveform requirements, Transgrid uses a combination of Root Mean Square analysis (using AFL calculation in PSS®E) and electromagnetic transient analysis (PSCAD™). This enables us to accurately model the benefits of grid-forming BESS, whose contribution to stable voltage waveform is not adequately represented in Available Fault Level calculations.

Figure 5.12: NSW's combined minimum pre-contingency fault level requirements from 2 December 2025 and efficient fault level projections to FY33, as a proxy for stable voltage waveform*



*The estimated efficient fault level required to ensure a stable voltage waveform for new connecting renewables in this chart uses an available fault level measurement as a proxy. This is consistent with the methodology outlined in AEMO's System Strength Impact Assessment Guidelines.[91]

89 Clause S5.1.14 of the National Electricity Rules
90 Aghanoori et. al., 2025, Comparison Between Synchronous Condensers and Grid-Forming BESS in Providing System Strength Support to IBRs in Weak and Strong Power Systems Using EMT Simulation, CIGRE, accessible here.
91 AEMO, System Strength Impact Assessment Guidelines, https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/system-strength-impact-assessment-guidelines

Table 5.4: NSW's combined cumulative minimum pre-contingency fault level requirements from 2 December 2025 and efficient fault level projections to FY33, as a proxy for stable voltage waveform (MVA fault level)

Node	Pre-contingent minimum	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33
Armidale	3,300	3,300	3,300	4,864	4,920	5,261	5,273	5,187	11,774
Buronga	1,755	1,755	1,755	2,009	2,012	1,952	1,946	1,950	1,950
Darlington Point	1,500	1,500	1,500	3,128	3,134	3,772	3,761	3,581	3,582
Newcastle	8,150	8,150	8,150	8,150	8,150	8,150	8,150	8,150	8,150
Sydney West	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450
Wellington	2,900	2,900	3,083	5,797	11,731	15,159	17,248	17,249	17,258

Possible future system strength nodes in NSW

As the electricity system transitions to renewables, additional nodes may be declared. AEMO is currently proposing three possible future system strength nodes in NSW (Table 5.5).

Table 5.5: Possible future system strength nodes (330 kV) in NSW region[92]

System strength node	Effective date range	Purpose of new node
Dinawan 330 kV	EnergyConnect commissioning	May provide better location for IBR in Southern NSW
Lower Tumut 330 kV	Eraring Power Station retirement	May allow for alternative synchronous sources in NSW
Wollar 330 kV	Removal of Wellington node	May provide better locations for IBR in Central West Orana

System strength locational factors for Transgrid's bulk supply points

We have calculated system strength locational factors (SSLF) for each of Transgrid's main supply points based on the latest version of the system strength impact assessment guideline.[93] SSLF is one of the variables which must be used along with System Strength Unit Price to calculate the system strength charge.

System strength and protection system correlation

Power electronics devices will constitute an indispensable part of the new power system. However, the presence of more of these devices will give the current power system different fault characteristics, like limited short-circuits and distorted phase angles. Also, as system strength declines, the three-phase fault level is decreasing in NSW. This imposes operational challenges and creates a risk of protection malfunction. Accordingly, we are investigating the performance of protection settings across the NSW network.

Transgrid Substation Buronga NSW

92 AEMO's 2024 System Strength Report, Dec 2024
93 AEMO, System Strength Impact Assessment Guidelines

5.1.6 Frequency control

Frequency control is provided across the NEM through inertia, Fast Frequency Response (FFR) and Frequency Control Ancillary Services. FFR has the potential to act quickly during disturbances and is a partial substitute for synchronous inertia. The NEM will have sufficient frequency control capability over the next 10 years, if there is adequate inertia.

5.1.7 Inertia

From 1 December 2024, AEMO set a 10-year forward requirement for the minimum system-wide inertia level – the minimum amount of inertia required for the mainland states to keep the power system in a secure operating state.[94] AEMO also set a new 'inertia sub-network allocation' from 2 December 2024 to 1 December 2034, at 9,600 MWs for NSW.

As part of the new rule, TNSPs must ensure inertia services are available continuously within three years of the requirements being published. Given AEMO identified no projected inertia shortfalls in NSW over the three-year period from December 2024 to December 2027, Transgrid therefore needs to procure sufficient inertia from 2 December 2027 onwards to meet these requirements.

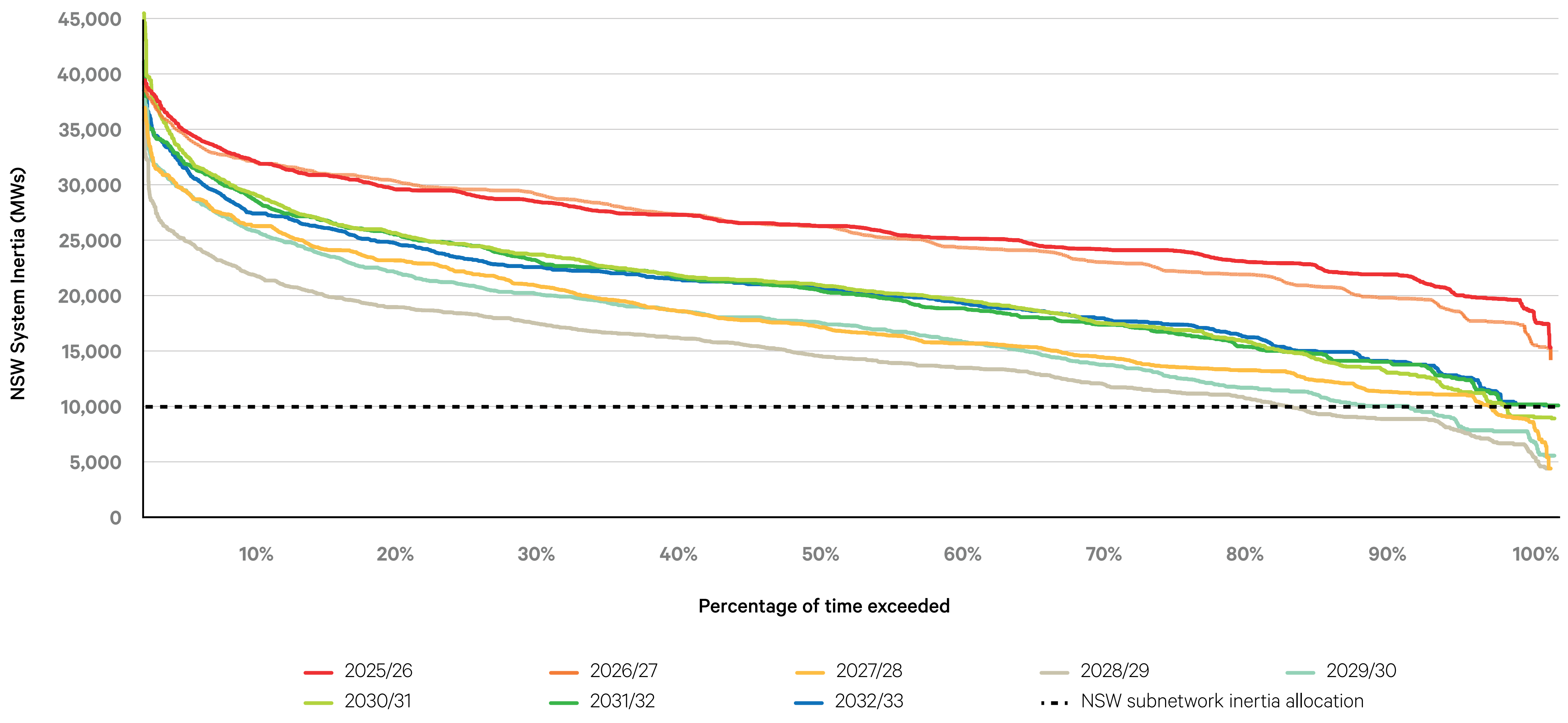
In March 2024, the AEMC introduced the 'improving security frameworks for the energy transition' rule change,[95] aligning new inertia requirements with system strength, so TNSPs can co-optimise inertia and system strength requirements together. Because our system strength modelling began before AEMO finalised the new rule, co-optimisation has not been undertaken. Still, the NSW power system will gain extra inertia from flywheels added to synchronous condensers to provide the stable voltage waveform support required to meet future efficient level system strength needs.

The changing landscape of inertia in NSW

Transgrid's undertook detailed power systems studies in PSS®E software to analyse the forecast inertia levels in NSW under typical energy market conditions, without new system strength services (with the exception of publicly announced synchronous condensers in Central West Orana REZ).

The results in Figure 5.13 show a continual decline in inertia over the next decade, driven by the progressive retirement of synchronous coal units from the energy market. Without the addition of new sources of system strength, gaps to NSW's 'inertia subnetwork allocation' of 9,600 MWs are expected to occur from FY31 onwards.

Figure 5.13: Forecast NSW system inertia levels between now and 2033/34 (without system strength remediation)



94 Available at: https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system_security_planning/2024-inertia-report
95 Available at: https://www.aemc.gov.au/rule-changes/improving-security-frameworks-energy-transition

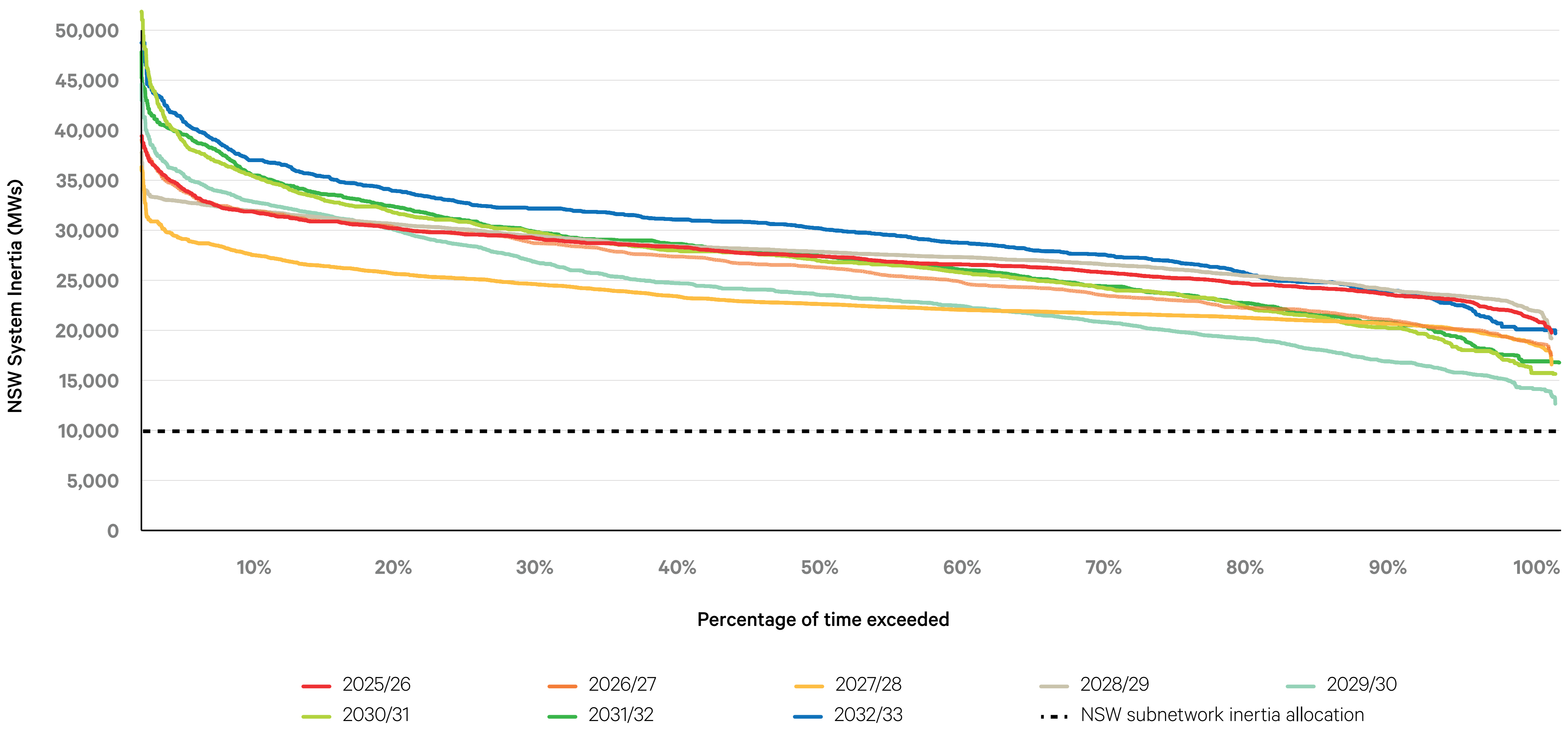
Addressing future inertia requirements

As part of the optimal portfolio of solutions for system strength requirements, 10 network synchronous condensers are required by FY30, each equipped with flywheels to produce 1,500 MWs of inertia per machine.

Adding flywheels to synchronous condensers provides a high level of inertia while only increasing project costs by about 3%. In fact, our modelling indicates that the addition of flywheels to each network synchronous condenser (for the purpose of stable voltage waveform support) will enable inertia requirements in NSW to be met without additional investment. This is demonstrated in Figure 5.14, which shows the cumulative probability of available inertia in NSW for each year between now and FY33, assuming that 10 synchronous condensers are deployed progressively from FY29. With these 10 network synchronous condensers equipped with flywheels, Transgrid predicts zero instances between now and FY33 where inertia in the system drops below the secure level.

The AER Efficient management of system strength framework guidance note[96] agrees that adding a flywheel to a synchronous condenser is expected to be considered prudent and efficient expenditure given the marginal cost of addressing inertia is typically relatively low.

Figure 5.14: Forecast NSW system inertia levels between now and FY33 where new sources of system strength are added



5.1.8 Remedial action schemes for system security

Transgrid's Emergency Control Schemes do not currently meet the definition under NER clause S5.1.8 Stability. Our studies show a risk of widespread over-voltage conditions on the main transmission network after a rare automatic under-frequency load-shedding event. To address this, a project is progressing to install an overvoltage control scheme following such an event. Risk will also be partially reduced as individual schemes are commissioned.

Transgrid already has automatic under-frequency load-shedding schemes at the following substations: Armidale, Coffs Harbour, Gunnedah, Inverell, Kempsey, Koolkhan, Moree, Muswellbrook, Narrabri, Port Macquarie, Tamworth, Taree, Panorama, Griffith, Tumut, Wagga Wagga and Yanco.

There are no known issues or conflicts between these schemes, with either protection or control systems.

5.1.9 REZ connection to Transgrid network

Our frequency stability studies show that the NEM may not tolerate large contingencies due to lack of available under-frequency load shedding, or cascading tripping due to exceeding the rate of change of frequency threshold. The combined power-transfer capacity of a large REZ (such as Central West Orana REZ or New England REZ) exceeds this threshold.

Unlike other large connections involving a single generating source, such as a hydroelectric power plant, a REZ is significantly more geographically distributed. As a result, there are security and resilience benefits from splitting REZ connections to the shared network across multiple circuits. Both the Central West Orana REZ and the New England REZ connections to the shared network have been jointly planned by EnergyCo and Transgrid to incorporate sufficiently resilient configurations and to N-1 Secure design standards to mitigate these issues.

96 AER – Efficient Management of System Strength Framework – Guidance note, December 2024, pg 15

5.2 Modern tools and skills for a complex power system

Transgrid's control-room systems are reaching their operability limits and urgently require enhancements if the network it to be managed safely and reliably over the next decade. Options such as hiring more control room operators or waiting for the lifecycle replacement of existing systems are not sufficient to keep pace with the energy transition.

Already, our grid is more frequently operating closer to the edge of its secure envelope. This requires increased scrutiny from operators who must intervene rapidly. The tools used to manage the old grid are not up to the challenge. As a priority, we need new digital tools – including real-time and look-ahead monitoring.

As our local and global industry peers acknowledge, the change from a handful of dispatchable, synchronous machines to large numbers of variable inverter-based resources are increasing the complexity of system operations (see Section 1.4). The variability of solar and wind generation sources, along with new inverter-based technologies, creates a dynamically less stable network.

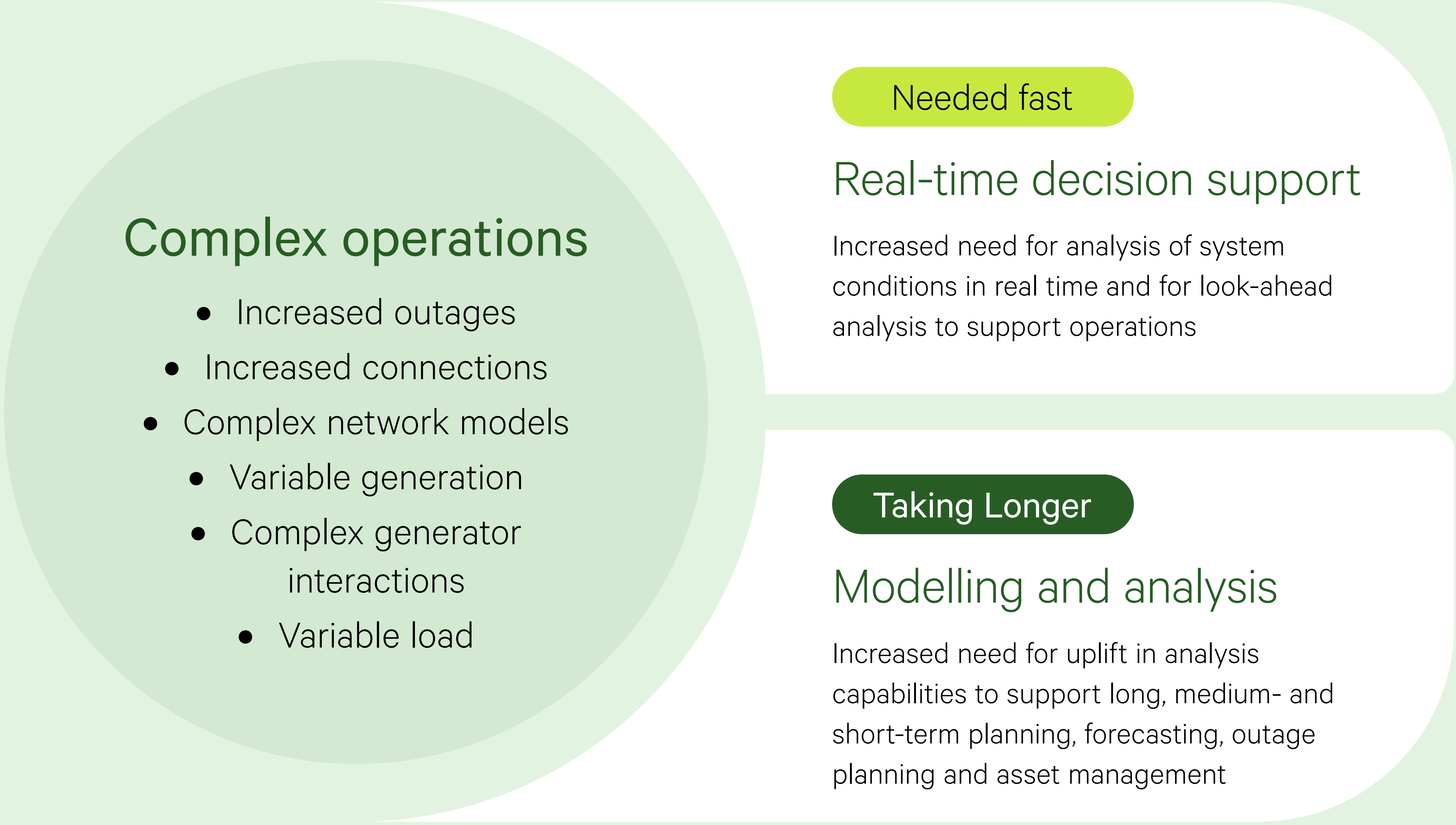
A proxy to determine the optimal rate of investment in operational software and capability uplift is the growth in Variable Renewable Energy (VRE). VRE drives the growth and complexity of the transmission network by adding more assets, more data and new technologies.

The current and increasing impact of VRE growth is that network modelling and analysis takes longer and real-time decisions are required faster (see Figure 5.15). Whenever the network is operating close to the edge of the technical envelope, it is more likely to tip into insecure operating conditions if a credible contingency occurs. Transgrid will therefore need advanced skills and modern software tools to deliver a secure and reliable energy service.

To optimise investment, Transgrid has recommended three distinct timeframes for uplifting operational tools and capabilities through our Operability RIT-T.[97]

- Phase 1 (complete between 2024–2025): addressing immediate risks to deliver short-term results that lay the foundation for future phases. This includes rationalised and improved alarm handling for the control room.
- Phase 2 (2025–2030): addressing the operational needs to manage the power system requirements outlined in AEMO's 2024 Integrated System Plan Step Change scenario. The scope and funding required for enhanced operational systems and data management will be sought through a contingent project application.
- Phase 3 (beyond 2030): setting visionary goals based on long-term energy transition projections. Maturing and leveraging the value generated from the previous phases. The scope and funding required will be determined within Phase 2 based on learnings, industry trends and the pace of the energy transition.

Figure 5.15: The growing complexity of the electricity system is driving capability gaps



97 System System Security Roadmap Operational Technology Upgrades RIT-T, PADR

5.2.1 Phase 1 – Short-term results to mitigate escalating operational risk

Alarm management

The growth and increasing complexity of modern network assets mean the number alarm points our control room has to monitor is increasing exponentially. The number of alarms doubled in the eight years between 2015 to 2023 from 18,000 to 36,000. Yet, it took just two years, from 2023 to 2025, for alarm points to almost double again to 65,000.

In response, this year, Transgrid completed our phase 1 alarm management initiative as planned, enhancing situational awareness and supporting real-time decision making. This initiative has:

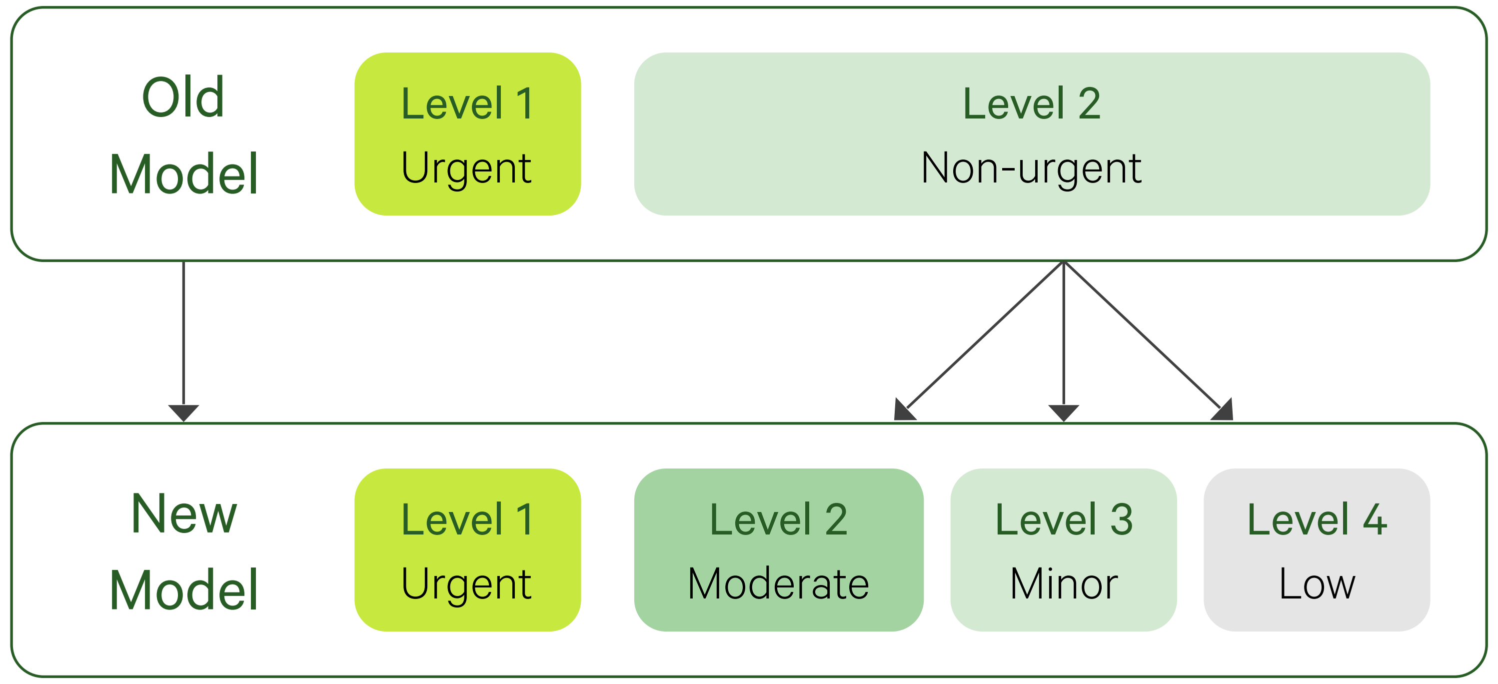
- Enhanced prioritisation and categorisation, resulting in a reduced cognitive load for operators
- Reduced alarms to operators through redistribution and improved alarm visualisation, thus accelerating alarm triaging
- Reduced alarms to events requiring no action
- Established an alarm-management philosophy to enable intelligent alarm-handing solutions that will be implemented in Phase 2, aggregating multiple alarms to present operators with prescriptive information to support better-informed, faster decision making.

Figure 5.16: Summary of alarm management benefits

- **Enhanced prioritisation** resulted in **reduced cognitive** load to Operators
- **Reduction of alarms to Operators** through redistribution
- **Reduction of alarms** to events requiring no action

Figure 5.17: Transition from two to four level alarm priorities

Adding two new priority levels enables operators to quickly identify the higher priorities within "non-urgent" alarms and reassign low priority alarms to other teams during business hours.



5.2.2 Phase 2 – Operability to 2030

Grid control rooms use operational technology – hardware and software that monitor and control devices, processes and infrastructure. At the heart of our control room is a set of three core, monolithic software applications required for network operations:

- Energy Management System/Supervisory Control and Data Acquisition
- Asset management and monitoring system
- Outage management system.

Transgrid's System Security Roadmap[98] details the future challenges to our current operating technology as the energy transition accelerates.

The Roadmap also notes that two additional issues make our capability uplift even more urgent:

- **The need for system integration:** Today's systems are independent applications, working in parallel. But in a more complex and volatile grid, these systems will need to be integrated so they can share data to support situational awareness. Operational and network planning require increasing integration with real-time operational data and asset information, along with more sophisticated modelling of potential operational outcomes and power system behaviours for future operational states, to ensure that planned operations remain N-1 secure. This can only be achieved efficiently and effectively in an integrated technology environment
- **The need to keep up with network change:** When network growth is rapid and new network technologies are constantly being integrated into the grid, international peers recommend we remain ahead of the growth and evolution in ISP-projected assets, resources and demand changes. Otherwise, international experience suggests that our operators will struggle to monitor and control for operational risks.

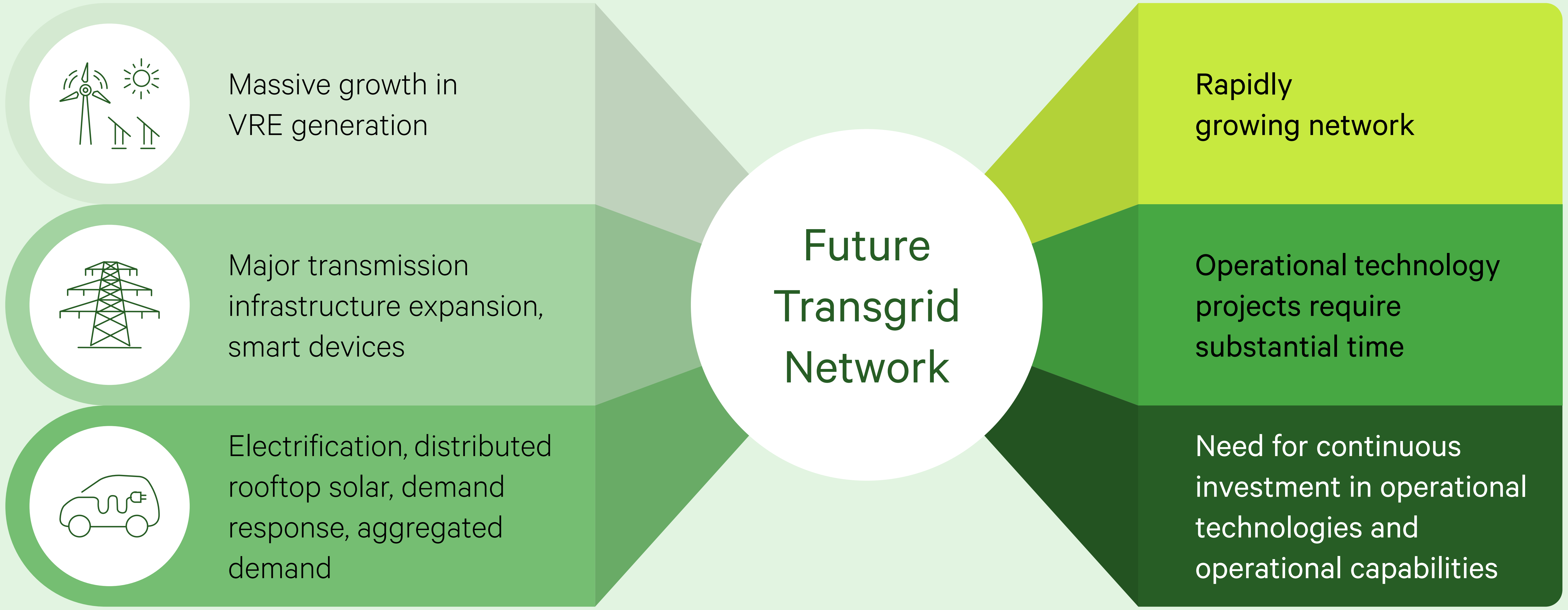
98 Transgrid, System Security Roadmap

We are working closely with AEMO to determine the most appropriate and future-proof suite of operational systems and skills[99] Our goal is to provide an uplift that aligns with AEMO's Operations Technology Roadmap[100] and Engineering Roadmap,[101] and we have sought independent advice from Electric Power Research Institute and GHD, other Australian TNSPs and industry peers. We are also engaging closely with Transgrid's Advisory Council to ensure consumers are kept top of mind as we plan for a modern control room.

Transgrid has completed the Project Assessment Draft Report stage of the RIT-T consultation process to apply for the necessary investment to modernise our operational technology via a Contingent Project Application. This investment is essential to ensure we can continue to operate the future network safely and reliably.

We hope for our System Security Roadmap – Operational Technology Upgrade Contingent Project Application to be supported in starting a range of projects to uplift operability from 2026.

Figure 5.18: Future network evolution drives need for continuous investment in operational technologies



99 AEMO letter of support
100 AEMO, Operations Technology Roadmap
101 AEMO, Engineering Roadmap to 100% Renewables

2025 NSW Region demand projection method

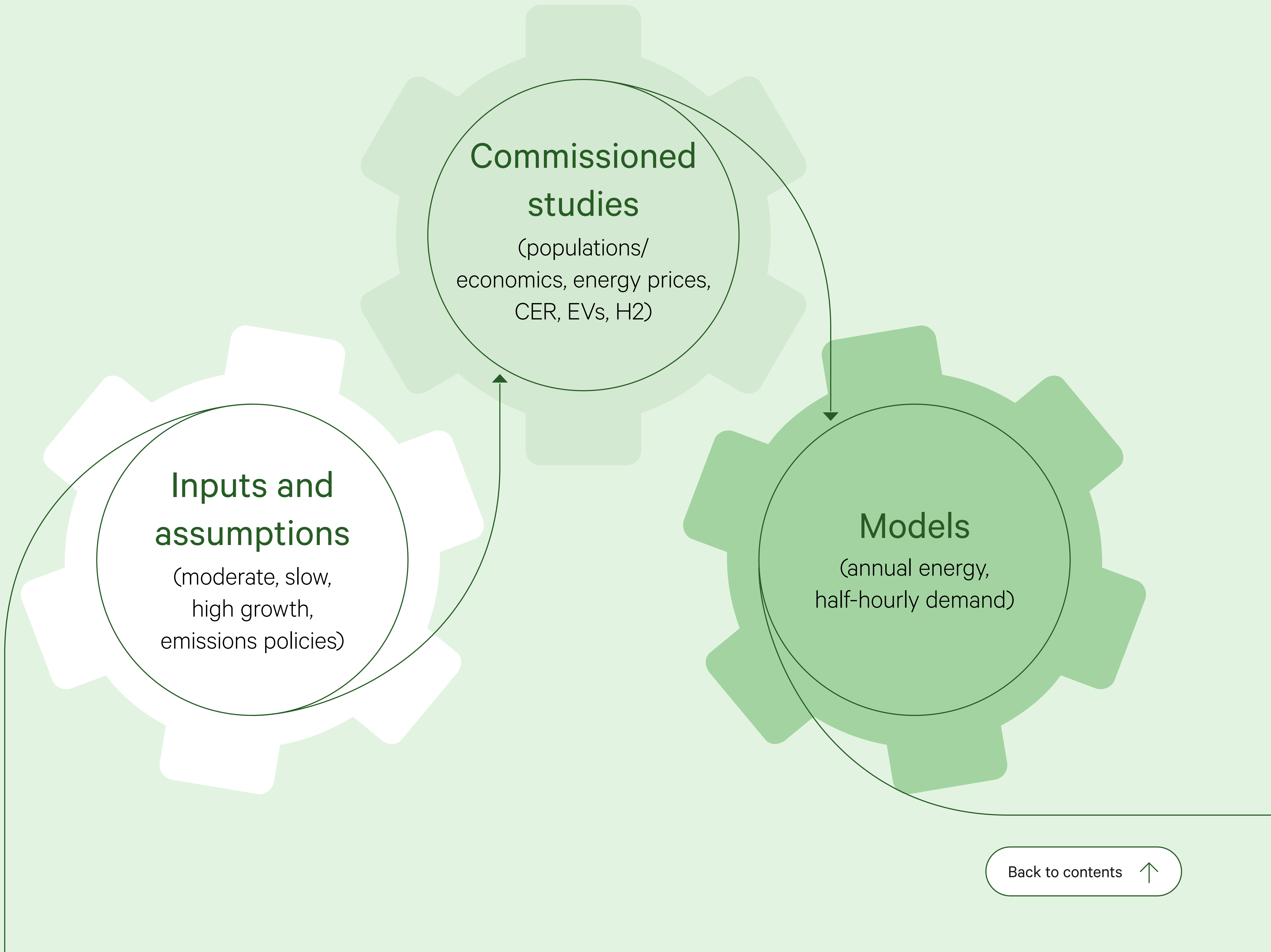
A1.1 Introduction

Future scenarios for NSW Region electricity demand are described in Chapter 4 and consist of medium, high and low projections of annual energy, summer and winter maximum demand and annual minimum demand.

Transgrid prepared the 2025 energy and demand projections by combining inputs and assumptions informed by independently commissioned studies with modelling undertaken in-house with assistance from GHD, as shown in Figure A1.1.

This appendix sets out our demand definitions, description of the forecasting model development, input sources and assumptions, forecast validation and model-derived future load profiles.

Figure A1.1: Preparation of the NSW Region electricity demand projections



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A1.2 Demand definitions

Figure A1.2 shows a typical power system operating in the NSW Region of the NEM. AEMO classifies each unit of generation connected to the NEM as either a scheduled, semi-scheduled or a non-scheduled generating unit. Energy flows can be measured at different points of the supply chain as described below.

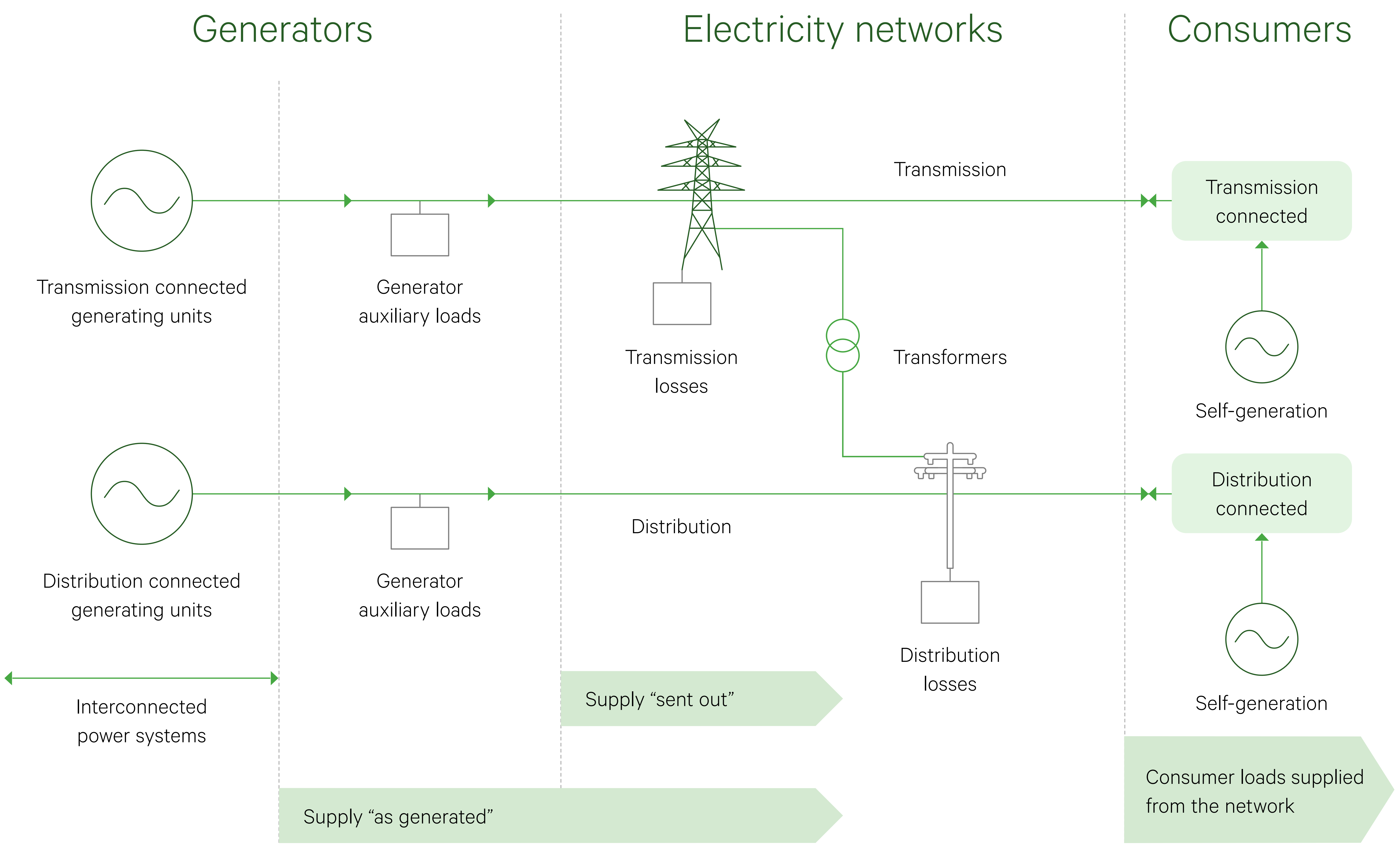
"As generated" refers to energy or demand that includes generator auxiliary loads, and "sent out" refers to consumption or demand that excludes generator auxiliary loads.

"Native" (or network) energy is equal to "operational" energy as defined by AEMO, with the addition of energy supplied by non-scheduled generating units of less than 30 MW capacity, measured in GWh over a financial year. The operational measure includes generation by scheduled, semi-scheduled and non-scheduled generating units greater than or equal to 30 MW. Transgrid measures and forecasts native energy on a "sent out" basis.

"Native" (or network) demand is equal to "operational" demand as defined by AEMO, with the addition of demand supplied by non-scheduled generating units of less than 30 MW capacity. The operational measure includes generation by scheduled, semi-scheduled and non-scheduled generating units greater than or equal to 30 MW, measured in MW at a half-hourly resolution. Transgrid measures and forecasts native demand on an "as generated" basis.

"Underlying" energy or demand refers to consumers' collective need for power to run their appliances. Underlying demand is estimated by removing the effects of consumer energy resources. Behind-the-meter solar generation and battery discharging are added to network demand. EV and behind-the-meter battery charging are subtracted from network demand.

Figure A1.2: Schematic power system



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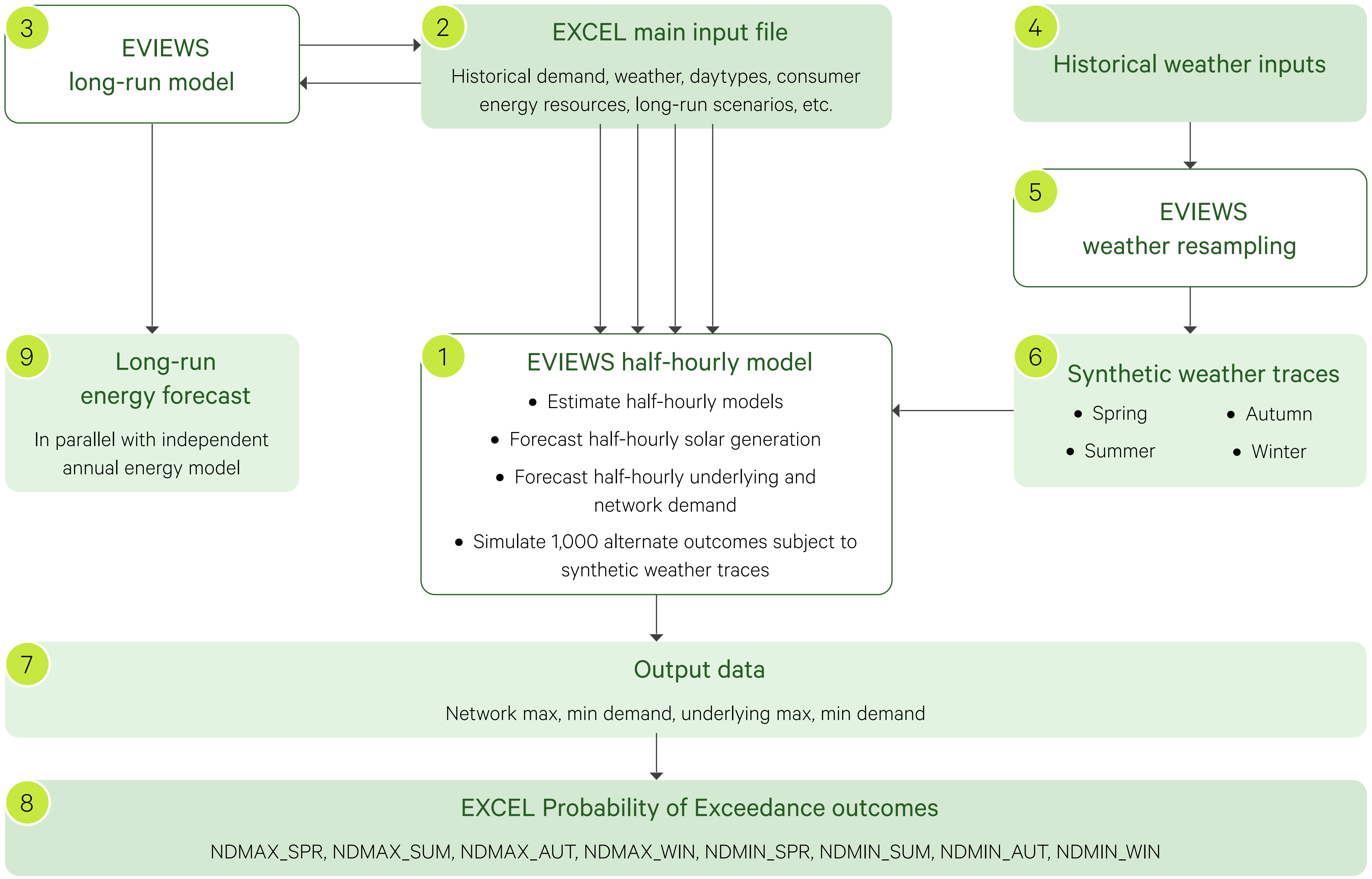
A1.2 Forecasting model development, input sources and assumptions

A1.2.1 Overview of the modelling approach

Transgrid uses an in-house forecasting model of half-hourly electricity demand to prepare simulations and estimate the probabilities of exceeding maximum and minimum demands for each season. This model is essentially unchanged since Transmission Annual Planning Report 2024 apart from updating for more recent actual demand and input data. The half-hourly model predicts variations around a long-run component represented as the average half-hourly demand for every season throughout the forecast horizon. The long-run, half-hourly model is also used to prepare annual energy forecasts, in conjunction with a separate annual model. A high-level schema of the modelling framework is shown in Figure A1.3. The numbers in the Figure show the steps in the Model Framework.

The main half-hourly model is estimated and used to simulate maximum and minimum demands using Eviews (www.Eviews.com).

Figure A1.3: Transgrid's load forecasting model framework



A1.2.2 Sources of model inputs

The demand projections are derived by combining inputs from a variety of sources, including:

- Econometric modelling of the impacts of population, price, economic growth, weather and other drivers of underlying consumer behaviour – undertaken independently by Transgrid with assistance from GHD
- Weather correction of historical electricity maximum and minimum demands and the calculation of probability of exceedance levels – undertaken independently by Transgrid with assistance from GHD
- Econometric modelling and simulation of maximum and minimum demand – undertaken independently by Transgrid with assistance from GHD
- Projected growth and daily profiles of large industrial, mining and data-centre loads – prepared by Transgrid with assistance from GHD
- Demographic and economic forecast scenarios for NSW (including the ACT) – provided by Oxford Economics
- Projections of future energy price paths – undertaken by Jacobs
- Modelling of rooftop solar installation and generation, and distributed battery storage – undertaken by Jacobs
- Projections of the take-up of externally charging electric vehicles – undertaken by Energeia
- Renewable hydrogen production scenarios for NSW – undertaken by GHD and derived from AEMO ISP 2026 draft stage 2 Inputs and Assumptions.

Each demand projection component or input was prepared in alignment with AEMO ISP scenarios including Step Change (i.e., Transgrid "Medium"), Green Energy Industries (i.e., Transgrid "High") and Progressive Change (i.e., Transgrid "Low").

A1.2.3 Model design, development and testing

To model consistent, economically meaningful relationships, we construct underlying demand in MW from network demand as set out below in Equation A1.1. Forecasts of underlying demand prepared using the model are then converted to network demands by reversing the process, using adopted future profiles for the right-hand-side variables. These future profiles are either derived from NSP connection enquiry information (industrial, hydrogen and data-centre loads) or attained from some of the sources noted above in section A1.2.2 (solar, battery and EV adoption and use).

Equation A1.1: Construction of underlying demand

$$UD = ND - IND - HYD - DAT + PV + BAT - EV$$

Where:

ND = As generated network demand (demand supplied by the transmission network)

UD = Underlying demand (power consumed by electrical appliances)

IND = Major industrial/mining load

HYD = future hydrogen electrolyser load

DAT = future large data-centre load

PV = consumer (small-scale) photovoltaic behind-the-meter generation

BAT = consumer (small-scale) battery discharging (positive) or charging (negative)

EV = electric vehicle charging

We represent underlying demand as a daily matrix of 48 half hours. Each model representing a particular time of day incorporates a common long-run component and a range of inputs that drive intra-daily, daily and seasonal variation, as shown in Table A1.1.

Table A1.1: Short-run demand model inputs (daily data)

Name	Description	Definition
Seasonal		
TOY	Time of year	A Fourier series sinoid function with two full cycles a year, ranging from +1 at midsummer and midwinter, to – 1 in mid-April and mid-October
Days of week		
SUN	Sunday	A binary variable equal to 1 if the day of the week is Sunday, and equal to 0 at other times
MON	Monday	A binary variable equal to 1 if the day of the week is Monday, and equal to 0 at other times
TUE	Tuesday	A binary variable equal to 1 if the day of the week is Tuesday, and equal to 0 at other times
THU	Thursday	A binary variable equal to 1 if the day of the week is Thursday, and equal to 0 at other times
FRI	Friday	A binary variable equal to 1 if the day of the week is Friday, and equal to 0 at other times
SAT	Saturday	A binary variable equal to 1 if the day of the week is Saturday, and equal to 0 at other times
Holidays		
XMAS	Christmas day	A binary variable equal to 1 if the date is 25 December, and equal to 0 at other times
BOX	Boxing day	A binary variable equal to 1 if the date is 26 December, and equal to 0 at other times

Name	Description	Definition
AHOL	Additional holiday	A binary variable equal to 1 if it is either (a) a Monday following a fixed date holiday on the previous Saturday (XMAS, BOX, NEW, AUS, ANZ), (b) a Monday following a fixed date holiday on the previous Sunday (NEW, AUS, ANZ), or (c) a Tuesday following a fixed date holiday on the previous Sunday (BOX), and equal to 0 at other times
NEW	New Year's Day	A binary variable equal to 1 if the date is 1 January, and equal to 0 at other times
AUS	Australia day	A binary variable equal to 1 if the date is 26 January, and equal to 0 at other times
GFRI	Good Friday	A binary variable equal to 1 if it is Good Friday, and equal to 0 at other times
ESAT	Easter Saturday	A binary variable equal to 1 if it is Easter Saturday, and equal to 0 at other times
ESUN	Easter Sunday	A binary variable equal to 1 if it is Easter Sunday, and equal to 0 at other times
EMON	Easter Monday	A binary variable equal to 1 if it is Easter Monday, and equal to 0 at other times
ANZ	ANZAC day	A binary variable equal to 1 if the date is 25 April, and equal to 0 at other times
KING	King's birthday	A binary variable equal to 1 if it is the second Monday in June, and equal to 0 at other times
LAB	Labour day	A binary variable equal to 1 if it is the first Monday in October, and equal to 0 at other times

Name	Description	Definition
PHOL	Monday preceding a public holiday	A binary variable equal to 1 if it is Monday and the following day will be Christmas Day (XMAS), New Year's Day (NEW), Australia Day (AUS) or Anzac Day (ANZ), and equal to 0 at other times
FHOL	Friday following a public holiday	A binary variable equal to 1 if it is Friday and the previous day was New Year's Day (NEW), Australia Day (AUS) or Anzac Day (ANZ), and equal to 0 at other times
SHOL	Summer break	A binary variable equal to 1 if the date is between 25 December of the current year and 14 January of the following year, and equal to 0 between those dates if any other holiday variable is in effect, and 0 outside those dates
DLS	NSW daylight savings	A binary variable equal to 1 if it the date is between the first Sunday of October of the current year and the first Saturday of April of the following year, and equal to 0 outside those dates
Weather		
HD, HD(-1) and HD(-2)	Heating degrees and lags of heating degrees	Variation below 18 in the calculated representative daily temperature (equal to zero if the temperature is 18 or above)
CD, CD(-1) and CD(-2)	Cooling degrees and lags of cooling degrees	Variation above 21 in the calculated representative daily temperature (equal to zero if the temperature is 21 or above)

Name	Description	Definition
TMAXP	Maximum temperature (Parramatta)	Maximum temperature recorded in the 24 hours to 9 a.m. the following morning at a Western Sydney site
TMINP	Minimum temperature (Parramatta)	Minimum temperature recorded in the 24 hours to 9 a.m. of the current day at a Western Sydney site
TMAXS	Maximum temperature (Sydney Airport)	Maximum temperature recorded in the 24 hours to 9 a.m. the following morning at an eastern Sydney site
TMINS	Minimum temperature (Sydney Airport)	Minimum temperature recorded in the 24 hours to 9 a.m. of the current day at an eastern Sydney site

The long-run model component has a seasonal resolution. This enables us to simultaneously estimate annual energy as generated, which we use in weighted combination with the separately prepared annual energy projection. The long-run model of underlying average demand incorporates the inputs shown in Table A1.2.

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Table A1.2: Long run demand model inputs (quarterly data)

Name	Description	Definition
POP	Population	Resident population of NSW and ACT
SFD	State Final Demand ($millions chain value measure)	State Final Demand of NSW and ACT
PE	Average electricity price	Weighted average, for NSW and ACT, of consumer and producer price indices
PG	Average price of gas and other fuels	Weighted average of NSW and ACT gas price indices
HDD	Heating degree days	Accumulated degree days (deviations below 18 degrees Celsius) using a weighted average of Sydney Airport and Parramatta daily minimum and maximum temperatures
CDD	Cooling degree days	Accumulated degree days (deviations above 21 degrees Celsius) using a weighted average of Sydney Airport and Parramatta daily minimum and maximum temperatures
DAYS	Number of days	Days in the current season (summer varies with leap years)
CPI	Consumer Price Index	Weighted average of All Groups Index for NSW and ACT

We combined results from the long and short-run models with independent estimates of consumer energy resources (solar and batteries), plug-in electric vehicle charging, and our own estimates of major industrial/mining loads to calculate network demand, using the equation above.

We also developed a solar-generation sub-model to estimate output on each day, subject to available capacity, the time of year, and prevailing weather and sunshine.

Long-run projection accuracy for half-hourly demand largely rests on the validity of our long-run model. We used an autoregressive distributed lag (ARDL) specification to improve forecasting reliability by including dynamics while utilising the statistical properties of the combined long-run data. ARDL models have gained popularity as a method of examining cointegrating relationships between variables, using the bounds testing approach, which builds on the cointegration techniques developed for longer term. Our testing of the estimated model supported the existence of cointegration and hence the property of so-called super consistency for combinations of cointegrated variables – implying that the estimated coefficients rapidly approach their true value as the sample size increases.

Model development and validation followed the following steps:

- Choose driver variables using previous experience and knowledge of demand theory
- Select ARDL lag length automatically using Akaike information criterion (AIC)
- Test model residuals for absence of autocorrelation and presence of homoskedasticity
- Test for cointegration using the bounds test, where a finding of cointegration adds reliability to forecasts made with the model
- Transform to error-correction form to easily identify the speed of adjustment coefficient and long-run elasticities, where:
    a. The speed of adjustment should be less than zero and greater than minus one for stability
    b. Income elasticity should be between zero and one to align with the direction of influence and previous findings of inelastic demand for electricity
    c. Price elasticity should be between zero and minus one to align with the direction of influence and previous findings of inelastic demand for electricity.
- Analyse forecast performance both within and out of sample, testing both goodness of fit and consistency across different periods.

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A1.2.4 Simulation of seasonal maxima and minima

Random resampling or bootstrapping refers to creating artificial but realistic series by joining together several observations or blocks of data chosen randomly and with replacement from a set of historical data. We generated distributions for our half-hourly model by repeatedly resampling 20 years of historical weather within seasons to create synthetic weather series.

Following resampling, we stored the synthetic weather series in files for input into the demand model. Synthetic weather includes cooling and heating degrees, and global solar exposure (GSE). Resampling replaces 10-day blocks randomly drawn from the same respective season in any of the 20-year samples. The length of the blocks is intended to capture plausible weather sequences.

We ran the model with each set of synthetic weather to develop multiple half-hourly demand projections. The process also includes estimating solar generation for each synthetic GSE trace. The primary forecast is for underlying demand, after which we calculated the equivalent network demands using the pre-determined battery and vehicle charging input values and the estimated solar generation for each half hour.

For each simulation, for each day, we selected and stored the daily minimum and maximum values for both underlying and network demand. We then used the multiple daily maxima and minima data to determine the seasonal demand maxima and minima for each simulation. We allowed for model residual variation by adjusting the projections on the assumption that the residuals follow a normal distribution.

We calculated probabilities of exceedance from the resulting 1,000 simulated maxima and minima for each season for each required historical or forecast year. The process was repeated for each of the three scenarios.

A1.2.5 Annual energy model

The published annual energy forecast is an average of quarterly energy forecasts derived from the long-run component of the half-hourly model described in Chapter A1.3 and the annual energy model described below.

Transgrid employed an in-house annual energy model, in parallel to the half-hourly demand model described above, to focus on residential and non-residential energy consumption and to align the energy projections with the traditional sent out measure of network energy.

Econometric modelling was used to estimate the independent impacts of population, electricity price, economic growth and weather on annual energy sent out. We first split out energy consumed by large industrial customers for this analysis. We modelled residential electricity consumption and the remaining non-residential energy consumption (including network losses) separately. Each sector was modelled in terms of underlying energy, as defined in Equation A1.1 above, and we then converted the projections to network energy using independent estimates of consumer energy resources (solar and batteries), plug-in electric vehicle charging, and our own estimates of major industrial/mining loads to calculate network demand.

Table A1.3 shows total energy used and proportions of electricity in total energy use for each sector in 2023. Electricity consumption is dominant in the residential and commercial sectors, as other sectors that may consume large amounts of energy do not in aggregate use a high proportion of electricity (e.g., land and air transport). Greater electrification of such sectors in the future may have significant ramifications for electricity consumption.

Troy Smithers – Plant and Civil Operator

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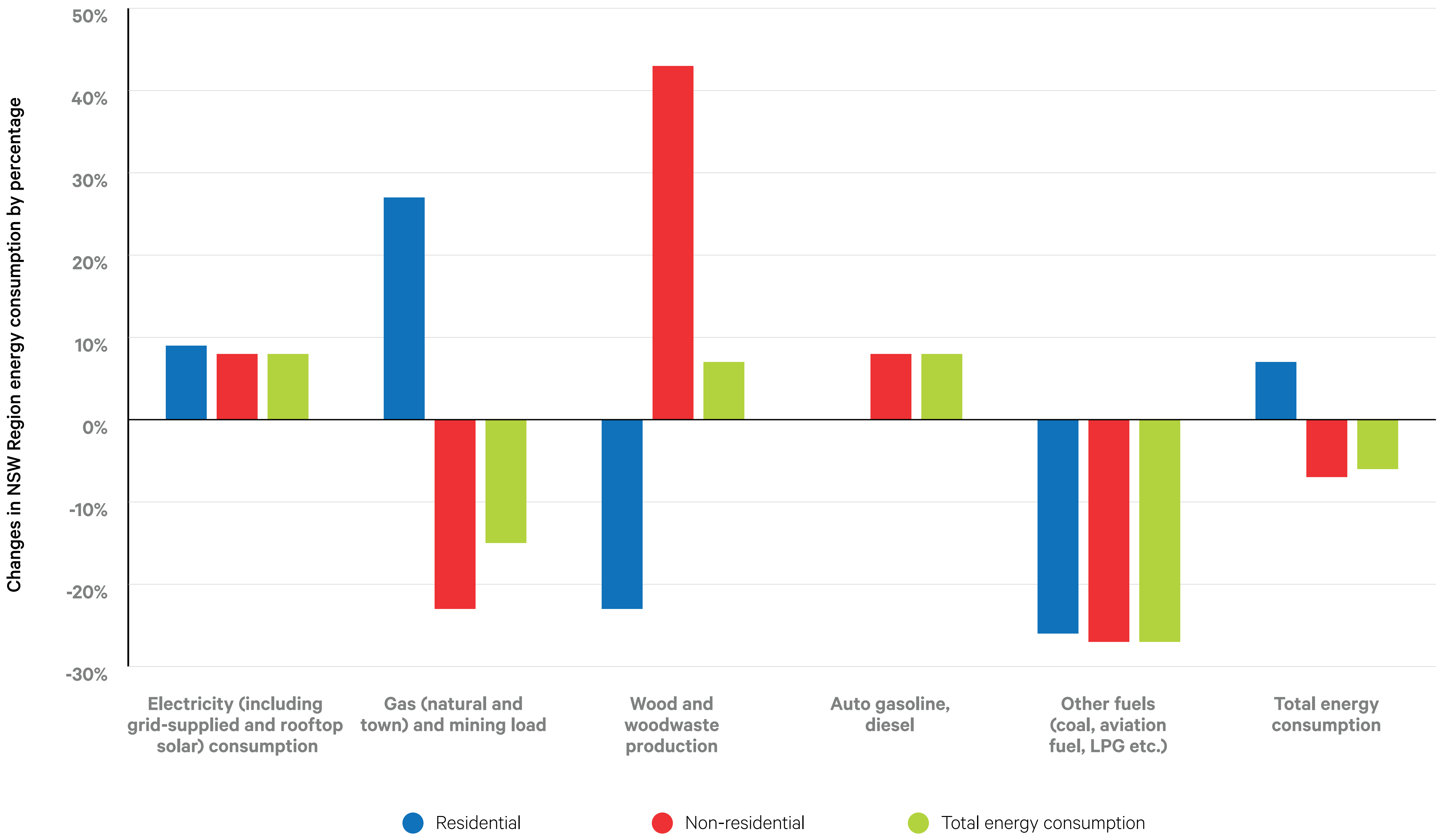
Table A1.3: Snapshot of NSW Region energy consumption in 2022-23 (PJ)[102]

	Electricity (including grid-supplied and rooftop solar)	Electricity proportion	Other fuels (natural gas, transport fuels, coal, etc.)	Other fuels proportion	Total energy consumption
Residential	94.2	32%	50.0	5%	144.2
Non-residential	196.3	68%	920.5	95%	1,116.9
Total energy consumption	290.5	100%	970.5	100%	1,261.1

Source: Department of Climate Change, Energy, the Environment and Water, Australian Energy Statistics, Table F, August 2024

As shown in Figure A1.4, NSW energy use in aggregate has fallen over the last decade, despite general growth in electricity consumption. Residential gas use peaked in 2022 and is generally expected to continue to decline as new builds and renovations increasingly choose electric water and space heating, and cooking. However, the network impact of this trend towards domestic electrification is partially offset by high adoption rates of small-scale solar and batteries.

Figure A1.4: Changes in NSW Region energy consumption between 2013 and 2023



Source: Department of Climate Change, Energy, the Environment and Water, Australian Energy Statistics, Table F, August 2024

102 Our primary data source of historical energy consumption is Australian Energy Statistics. This was supplemented by estimates of small-scale consumer rooftop solar generation provided to Transgrid by APVI, and network electricity generation data published by AEMO.

The estimated forecasting equations resulted in identifying the sensitivities shown in Table A1.4 and Table A1.5.

Table A1.4: Estimated long-run price and income elasticities of demand for energy in NSW

	Price (p-value)	Income (p-value)
Residential (annual model)	-0.495 (0.00)	0.290 (0.59)
Non-residential (annual model)	-0.407 (0.00)	0.200 (0.01)
Combined (quarterly model)	-0.498 (0.00)	0.376 (0.04)

Table A1.4 shows that for 1% increase in price or income, the long-run impact on energy consumption (for the respective sector) is estimated to be the percentage change as indicated in the corresponding column. For example, an increase in the residential electricity price of one per cent would lead to a long-run decrease in residential electricity consumption (all other things remaining the same) of 0.495%.

The p-values, presented in brackets in Table A1.8 after the price and income elasticities, indicate the likelihood (in percentage terms) of an estimated value not being significantly different from zero. That is, a p-value close to zero indicates there is a very high likelihood the real value is not zero. All estimated elasticities with the exception of the residential income elasticity are estimated to a high degree of confidence.

Short-run weather impacts are quantified as either heating or cooling degree days, or the temperature below or above the human comfort range inside buildings each day, for all days in a year. Future weather is modelled as a continuation of average warming trends over the last 20 years.

Table A1.5 shows estimated temperature impacts on energy consumption. The table shows that for an average temperature increase of 1 degree on any day during summer, NSW Region residential and non-residential energy consumed increases by 233 GWh for cooling requirements. Similarly for an average temperature fall of 1 degree on any day during winter, NSW Region residential and non-residential energy consumed increases by 250 GWh for heating requirements.

Table A1.5: Estimated short-run temperature sensitivities of energy (GWh/degree >21 or <18 degrees)

	Cooling	Heating
Residential & Non-residential	233	250

A1.3.1 Current model accuracy

Simulated POE demand levels (weather correction)

The purpose of weather correction of historical demands is to remove the influence of weather variation and to calculate levels of maximum or minimum demand that correspond to given probabilities of exceedance (POEs).

We carried out historical simulations using the half-hourly demand model in an identical manner to that used to prepare future projections. This process involves resampled daily weather data to input repeatedly to the model. From the 1,000 or so resulting simulations, we calculate percentiles of the most extreme demands reached in each season across the simulated outcomes. The historical simulations provide guidance in the preparation of future projections.

Figures A1.5 to A1.7 show actuals and simulated 10-90th percentile probability of exceedance bands for summer maximum demand, winter maximum demand and minimum demand, respectively. As the number of observations increases, we would expect that the mean actual values would converge towards the mean of the 50% POE values, and that the actual would have an increasing tendency to being above the 10% POE line or below the 90% POE line one year in every 10. While we only have a limited number of observations, a visual inspection of the data as in the figures below provides no reason to believe the simulated POE levels are wildly inaccurate.

Figure A1.5: NSW Region summer maximum demand and 10% POE, 50% POE and 90% POE estimates

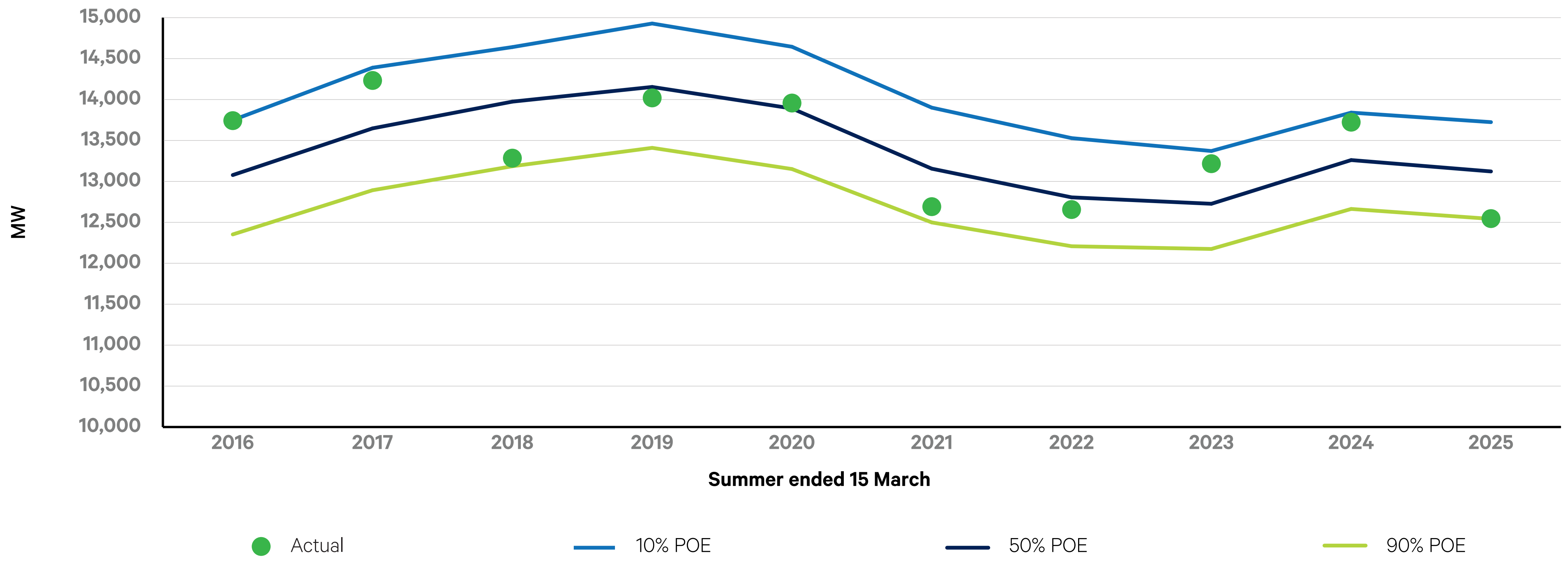


Figure A1.6: NSW Region winter maximum demand and 10% POE, 50% POE and 90% POE estimates

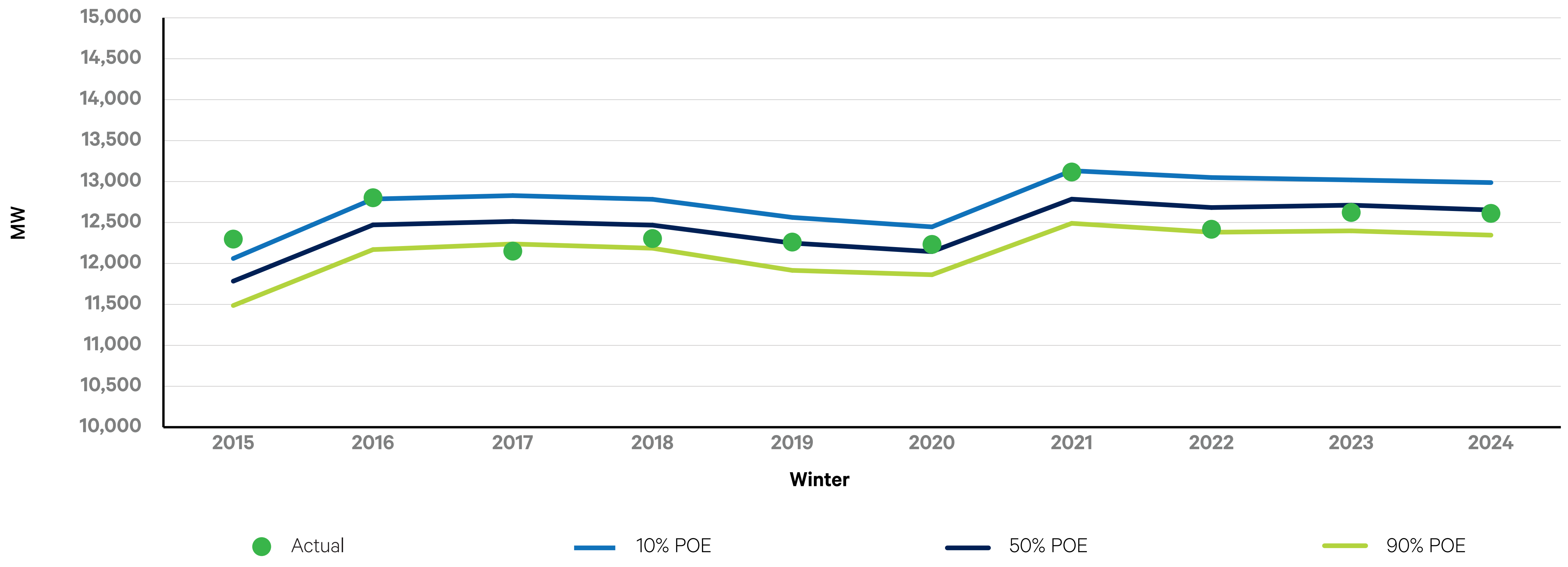


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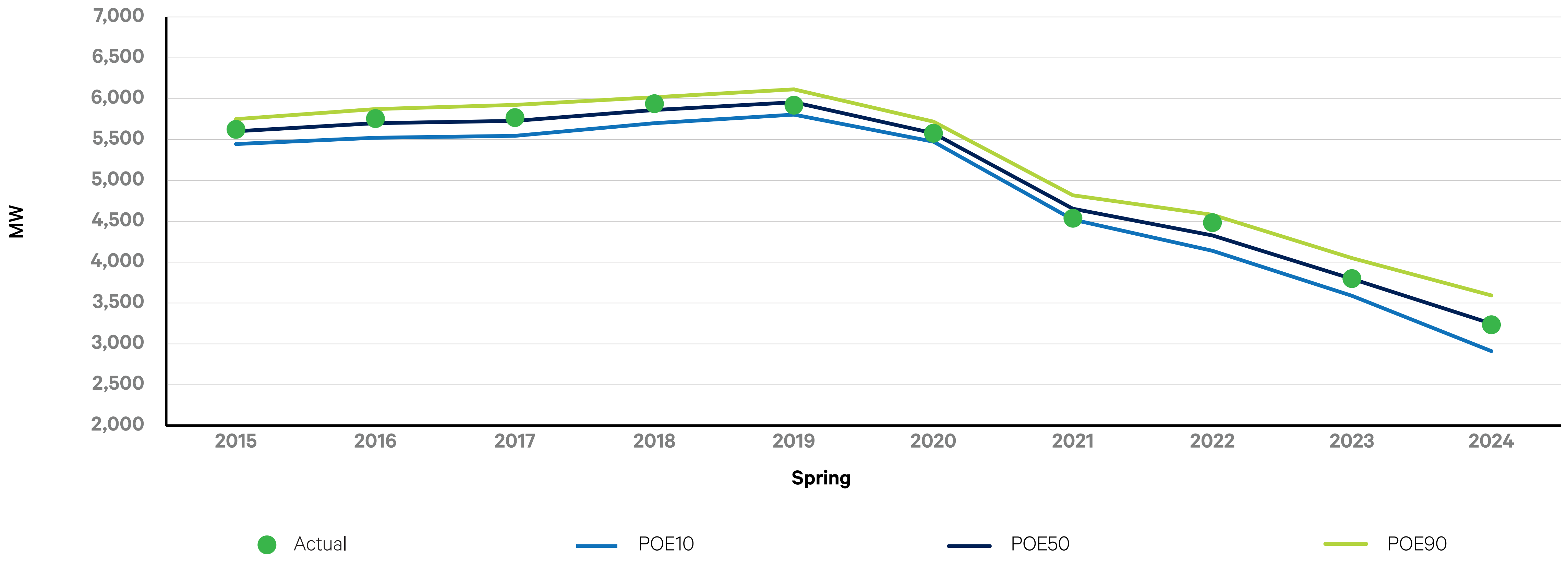
Figure A1.7: NSW Region spring minimum demand and 10% POE, 50% POE and 90% POE estimates



Annual energy model

We analysed the performance of the independent annual energy model, which consists of a residential and non-residential component, as follows:

- We estimated the model using all currently available data and used it to back cast actual outcomes, with the full knowledge of hindsight (an in sample forecast).
- We re-estimated the model using only data up to FY14 and used it to prepare a new forecast, as if we had prepared a forecast in 2014 with perfect foresight of the model inputs (an out-of-sample forecast).

Although the projections fit the data quite well for most of this 10-year projection horizon, the out-of-sample forecast finishes almost 7,000 GWh higher than the actual outcome for FY24. Because of this, we relied more heavily on the combined long-run (quarterly) energy model to prepare the energy forecasts and used the annual model mainly to estimate the residential proportion.

The fit of the combined annual energy model (comprising residential and non-residential components) to the historical data sample is shown in Figure A1.8, Figure A1.9 and Table A1.5. Key indications of a reliable forecast would be that:

- Fitted lines are contained within a 95% confidence interval
- Derived Mean Absolute Percentage Errors (MAPEs) are relatively low
- The out-of-sample forecast should not deviate from the actual in one direction or the other.

The evidence suggests that the overall model is valid across the entire sample period. the model is relatively accurate but may be given to some upward bias over the long run.

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Figure A1.8: Energy sent out (annual model) in-sample[103] forecast

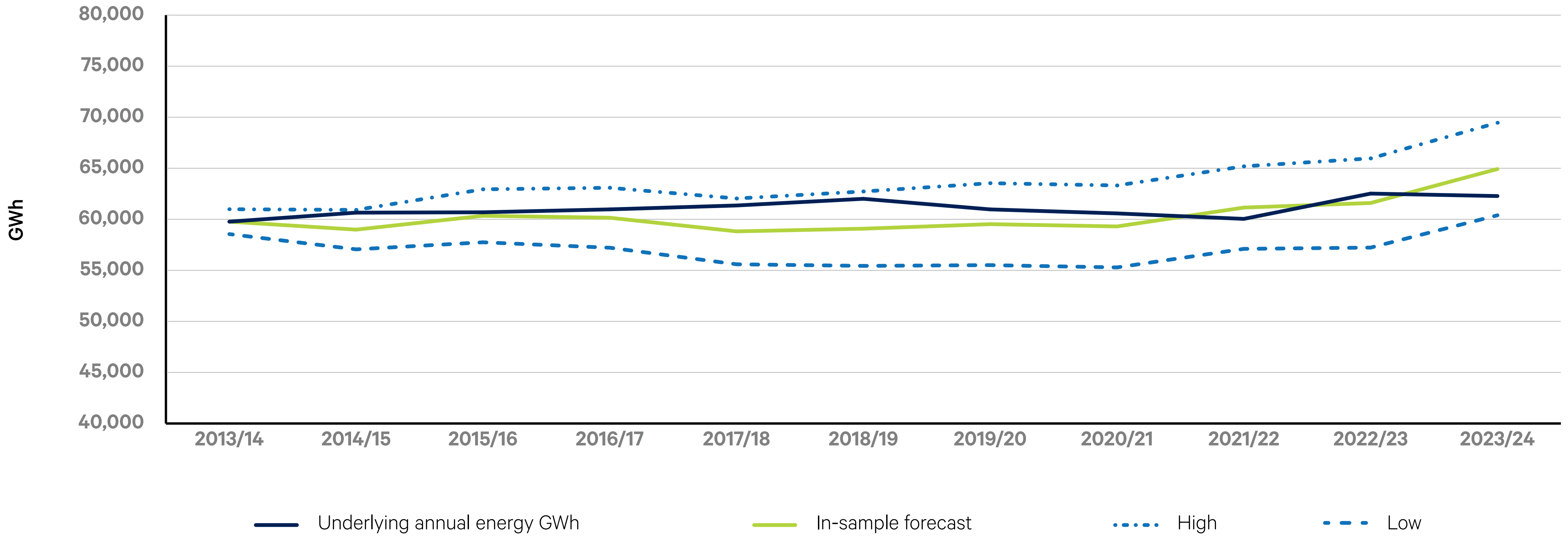

Figure A1.9: Energy sent out (annual model) out-of-sample[104] forecast

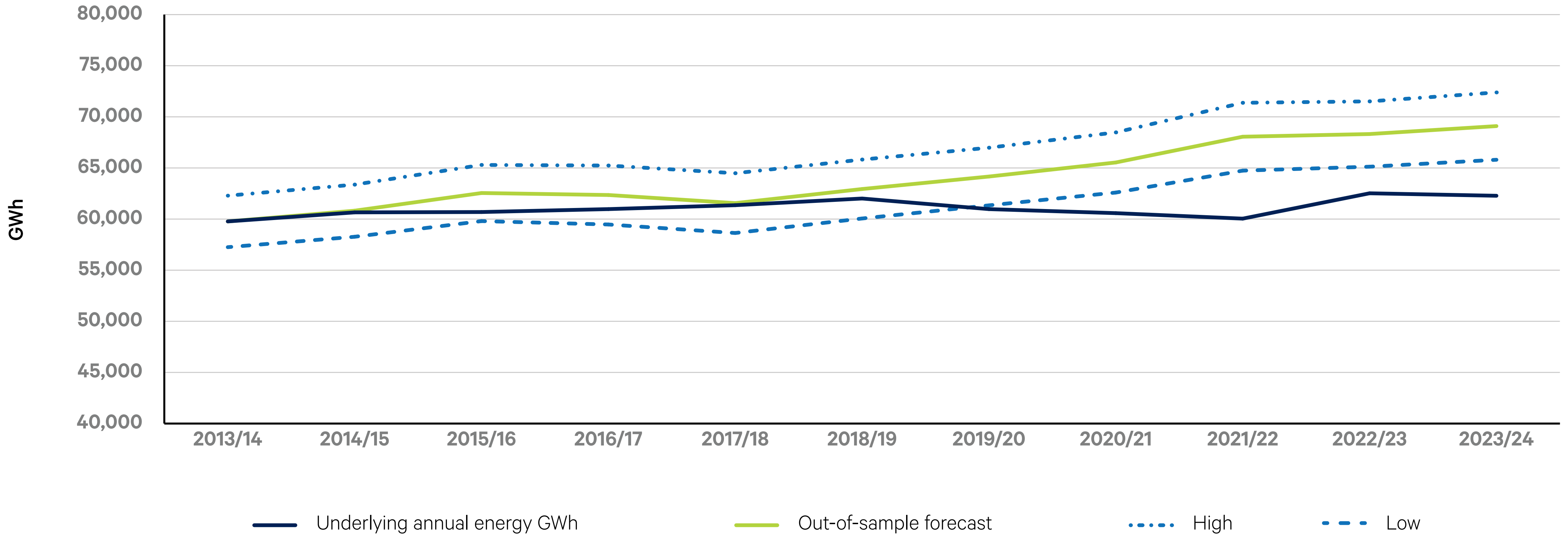

Table A1.6: NSW Region energy forecast (annual model) error analysis performed over the period FY14 to FY24

	In-sample fit	Out-of-sample forecast
Root mean square error (RMSE)	1,689	4,104
Mean absolute error (MAE)	1,426	3,028
Mean absolute percentage error (MAPE)	2.3%	5.0%
Root mean squared percentage error (RMSE)	2.7%	6.7%
Thiel's inequality coefficient (U)	0.014	0.034
Bias proportion (UB)	0.194	0.544
Variance proportion (UV)	0.245	0.292
Covariance proportion (UC)	0.561	0.164

Quarterly energy model

The fit of the quarterly energy model (derived from the long-run component of the half hourly model) to the historical data sample is shown in Figure A1.10, Figure A1.11 and Table A1.7. The data for this figure were produced by replicating the forecasting process using all the available input data to produce the in-sample fit. However, we also re-estimated the entire model using only the input data up to FY14 to produce a new out-of-sample forecast that mimics the performance of the model had it been used to prepare a 10-year forecast at that time.

Some key indications of the reliability of the forecasts are that:

- Fitted lines are contained within a 95% confidence interval
- Derived Mean Absolute Percentage Errors (MAPEs) are relatively low (0.5 in sample and 2.2 out-of-sample)
- Despite some upward bias, the out-of-sample forecast remains relatively close to the actual throughout the forecast period.

The evidence suggests that the overall model is valid across the entire 10-year sample period. The model is relatively accurate and is not given to significant bias up or down.

103 An in-sample forecast is prepared by using a model that was estimated with a given sample of historical data to forecast over all or some of the same period. Forecast accuracy can be tested by comparing the forecast with actual data, and if estimated by least squares, the mean of the forecast is likely to equal the mean of the actuals.

104 An out-of-sample forecast is prepared by using a model that was estimated with a given sample of historical data to forecast outside the sample. Typically, this is done by reserving some of the historical data available for estimation, so that the forecast can still be compared with actual data for accuracy. This is the most stringent test for the model's ability to predict the future.

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Figure A1.10: Energy sent out (quarterly model) in-sample[105] forecast

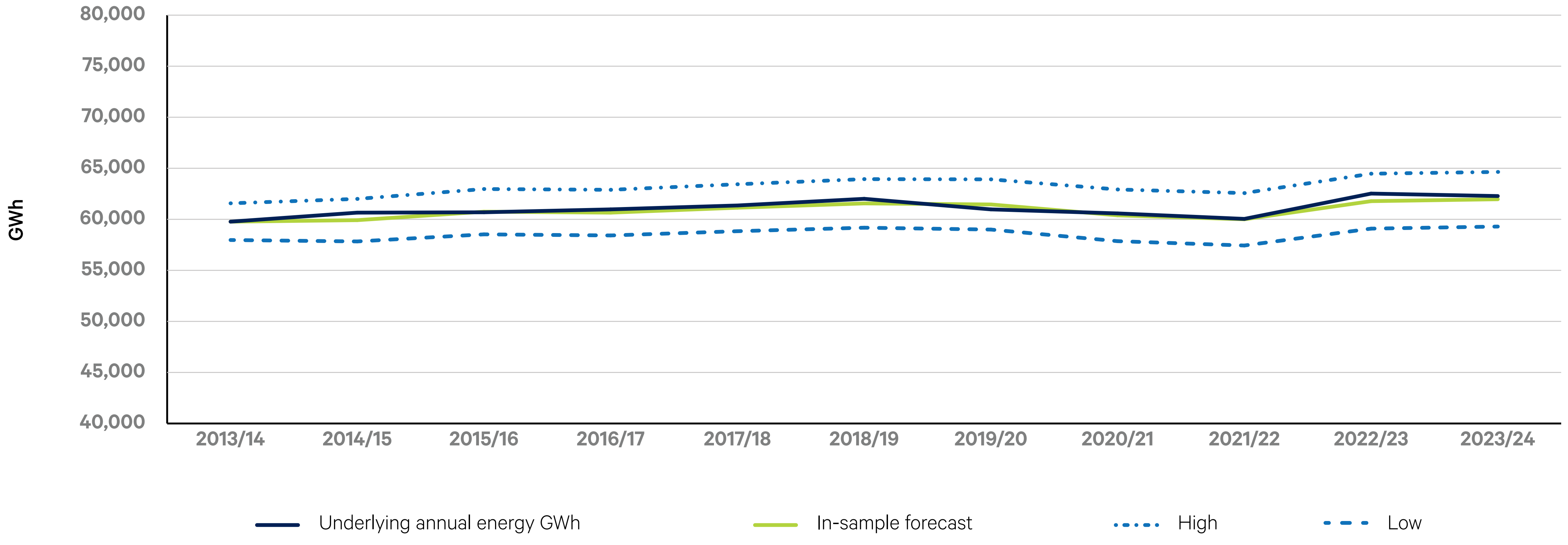

Figure A1.11: Energy sent out (quarterly model) out-of-sample[106] forecast

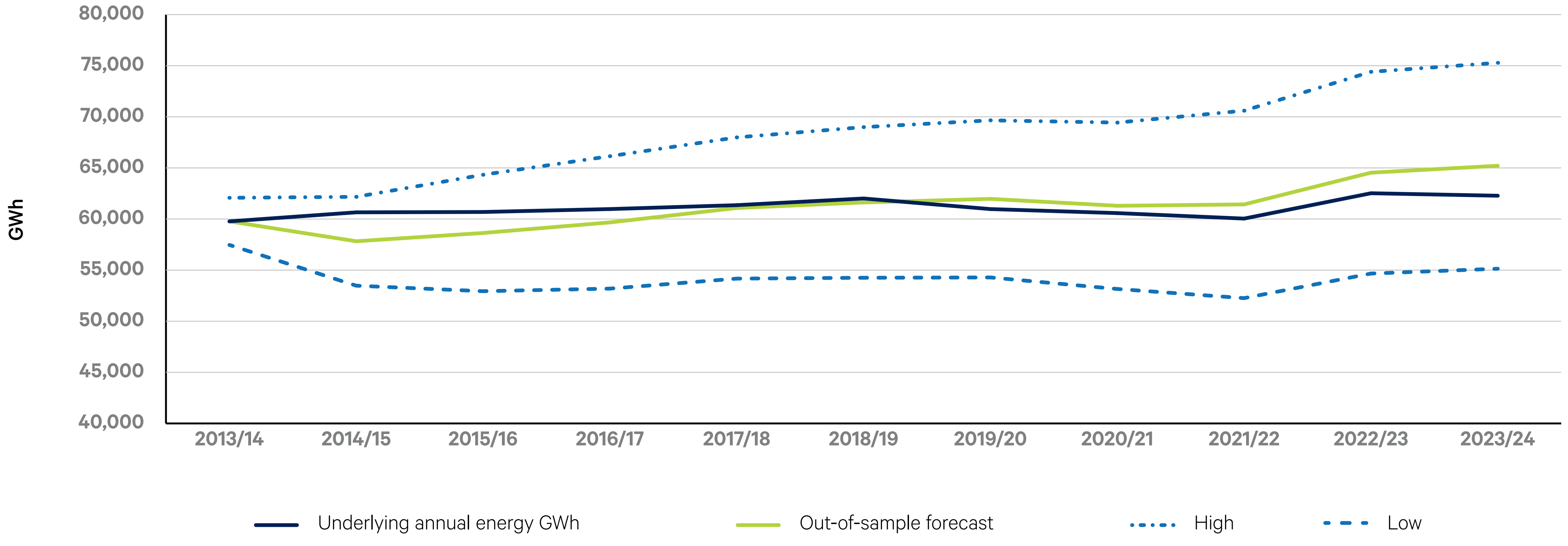

Table A1.7: NSW Region energy forecast (quarterly model) error analysis performed over the period FY14 to FY24

	In-sample fit	Out-of-sample forecast
Root mean square error (RMSE)	407	1,658
Mean absolute error (MAE)	323	1,355
Mean absolute percentage error (MAPE)	0.5%	2.2%
Root mean squared percentage error (%RMSE)	0.7%	2.7%
Thiel's inequality coefficient (U)	0.003	0.014
Bias proportion (UB)	0.304	0.004
Variance proportion (UV)	0.063	0.611
Covariance proportion (UC)	0.633	0.385

105 An in-sample forecast is prepared by using a model that was estimated with a given sample of historical data to forecast over all or some of the same period. Forecast accuracy can be tested by comparing the forecast with actual data, and if estimated by least squares, the mean of the forecast is likely to equal the mean of the actuals.
106 An out-of-sample forecast is prepared by using a model that was estimated with a given sample of historical data to forecast outside the sample. Typically, this is done by reserving some of the historical data available for estimation, so that the forecast can still be compared with actual data for accuracy. This is the most stringent test for the model's ability to predict the future.

A1.3.2 Performance of Transmission Annual Planning Report 2024 projections

This section reviews the accuracy of the Transmission Annual Planning Report 2024 electricity demand and energy projections one year out.

FY24 annual energy

Projected NSW Region annual energy for FY24 in the 2024 Transmission Annual Planning Report was 67,250 GWh, compared with an actual outcome of 66,285 GWh, an apparent over-projection of 965 GWh or 1.4%. However, the 2024 Transmission Annual Planning Report forecast was prepared using historical energy-sent-out data that have since been revised down. We estimate that the projection that would have been made at the time of the 2024 Transmission Annual Planning Report using updated energy-sent-out data up to the time of the original forecast preparation (March 2024) is 66,745 GWh. This is still an over-projection and represents a gap of 505 GWh or 0.8%.

The energy projection was based on a forecasting model informed by predicted input variables. Transgrid re-ran the forecasting model using actual right-hand side (RHS) input variables to determine the extent to which the forecast outcome was driven by errors in predicted input variables, and the extent to which the model itself was inaccurate.

At the time of the 2024 Transmission Annual Planning Report, we assumed a modest increase in retail electricity prices in real terms. However, the spotlight on cost-of-living increases during 2024 may have partly driven a reduction in electricity consumption. NSW population growth was lower, and solar installation higher, which contributed to lower than projected electricity consumption.

Table A1.8 show the published Medium energy projection for FY24, the revised projection based on the new energy data, the actual outcome and a new prediction using the same model with actual, rather than forecast values, for the input variables. The measures below show that the model inputs were the greatest source of projection error, with model inaccuracy driving the forecast in the opposite direction to partially offset the impacts of the inaccurate inputs and data revision.

Table A1.8: Transmission Annual Planning Report 2024 Medium energy projection for FY24 compared with the actual outcome

Measures:	**GWh**	
Current actual	66,285 (A)	
Forecast published in TAPR 2024	67,250 (B)	
Revised forecast using updated energy data	66,745 (C)	
Updated prediction using same model as in TAPR 2024, actual inputs instead of forecast inputs	65,887 (D)	
Forecasting gaps:	**GWh**	**Difference**
Total gap not including energy data revision (actual less published forecast) (A-B)	-965	-1.4%
Total gap including energy data revision (actual less revised forecast) (A-C)	-460 (E)	-0.7%
Due to model inaccuracy (current actual less updated model prediction with actual inputs) (A-D)	398 (F)	0.6%
Due to inaccurate inputs (total gap including energy data revision less gap due to model inaccuracy) (E-F)	-858	-1.3%

FY25 summer maximum demand

Projected NSW Region 50% POE summer maximum demand for FY25 was 13,570 MW, compared with our updated estimated actual of 13,122 MW, an over-projection of 448 MW.

Table A1.9 shows the Transmission Annual Planning Report 2024 projections of 10%, 50% and 90% POE NSW Region summer MD. These forecasts were between 1,026 MW and 58 MW higher than (and within 7.5% of) the currently estimated POE values, based on actual data for the recent summer.

We estimate that the actual MD of 12,546 MW, which occurred in the half hour ended 17:00 hours EST on Tuesday 17 December 2024, represented a 91% POE level of demand.

The daily average temperature at the time of the FY24 summer MD was 29.5 degrees at Parramatta (80% temperature POE) and 27.6 degrees at Sydney (99% temperature POE), which was a clear, sunny day. The hottest day of the summer was 28 January 2025, the Tuesday following the Australia Day long weekend, with an average temperature of 32.0 degrees at Sydney Airport but with some cloud cover and light rain.

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Table A1.9: Transmission Annual Planning Report 2024 Medium maximum demand (MD) projection for summer FY25 compared with actual outcomes (MW)

	Actual MD	POE level*	10% POE	50% POE	90% POE
Actual MD Tuesday 17 Dec 2024 and actual POEs#	12,546	91%	13,724	13,122	12,542
2024 Transmission Annual Planning Report forecasts			14,750	13,570	12,600
Difference (actual POEs less 2024 Transmission Annual Planning Report forecasts)			-1,026 (-7.5%)	-448 (-3.4%)	-58 (-0.5%)
Parramatta average temperature on 17 Dec 2024, degrees	29.5	80%			
(Summer maximum Parramatta average temperature, Tuesday 28 Jan 2025, degrees)	(31.5)	(55%)			
Sydney Airport average temperature on the day, degrees	27.6	99%			
(Summer maximum Sydney Airport average temperature, Tuesday 28 Jan 2025, degrees)	(32.0)	(55%)			

*Temperature percentiles are calculated from seasonal maxima and minima for the last 20 years.
#Both last year's forecast POE levels for summer 2024–25 and the recently estimated actual POE levels are based on multiple simulations of daily maximum demands occurring at a typical time of day on a typical non-holiday weekday. Neither the forecast nor the actual POE levels represent a particular time of day or day of the season.

2024 winter maximum demand

Projected NSW Region 50% POE winter maximum demand for 2024 was12,940 MW, compared with our updated estimated actual of 12,653 MW, an over-projection of 287 MW.

Table A1.10 shows the Transmission Annual Planning Report 2024 projections of 10%, 50% and 90% POE NSW Region winter maximum demand. These forecasts for winter 2024 were between 64 and 522 MW higher than (and within 4.0% of) the currently estimated POE values, based on actual data for last winter.

We estimate that the actual maximum demand of 12,612 MW, which occurred in the half hour ended 18:30 hours EST on Monday 15 July 2024, represented a 57% POE level of demand.

The daily average temperature at the time of the 2024 winter maximum demand was 11.5 degrees at Sydney Airport and 10.1 degrees in Parramatta. Both temperatures are above the range of recorded winter minimum average temperatures for the last 20 years.

Table A1.10: Transmission Annual Planning Report 2024 Medium maximum demand (MD) projection for winter 2024 compared with actual outcomes (MW)

	Actual MD	POE level*	10% POE	50% POE	90% POE
Actual MD Monday 15 July 2024 and actual POEs#	12,612	57%	12,988	12,653	12,346
2024 Transmission Annual Planning Report forecasts			13,510	12,940	12,410
Difference (actual POEs less 2024 Transmission Annual Planning Report forecasts)			-522 (-4.0%)	-287 (-2.3%)	-64 (-0.5%)
Parramatta average temperature on 15 July 2024, degrees	10.1	n.a.			
(Winter minimum Parramatta average temperature, Sunday 30 June 2024, degrees)	(9.4)	(63%)			
Sydney Airport average temperature on 15 July 2024, degrees	11.5	n.a.			
(Winter minimum Sydney Airport average temperature, Monday 1 July 2024, degrees)	(10.3)	(58%)			

*Temperature percentiles are calculated from seasonal maxima and minima for the last 20 years.
#Both last year's forecast POE levels for summer 2024–25 and the recently estimated actual POE levels are based on multiple simulations of daily maximum demands occurring at a typical time of day on a typical non-holiday weekday. Neither the forecast nor the actual POE levels represent a particular time of day or day of the season.

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2024 annual minimum demand

Table A1.11 shows the Transmission Annual Planning Report 2024 projections of 10%, 50% and 90% POE NSW Region Minimum Demand. These forecasts for spring 2024* were between 519 MW and 348 MW higher than (and up to 17.8% at variance from) the currently estimated actual POE values, based on actual data for last year.

The actual minimum demand of 3,234 MW, which occurred in the half hour ended 13:00 hours EST on Saturday 26 October 2024, represented a 47% POE level of demand. This was a clear, weekend day, with notably high solar exposure.

Predicted consumer solar installations are critical to the accuracy of minimum demand projections. The 2024 Transmission Annual Planning Report allowed for around 70 MW less installed consumer solar capacity than we now estimate was actually installed, and 13 GWh more EV charging than our current estimate. This contributed to the gap between projected and actual minimum demand.

Table A1.11: Transmission Annual Planning Report 2024 Medium minimum demand projection for spring 2024 compared with actual outcomes (MW)

	Actual Minimum Demand	POE level*	10% POE	50% POE	90% POE
Actual minimum demand Saturday 26 Oct 2024 and actual POEs#	3,234	47%	2,911	3,247	3,592
2024 Transmission Annual Planning Report forecasts			3,430	3,680	3,940
Difference due to input assumptions (actual minus predicted solar generation, battery charging and EV charging)			-388	-388	-388
Difference due to model inaccuracy (total difference minus difference due to input assumptions)			-131	-45	40
Total difference (actual POEs less 2024 Transmission Annual Planning Report forecasts)			-519 (-17.8%)	-433 (-13.3%)	-348 (-9.7%)

*Temperature percentiles are calculated from seasonal maxima and minima for the last 20 years.
#Both last year's forecast POE levels for summer 2024–25 and the recently estimated actual POE levels are based on multiple simulations of daily maximum demands occurring at a typical time of day on a typical non-holiday weekday. Neither the forecast nor the actual POE levels represent a particular time of day or day of the season.

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A1.4 Model results – future demand profiles

The following figures show projected changing contributions of underlying demand, consumer energy resources and electric vehicle charging to extreme network demands.

A1.4.1 Summer maximum demand

Figure A1.12 shows our 50% POE Medium projection for summer maximum demand FY26 broken into estimated components and Figure A1.13 shows the equivalent for 2034/35. The early afternoon peak in underlying demand will continue to be offset by solar generation, pushing the actual network peak later. An increase in evening battery discharging will contribute to a small but significant reduction in summer maximum demand by FY35. Overcast days with otherwise high demand may also start to draw high network loads due to the absence of consumer solar generation.

Figure A1.12: Day profile of network FY26 summer maximum demand projection

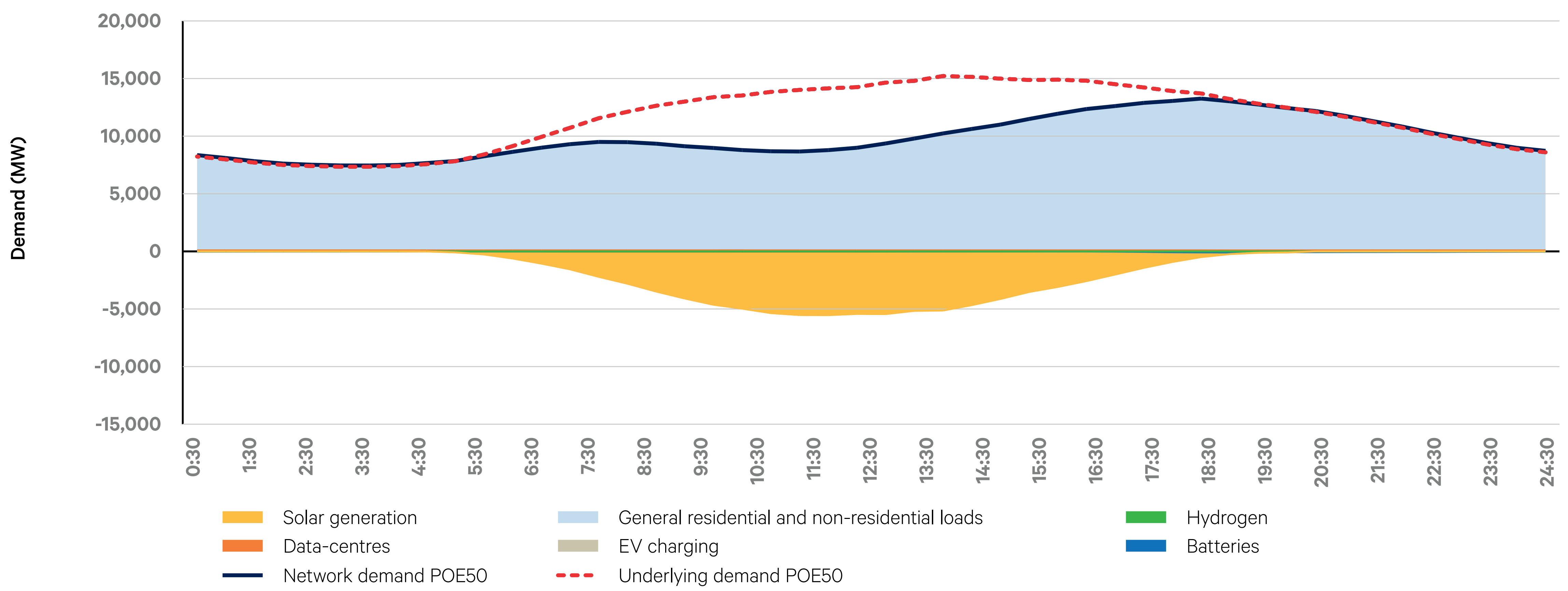
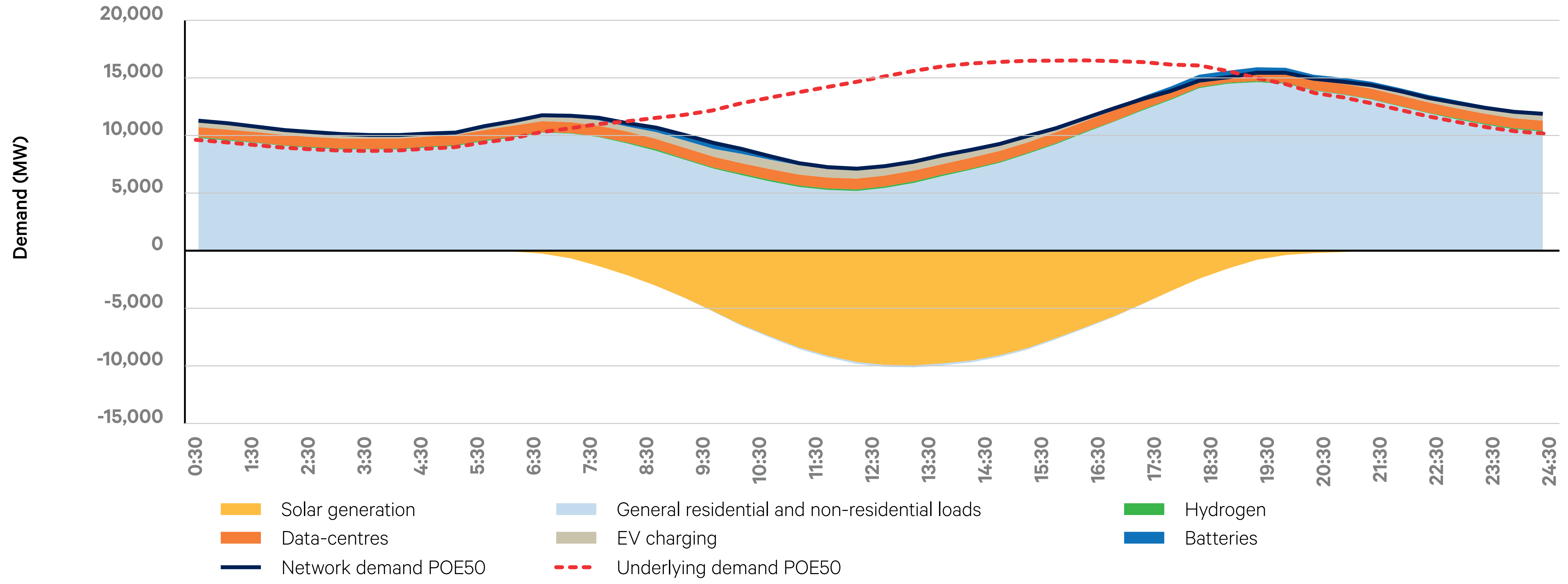


Figure A1.13: Day profile of network FY35 summer maximum demand projection



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A1.4.2: Winter maximum demand

Figure A1.14 shows our 50% POE Medium projection for winter maximum demand 2025 broken into estimated components and Figure A1.15 shows the equivalent for 2034. Significant projected growth in consumer solar generation will do nothing to reduce the evening network peak; however small battery discharging and a drop in EV charging at these times will make a significant contribution. The assumed patterns of future battery and EV charging are critical to these conclusions.

Figure A1.14: Day profile of network 2025 winter maximum demand projection

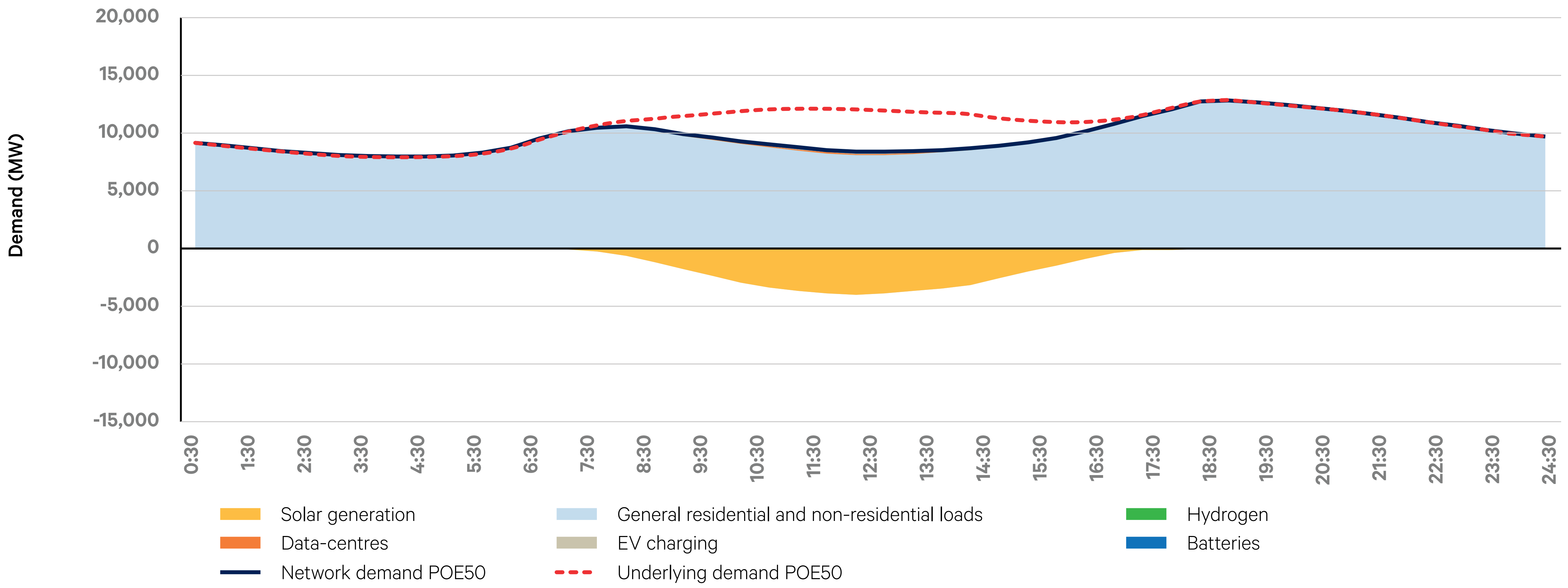
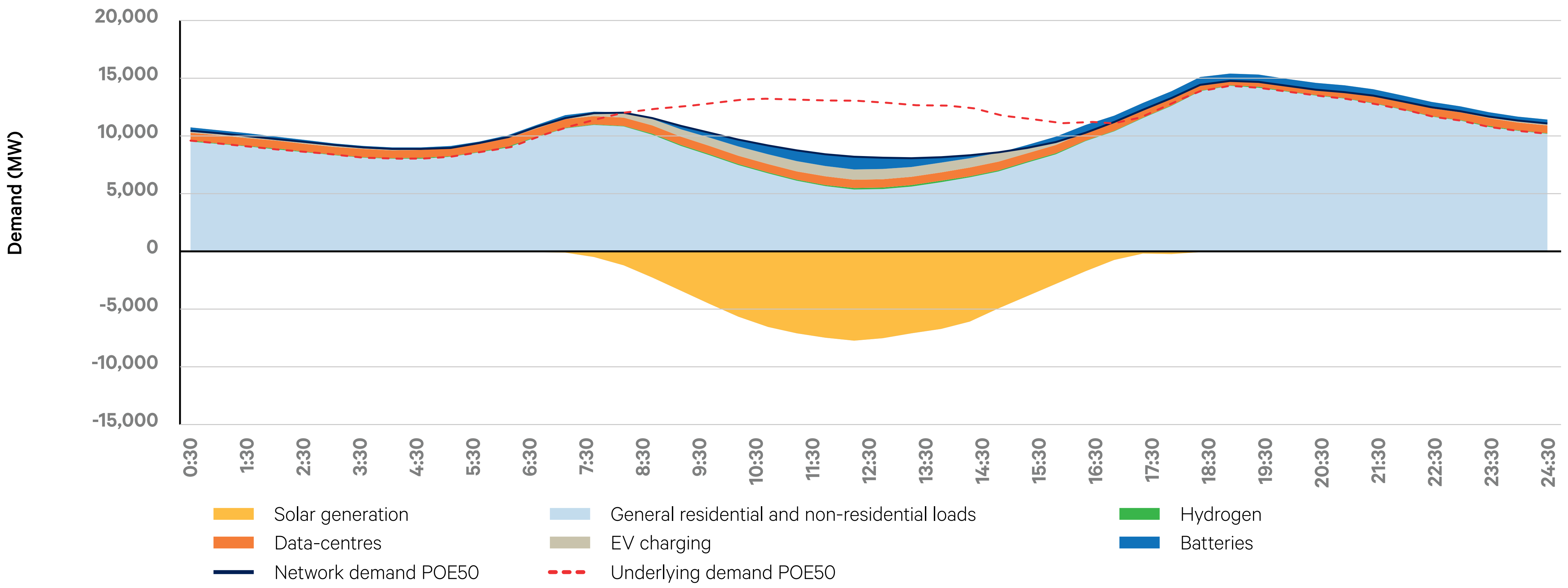


Figure A1.15: Day profile of network 2034 winter maximum demand projection



A1.4.3: Minimum demand

Figure A1.16 shows our 50% POE Medium projection for annual minimum demand 2025 broken into estimated components and Figure A1.17 shows the equivalent for 2034. The rapid fall in projected minimum demand is mainly due to continued growth in consumer solar generation. The fall in minimum demand will be partly offset by new data-centre loads, EV and small-scale battery charging during the middle of the day, and the development of renewable hydrogen production. However, significant additional large-scale battery or pumped hydroelectric energy storage capacity, or other large-loads, would be required to arrest the decline in minimum demand.

Figure A1.16: Day profile of network 2025 minimum demand projection

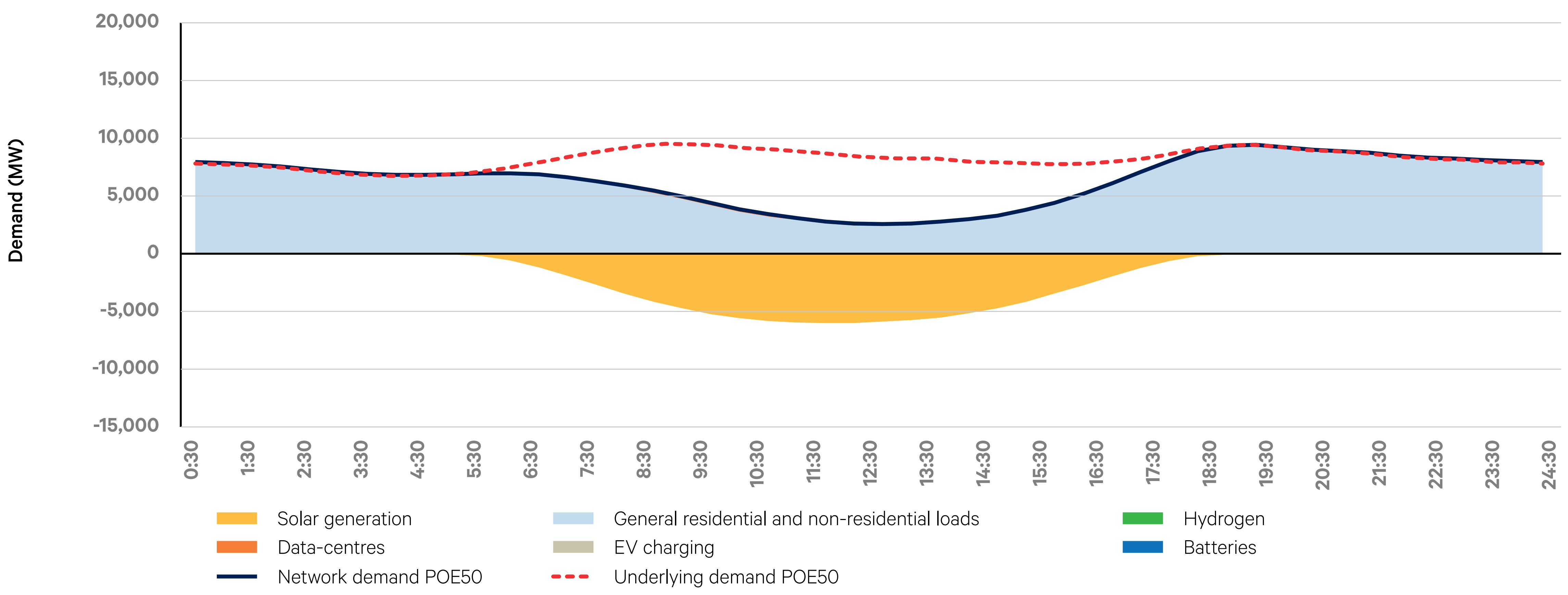
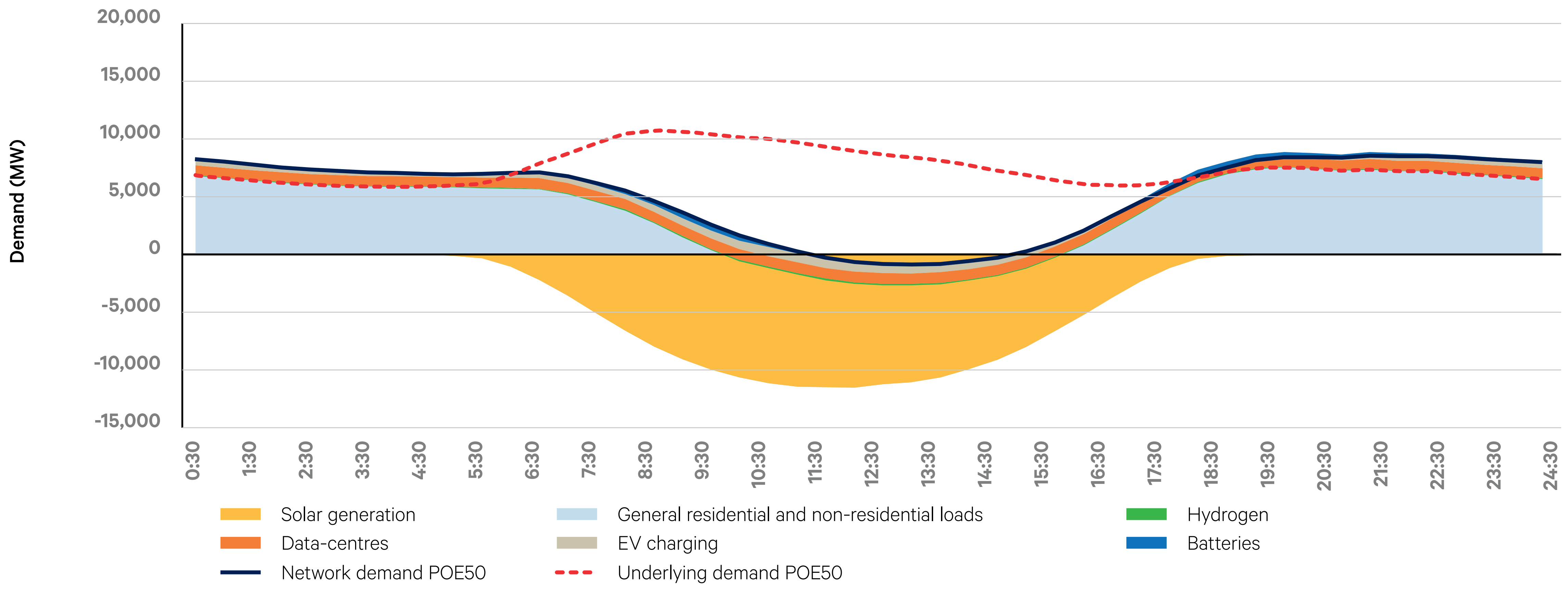


Figure A1.17: Day profile of network 2034 minimum demand projection



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Construction of HumeLink

Bulk supply point projections

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A2.1 Individual bulk supply point projections

Transgrid

This section provides the maximum demand projections supplied by our customers for individual bulk supply points, based on local knowledge and the availability of historical data.

Our customers have provided maximum demand projections, in terms of both megawatts (MW), megavolt ampere reactive (MVAr) and megavolt ampere (MVA) for individual bulk supply points between the NSW transmission network and the relevant customer's network. These projections are produced using methodologies that are likely to have been tailored to the circumstances relating to the load(s) at particular bulk supply point(s), such as the degree of local knowledge and the availability of historical data. The projections are given in the tables below.

Some large and relatively stable industrial loads, mainly connected directly to Transgrid's network that we isolate for modelling purposes, have been removed from the bulk supply point projections and aggregated. Other industrial loads are included in bulk supply point forecasts provided by distributors. Aggregate projections for all identified major industrial loads (excluding those that are also in the bulk supply point forecasts) at the time of maximum NSW Region demand are given in Table A2.11 to Table A2.12.

Table A2.1 to Table A2.10 provide projections of noncoincident maximum demand occurring during a particular season at a particular bulk supply point (or group of bulk supply points) on the NSW transmission network. They do not represent projections of demand contributions at these bulk supply points at the time of overall NSW Region maximum demand.

Table A2.1: Ausgrid bulk supply point summer maximum demand[107]

	2025/26			2026/27			2027/28			2028/29			2029/30			2030/31			2031/32			2032/33			2033/34			2034/35		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Beaconsfield West 132 kV	483	46	485	487	128	504	501	112	513	488	166	515	496	156	520	492	174	522	593	172	617	579	233	624	595	267	652	597	337	686
Rookwood Rd 132 kV	239	31	241	250	38	253	253	30	255	247	21	248	254	34	256	254	26	255	306	62	312	294	5	294	298	10	298	301	-10	301
Haymarket 132 kV	487	41	489	485	48	487	497	92	505	527	64	531	531	66	535	557	80	563	503	72	508	517	42	519	521	48	523	536	19	536
Liddell 33 kV	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9
Munmorah 132 kV & 33 kV	110	27	113	153	22	155	154	26	156	151	23	153	153	22	155	156	24	158	155	23	157	155	18	156	156	22	158	156	21	157
Muswellbrook 132 kV	231	87	247	237	92	254	238	92	255	240	92	257	242	94	260	244	94	261	246	96	264	248	94	265	250	95	267	250	95	267
Newcastle 132 kV	603	223	643	604	210	639	607	237	652	644	231	684	653	210	686	666	232	705	672	243	715	692	257	738	698	264	746	702	282	757
Sydney East 132 kV	703	112	712	706	175	727	730	189	754	742	193	767	761	205	788	771	216	801	794	230	827	813	228	844	826	240	860	836	243	871
Sydney North 132 kV	854	263	894	933	173	949	999	202	1019	1067	243	1095	1157	307	1197	1223	353	1273	1291	401	1352	1326	421	1391	1346	424	1411	1357	435	1425
Sydney South 132 kV	1182	130	1189	1196	208	1214	1214	205	1231	1246	199	1262	1263	209	1280	1290	213	1307	1242	221	1262	1262	252	1287	1275	237	1297	1289	233	1310
Tomago 132 kV	347	108	363	349	83	359	353	96	366	358	99	371	359	90	370	374	80	382	381	84	390	412	83	420	415	84	423	420	74	426
Tuggerah 132 kV	328	74	336	301	89	314	300	80	310	298	92	312	305	94	319	310	90	323	316	94	330	324	105	341	324	98	338	326	98	340
Vales Point 132 kV	139	-4	139	138	0	138	140	3	140	120	5	120	120	4	120	122	1	122	127	-4	127	133	0	133	133	3	133	134	26	136
Waratah West 132 kV	78	28	83	80	12	81	80	30	85	82	13	83	85	32	91	87	32	93	87	33	93	87	34	93	88	34	94	87	34	93

107 Zone substation projections aggregated to Transgrid bulk supply points using agreed load flow models.

Table A2.2: Ausgrid bulk supply point winter maximum demand[108]

	2025			2026			2027			2028			2029			2030			2031			2032			2033			2034		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Beaconsfield West 132 kV	445	78	452	443	76	449	461	78	468	491	76	497	469	130	487	481	128	498	486	139	505	578	114	589	587	95	595	594	110	604
Rookwood Rd 132 kV	216	-7	216	215	-8	215	226	11	226	240	28	242	233	2	233	237	17	238	237	24	238	285	30	287	290	39	293	292	28	293
Haymarket 132 kV	409	84	418	425	90	434	441	106	454	449	96	459	482	96	491	495	96	504	506	98	515	461	118	476	463	124	479	467	128	484
Liddell 33 kV	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9	8	4	9
Munmorah 132 kV & 33 kV	141	9	141	137	10	137	140	11	140	145	8	145	140	9	140	143	11	143	146	9	146	147	9	147	149	11	149	150	12	150
Muswellbrook 132 kV	218	96	238	238	114	264	240	116	267	242	116	268	246	118	273	248	119	275	251	121	279	254	122	282	256	124	284	257	125	286
Newcastle 132 kV	521	103	531	499	112	511	508	117	521	516	133	533	563	94	571	574	113	585	589	120	601	596	140	612	606	144	623	613	148	631
Sydney East 132 kV	679	184	703	702	183	725	724	199	751	739	211	769	774	225	806	794	241	830	809	256	849	825	262	866	835	269	877	843	274	886
Sydney North 132 kV	731	37	731	792	62	795	867	92	872	943	127	951	1017	170	1031	1081	209	1101	1151	259	1180	1192	287	1226	1208	294	1243	1216	305	1254
Sydney South 132 kV	1040	148	1050	1071	161	1083	1103	160	1115	1121	182	1136	1177	191	1192	1209	205	1226	1239	219	1258	1184	237	1207	1198	249	1224	1209	257	1236
Tomago 132 kV	334	44	337	315	34	317	322	36	324	307	34	309	329	34	331	334	24	335	343	28	344	347	15	347	353	18	353	357	19	358
Tuggerah 132 kV	259	34	261	265	40	268	270	38	273	273	52	278	276	54	281	282	48	286	289	53	294	298	55	303	302	60	308	304	62	310
Vales Point 132 kV	130	-2	130	127	10	127	130	12	131	128	10	128	110	4	110	112	2	112	114	-2	114	119	-2	119	121	1	121	122	2	122
Waratah West 132 kV	118	21	120	118	21	120	123	23	125	123	24	125	130	26	133	134	28	137	134	28	137	136	28	139	136	29	139	136	29	139

108 Zone substation projections aggregated to Transgrid bulk supply points using agreed load flow models.

Table A2.3: Endeavour Energy bulk supply point summer maximum demand[109]

	2025/26			2026/27			2027/28			2028/29			2029/30			2030/31			2031/32			2032/33			2033/34			2034/35		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Dapto 132 kV	657	-29	657	668	-30	668	676	-30	677	684	-31	684	694	-31	695	704	-32	705	715	-32	716	728	-33	728	786	-35	786	835	-37	836
Holroyd 132 kV	421	-50	424	462	-55	465	488	-58	492	514	-61	518	536	-64	540	557	-66	561	594	-71	598	623	-74	627	651	-77	656	676	-80	681
Ilford 132 kV	20	0	20	20	0	20	20	0	20	20	0	20	20	0	20	21	0	21	21	0	21	22	0	22	22	0	22	22	0	22
Ingleburn 66 kV	124	24	127	124	24	126	124	24	126	130	25	133	137	26	140	144	28	147	150	29	153	157	30	160	163	31	166	171	33	174
Kemps Creek 132kV	0	0	0	0	0	0	82	40	91	116	56	129	146	71	162	177	86	197	211	102	235	241	117	268	264	128	293	344	166	382
Liverpool 132 kV	450	89	459	464	92	473	471	93	480	497	98	507	521	103	531	542	107	553	564	112	575	587	116	598	610	121	622	618	122	630
Macarthur 66 kV	198	27	199	213	29	215	224	30	226	234	32	236	245	33	247	254	34	257	263	36	266	272	37	274	281	38	284	294	40	297
Macarthur 132 kV	214	25	215	222	26	223	236	28	237	255	30	257	289	34	291	320	38	323	354	42	356	388	46	391	424	50	427	459	55	462
Marulan 132 kV	109	22	111	111	22	113	113	23	115	115	23	118	118	24	120	121	24	123	123	25	126	125	25	128	128	26	130	130	26	133
Mount Piper 66 kV	31	10	32	31	10	32	31	10	32	31	10	32	31	10	32	31	10	32	31	10	33	31	10	33	31	10	33	31	10	33
Regentville 132 kV	318	-66	325	318	-66	324	324	-68	331	328	-68	335	332	-69	339	336	-70	343	340	-71	348	345	-72	352	345	-72	352	345	-72	352
Sydney North 132 kV	39	19	44	39	19	44	39	19	44	45	22	51	48	24	54	51	25	57	54	27	61	57	28	64	60	30	67	63	31	71
Sydney West 132 kV	1457	-272	1483	1546	-289	1573	1615	-302	1643	1694	-316	1723	1779	-332	1810	1858	-347	1890	1930	-360	1963	2002	-374	2037	2070	-387	2106	2136	-399	2173
Vineyard 132 kV	592	37	593	630	40	631	673	43	675	720	46	722	747	47	748	777	49	778	798	51	799	816	52	818	829	53	831	834	53	836
Wallerawang 66 kV	42	10	43	42	10	43	42	10	43	42	10	43	42	10	44	43	10	44	43	10	44	44	10	45	44	10	45	44	10	45
Wallerawang 132 kV	39	-5	39	38	-5	39	39	-5	39	39	-5	39	39	-5	40	40	-5	40	41	-5	41	42	-5	42	43	-5	43	43	-5	43

109 Marulan 132 kV: Both Endeavour Energy and Essential Energy take supply from Marulan. This forecast is for Endeavour Energy component.

Transgrid

Table A2.4: Endeavour Energy bulk supply point winter maximum demand[110]

	2025			2026			2027			2028			2029			2030			2031			2032			2033			2034		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Dapto 132 kV	885	141	896	905	144	916	917	146	929	928	148	940	940	150	952	956	152	969	973	155	985	991	158	1003	1009	161	1022	1089	174	1103
Holroyd 132 kV	269	46	273	269	46	273	307	53	311	321	55	326	336	58	341	355	61	360	384	66	389	419	72	425	432	74	438	446	77	453
Ilford 132 kV	19	16	25	65	55	85	18	15	23	18	15	23	18	15	24	18	15	24	19	16	24	19	16	25	20	16	25	20	17	26
Ingleburn 66 kV	100	12	100	102	12	103	102	12	103	103	12	103	109	13	110	116	14	117	124	15	124	130	15	131	137	16	138	144	17	145
Kemps Creek 132kV	0	0	0	0	0	0	0	0	0	82	40	91	116	56	129	149	72	165	180	87	201	214	104	238	244	118	271	269	130	298
Liverpool 132 kV	317	24	318	325	24	326	336	25	337	352	26	353	378	28	379	404	30	405	430	32	431	454	34	455	479	36	480	504	38	506
Macarthur 66 kV	145	14	146	165	15	166	180	17	181	189	18	190	199	19	200	201	19	202	210	20	210	216	20	217	222	21	223	229	21	230
Macarthur 132 kV	220	5	220	219	4	219	231	5	231	257	5	257	281	6	281	323	7	323	361	7	361	400	8	400	440	9	440	483	10	483
Marulan 132 kV	135	29	138	136	29	140	136	29	140	138	30	141	139	30	142	142	30	145	143	31	146	145	31	148	147	31	150	149	32	152
Mount Piper 66 kV	37	10	38	37	10	39	37	10	39	37	10	39	37	10	39	37	10	39	38	10	39	38	11	39	38	11	39	38	11	40
Regentville 132 kV	212	45	217	218	46	223	219	46	223	224	47	229	227	48	232	228	48	233	230	49	235	231	49	236	232	49	238	232	49	237
Sydney North 132 kV	27	6	27	27	6	28	28	6	28	28	6	29	30	7	31	32	7	33	34	8	35	37	8	37	39	9	40	41	9	42
Sydney West 132 kV	1032	141	1041	1150	157	1161	1208	165	1220	1269	173	1281	1365	186	1378	1443	197	1457	1516	207	1530	1580	216	1595	1642	224	1657	1698	232	1714
Vineyard 132 kV	373	42	375	422	47	424	466	52	469	508	57	511	545	61	548	579	64	582	606	68	610	623	69	627	639	71	643	650	72	654
Wallerawang 66 kV	36	5	36	49	7	50	48	7	48	48	7	48	48	7	49	48	7	49	49	7	49	49	7	50	50	7	50	50	8	51
Wallerawang 132 kV	51	4	52	52	4	52	51	4	51	52	4	52	52	4	52	53	4	53	54	4	54	55	4	55	56	4	56	57	4	57

110 Marulan 132 kV: Both Endeavour Energy and Essential Energy take supply from Marulan. This forecast is for Endeavour Energy component.

Table A2.5: Essential Energy (North) bulk supply point summer maximum demand

	2025/26			2026/27			2027/28			2028/29			2029/30			2030/31			2031/32			2032/33			2033/34			2034/35		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Armidale 66 kV	28	1	28	28	1	28	28	1	28	28	1	28	29	1	29	29	1	29	29	1	29	29	1	29	29	1	29	29	1	29
Boambee South 132 kV	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19	19	0	19
Casino 132 kV	27	8	29	28	8	29	28	8	29	28	8	29	27	8	28	27	8	29	27	8	29	27	8	28	28	8	29	27	8	29
Coffs Harbour 66 kV	61	2	61	61	-1	61	61	-4	61	61	-6	62	61	-9	62	61	-12	62	61	-14	63	61	-17	64	61	-19	64	61	-22	65
Dorrigo 132 kV	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	-1	2
Dunoon 132 kV	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6
Glen Innes 66 kV	11	-4	12	11	-5	12	11	-5	12	11	-5	12	11	-6	12	11	-6	12	11	-6	13	11	-6	13	11	-7	13	11	-7	13
Gunnedah 66 kV	39	5	39	39	5	39	39	5	39	39	5	39	39	5	39	39	5	39	39	5	39	39	6	39	39	6	39	39	5	39
Hawks Nest 132 kV	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11
Herons Creek 132 kV	12	2	12	12	2	12	12	2	12	12	2	12	12	2	12	12	2	12	12	2	12	12	2	12	12	2	12	11	2	12
Inverell 66 kV	39	-3	40	39	-3	40	39	-3	39	39	-3	40	39	-3	39	39	-3	40	39	-3	39	39	-3	39	39	-3	39	39	-3	39
Kempsey 33 kV	31	5	31	31	5	31	31	5	31	31	5	31	31	5	32	31	5	31	31	5	32	31	5	32	31	5	32	31	5	32
Koolkhan 66 kV	56	-12	58	57	-14	59	57	-17	60	57	-20	61	58	-22	62	58	-25	63	58	-28	64	58	-31	66	59	-33	68	59	-36	69
Lismore 132 kV	101	11	102	102	10	102	101	10	102	102	10	102	102	10	103	102	9	102	102	9	102	102	10	102	102	9	102	102	9	102
Macksville 132 kV	10	0	10	10	0	10	10	0	10	10	0	10	10	0	10	10	0	10	10	-1	10	10	-1	10	10	-1	10	10	-1	10
Moree 66 kV	28	1	28	30	1	30	34	1	34	38	2	39	42	3	42	45	3	45	48	3	48	51	4	51	54	4	54	56	4	56
Mullumbimby 11 kV	9	-1	9	9	-1	9	9	-1	9	9	-1	9	9	-1	9	9	-2	10	10	-2	10	9	-2	10	9	-2	10	9	-2	10
Mullumbimby 132 kV	53	0	53	54	0	54	53	0	53	54	0	54	54	0	54	55	0	55	55	0	55	56	0	56	56	1	56	56	1	56
Nambucca 66 kV	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8
Narrabri 66 kV	62	-1	62	62	-1	62	88	7	88	88	7	88	88	7	88	90	8	91	104	13	105	104	13	105	104	13	105	104	13	105
Port Macquarie 33 kV	75	5	75	76	5	76	77	5	77	78	5	78	79	5	79	80	5	81	81	5	82	83	5	83	84	5	84	85	5	85
Raleigh 132 kV	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11	11	1	11
Stroud 132 kV	37	8	37	36	8	37	37	8	37	36	8	37	37	8	37	36	8	37	37	8	38	37	8	38	37	8	37	36	8	37
Tamworth 66 kV	117	20	119	126	23	128	128	23	131	130	24	132	131	24	133	134	25	136	134	25	136	137	25	139	137	26	140	138	26	140
Taree 33 kV	33	5	34	33	4	33	33	4	34	33	4	33	33	4	33	33	4	33	32	4	33	33	4	33	33	4	33	32	4	33
Taree 66 kV	55	7	55	55	6	55	55	6	55	54	7	55	54	7	55	54	6	54	54	6	54	54	7	54	54	6	54	53	7	54
Tenterfield 22 kV	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4
Terranora 110 kV	95	10	95	96	10	96	97	10	97	98	10	98	99	10	99	100	10	100	100	10	101	102	10	102	102	10	103	103	10	104

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Table A2.6: Essential Energy (North) bulk supply point winter maximum demand

	2025			2026			2027			2028			2029			2030			2031			2032			2033			2034		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Armidale 66 kV	43	0	43	43	-1	43	43	-2	43	44	-3	44	44	-3	44	44	-4	44	44	-5	45	45	-5	45	45	-6	45	45	-7	45
Boambee South 132 kV	19	-1	19	19	-1	19	19	-1	19	20	-1	20	20	-1	20	20	-1	20	20	-1	20	20	-1	20	21	-1	21	21	-1	21
Casino 132 kV	24	2	24	24	3	24	24	3	24	24	2	24	24	3	24	24	3	24	24	3	24	24	2	24	24	3	24	24	3	24
Coffs Harbour 66 kV	66	-4	67	67	-5	67	68	-5	68	69	-6	69	70	-6	70	71	-6	71	71	-7	72	72	-7	72	73	-7	73	74	-8	74
Dorrigo 132 kV	3	0	3	3	0	3	3	0	3	3	0	3	3	0	3	3	0	3	3	0	3	3	0	3	3	0	3	3	0	3
Dunoon 132 kV	6	0	6	6	0	6	6	0	7	7	0	7	7	0	7	7	0	7	7	0	7	7	0	7	7	0	7	7	0	7
Glen Innes 66 kV	16	-2	16	16	-2	16	16	-2	16	16	-2	16	16	-2	16	16	-2	17	17	-2	17	17	-2	17	17	-2	17	17	-2	17
Gunnedah 66 kV	24	-1	24	34	3	34	34	3	34	34	3	35	34	3	34	34	2	34	34	2	34	34	2	34	34	2	34	34	2	34
Hawks Nest 132 kV	8	1	9	8	1	9	8	1	9	8	1	9	8	1	9	8	1	9	8	1	9	8	1	9	8	1	9	8	1	9
Herons Creek 132 kV	11	0	11	11	0	11	11	0	11	11	0	11	11	0	11	11	-1	11	11	-1	11	11	-1	11	11	-1	11	11	-1	11
Inverell 66 kV	44	-6	45	44	-6	45	45	-5	45	45	-5	45	45	-5	45	45	-5	46	45	-5	46	45	-5	45	46	-5	46	46	-5	46
Kempsey 33 kV	31	1	31	31	1	31	31	0	31	31	0	31	31	0	31	31	-1	31	31	-1	31	31	-1	31	31	-2	31	31	-2	31
Koolkhan 66 kV	48	-9	49	48	-10	49	49	-11	50	49	-12	50	49	-13	51	50	-14	51	50	-15	52	50	-15	52	50	-16	53	51	-17	53
Lismore 132 kV	91	8	92	91	7	91	91	7	92	91	7	92	91	7	92	91	7	91	91	7	91	91	7	91	91	7	92	91	7	91
Macksville 132 kV	10	0	10	10	0	10	10	0	10	10	-1	10	10	-1	10	10	-1	10	10	-1	10	10	-1	10	10	-1	10	10	-2	10
Moree 66 kV	34	-2	34	34	-2	34	36	-2	36	40	-1	40	44	-1	44	48	0	48	51	0	51	54	1	54	56	1	56	58	1	58
Mullumbimby 11 kV	9	0	9	10	0	10	10	0	10	10	0	10	10	-1	10	11	-1	11	11	-1	11	11	-1	11	11	-1	11	11	-1	11
Mullumbimby 132 kV	53	0	53	53	0	53	54	0	54	54	0	54	54	0	54	54	1	54	55	0	55	55	1	55	55	1	55	56	1	56
Nambucca 66 kV	9	0	9	9	0	9	9	0	9	9	0	9	9	0	9	10	0	10	10	0	10	10	0	10	10	0	10	10	0	10
Narrabri 66 kV	53	-8	54	62	-5	62	63	-5	63	89	3	89	90	3	90	90	3	90	93	4	93	108	9	108	108	9	109	109	9	109
Port Macquarie 33 kV	81	5	81	81	5	81	81	5	81	81	6	82	82	5	82	82	5	82	82	6	82	82	6	82	82	6	83	82	6	82
Raleigh 132 kV	11	1	11	12	1	12	12	1	12	12	1	12	12	1	12	12	1	12	13	1	13	13	1	13	13	1	13	13	1	13
Stroud 132 kV	34	-1	34	34	-1	34	34	-1	34	34	-1	34	34	-1	34	34	-1	34	34	-1	34	34	-1	34	34	-1	34	34	-1	34
Tamworth 66 kV	108	8	108	116	11	117	119	11	119	122	12	123	125	12	125	126	12	127	130	13	131	131	13	132	135	14	135	136	14	137
Taree 33 kV	26	2	26	26	2	26	26	2	26	26	2	26	26	2	26	26	2	26	26	2	26	26	2	26	26	2	26	26	2	26
Taree 66 kV	58	5	58	58	5	58	58	5	58	58	5	58	58	5	58	58	5	58	58	5	58	58	5	58	58	5	59	58	5	59
Tenterfield 22 kV	6	0	6	6	0	6	6	0	6	6	0	6	6	0	6	6	0	6	6	0	6	6	0	6	6	0	6	6	0	6
Terranora 110 kV	98	1	98	101	1	101	103	1	103	105	1	105	106	1	106	108	1	108	110	1	110	112	1	112	114	1	114	116	1	116

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Table A2.7: Essential Energy (Central) bulk supply point summer maximum demand

	2025/26			2026/27			2027/28			2028/29			2029/30			2030/31			2031/32			2032/33			2033/34			2034/35		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Beryl 66 kV	86	16	87	87	16	89	89	16	90	90	15	91	91	15	93	93	15	94	93	15	95	95	16	96	96	15	97	97	15	98
Cowra 66 kV	33	1	33	33	1	33	33	1	33	33	1	33	33	1	33	33	1	33	33	1	33	33	1	33	33	1	33	33	1	33
Forbes 66 kV	34	0	34	34	0	34	34	0	34	33	0	33	33	0	33	33	0	33	33	0	33	33	0	33	33	0	33	32	-1	32
Manildra 132 kV	10	3	10	10	3	10	10	3	10	9	3	10	9	3	10	9	3	10	9	3	10	9	3	10	9	3	10	9	3	10
Molong 66 kV	6	0	6	6	0	6	6	0	6	6	0	6	5	0	5	5	0	5	6	0	6	6	0	6	6	0	6	5	0	5
Mudgee 132 kV	24	6	25	24	6	25	24	6	25	24	6	25	25	6	25	25	6	26	25	6	26	25	6	26	25	6	26	25	7	26
Orange 66 kV	49	-6	50	50	-6	50	50	-6	50	50	-6	50	50	-6	50	51	-5	51	50	-6	51	51	-6	51	51	-6	52	51	-6	52
Orange 132 kV	172	30	174	176	30	178	179	31	182	182	32	185	186	33	189	189	33	192	193	34	196	196	35	199	200	35	203	203	36	206
Panorama 66 kV	76	4	76	76	3	76	75	2	75	75	1	75	75	0	75	75	-1	75	74	-3	74	75	-4	75	75	-5	75	75	-6	75
Parkes 66 kV	34	-3	34	34	-3	34	34	-3	35	35	-4	35	35	-3	35	35	-3	35	35	-3	35	35	-3	36	36	-3	36	36	-3	36
Parkes 132 kV	39	7	39	47	8	48	56	10	57	59	10	60	63	11	63	67	12	68	71	12	72	74	13	75	77	13	78	80	14	81
Wallerawang 66 kV	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6	6	1	6
Wallerawang 132 kV	32	18	37	33	18	38	34	18	38	35	18	39	35	18	40	36	18	41	37	18	41	38	18	42	39	18	43	40	18	44
Wellington 132 kV incl Town	201	19	202	201	18	202	224	22	225	247	24	248	249	24	250	249	24	250	250	24	251	250	23	251	251	24	252	252	24	253

Table A2.8: Essential Energy (Central) bulk supply point winter maximum demand

	2025			2026			2027			2028			2029			2030			2031			2032			2033			2034		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Beryl 66 kV	88	10	89	90	10	90	91	10	92	92	11	93	93	10	94	94	11	95	95	11	96	96	11	97	97	11	98	98	11	99
Cowra 66 kV	28	-1	28	28	-1	28	28	-1	28	28	-1	28	29	-1	29	28	-1	28	29	-1	29	29	-1	29	29	-1	29	29	-1	29
Forbes 66 kV	25	-4	26	25	-4	26	25	-4	25	25	-4	26	25	-4	25	25	-4	26	25	-4	26	25	-4	26	25	-4	26	25	-4	26
Manildra 132 kV	9	3	10	9	3	10	9	3	10	9	3	9	9	3	9	9	3	9	9	3	9	9	3	9	9	2	9	9	2	9
Molong 66 kV	5	-1	5	5	-1	5	5	-1	5	5	-1	5	5	-1	5	5	-1	5	5	-1	6	6	-1	6	6	-1	6	6	-1	6
Mudgee 132 kV	27	2	27	27	2	27	27	3	27	28	3	28	28	3	28	28	3	28	28	3	28	28	3	28	28	4	28	28	4	28
Orange 66 kV	65	-5	66	65	-4	66	65	-4	65	66	-5	66	66	-4	66	66	-4	66	66	-5	66	66	-4	66	66	-5	66	66	-5	66
Orange 132 kV	175	26	177	180	27	182	184	28	187	189	28	191	193	29	195	198	30	201	203	30	205	207	31	209	211	32	214	216	32	219
Panorama 66 kV	77	9	78	78	10	78	78	9	79	79	9	80	79	10	80	80	10	80	80	10	81	81	10	81	81	10	82	81	10	82
Parkes 66 kV	29	1	29	30	1	30	30	1	30	30	1	30	31	1	31	31	1	31	32	1	32	32	1	32	32	1	32	33	2	33
Parkes 132 kV	34	6	35	43	7	43	51	9	52	60	10	61	64	11	65	68	12	69	72	12	73	75	13	76	78	13	79	81	14	82
Wallerawang 66 kV	10	4	11	10	4	10	10	4	11	10	4	10	10	4	11	10	4	11	10	4	10	10	4	11	10	4	11	10	4	11
Wallerawang 132 kV	32	18	37	33	18	38	34	18	38	35	18	39	36	18	40	37	18	41	37	18	41	38	18	42	39	18	43	40	18	44
Wellington 132 kV incl Town	162	-8	162	162	-8	162	185	-5	185	208	-2	208	208	-1	208	208	-2	208	208	-2	208	208	-2	208	208	-2	208	208	-2	208

Transgrid

Table A2.9: Essential Energy (South) and Evoenergy bulk supply point summer maximum demand

	2025/26			2026/27			2027/28			2028/29			2029/30			2030/31			2031/32			2032/33			2033/34			2034/35		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Albury & Finley 132 kV	113	3	113	113	2	113	113	1	113	113	0	113	113	-1	113	113	-2	113	113	-3	113	113	-3	113	113	-4	113	113	-5	113
Balranald 22 kV	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	-1	4	4	-1	4	4	-1	4	4	-1	4	4	-1	4
Broken Hill 22 kV	39	1	39	40	0	40	39	-1	40	40	-2	40	40	-3	40	40	-4	40	40	-5	40	40	-6	40	40	-7	40	40	-8	41
Canberra 132 kV Evoenergy	294	66	301	321	74	329	326	75	334	332	76	340	341	72	348	347	76	356	353	83	363	360	75	368	365	82	374	366	84	376
Coleambally 132 kV	12	4	13	12	4	13	12	4	13	12	4	13	12	4	13	12	4	13	12	4	13	12	4	13	12	4	13	12	4	13
Cooma 66 kV	17	-2	18	18	-3	18	18	-3	18	18	-3	18	18	-3	18	18	-3	19	18	-3	18	19	-3	19	19	-3	19	19	-3	19
Cooma 132 kV	39	-4	39	39	-4	39	39	-4	40	39	-4	40	39	-4	39	39	-4	39	39	-4	39	39	-4	40	39	-4	40	39	-4	39
Darlington Point 132 kV	25	8	26	25	8	26	25	8	26	25	8	26	25	8	26	25	8	27	26	8	27	26	8	27	26	8	27	26	8	27
Deniliquin 66 kV	47	-1	47	47	-1	47	47	-1	47	47	-1	47	47	-1	47	46	-1	46	46	-1	46	46	-1	46	45	-1	45	45	-1	45
Finley 66 kV	16	2	16	16	2	16	16	2	16	16	2	16	16	2	16	16	2	16	16	2	16	16	2	16	16	2	16	16	2	16
Griffith 33 kV	102	8	103	103	8	103	104	8	104	104	8	104	105	8	105	105	8	105	106	8	106	106	8	106	106	8	107	107	8	107
Marulan 132 kV	47	-2	48	47	-2	47	46	-2	46	46	-2	46	46	-2	46	46	-2	46	46	-2	46	46	-2	46	47	-2	47	46	-2	46
Morven 132 kV	9	1	9	9	1	9	9	1	9	9	1	9	9	1	9	9	1	9	9	1	9	9	1	9	9	1	9	9	1	9
Munyang 33 kV	3	-1	4	3	-1	4	3	-1	4	3	-1	4	3	-1	4	3	-1	4	3	-1	4	3	-1	4	3	-1	4	4	-1	4
Murrumbateman 132 kV	5	0	5	5	0	5	5	0	5	5	0	5	5	0	5	5	0	5	5	0	5	5	0	5	5	0	5	5	0	5
Murrumburrah 66 kV	35	2	35	34	3	34	34	3	34	34	2	34	33	2	33	33	3	33	33	2	33	32	2	32	32	3	32	32	3	32
Queanbeyan 66 kV Essential Energy	53	6	54	58	7	58	64	9	64	69	10	70	73	11	74	79	13	80	84	14	85	92	16	93	94	17	96	96	17	97
Queanbeyan 66 kV Evoenergy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Queanbeyan 132 kV	10	-1	10	10	-1	10	10	-1	10	11	-1	11	11	-2	11	11	-1	11	11	-1	12	12	-1	12	12	-1	12	12	-1	12
Snowy Adit 132 kV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stockdill 132 kV Evoenergy	123	18	124	131	19	133	130	18	131	132	19	133	133	19	134	135	19	136	135	19	137	132	19	133	131	19	133	130	18	131
Tumut 66 kV	27	5	28	26	5	27	26	5	26	26	5	26	25	5	25	25	5	25	24	5	25	24	5	24	23	5	24	23	5	23
Upper Tumut (Cabramurra) 11 kV	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1
Wagga Wagga 66 kV	65	9	66	65	9	66	65	9	66	65	9	66	65	9	66	65	9	66	65	9	66	65	9	66	65	9	66	65	9	66
Wagga Wagga North 132 kV	68	-4	68	68	-4	68	68	-4	68	67	-4	67	68	-4	69	68	-4	68	68	-4	68	69	-4	69	68	-4	68	69	-4	69
Wagga Wagga North 66 kV	28	5	29	31	5	31	33	5	34	36	5	36	38	5	38	41	6	41	51	7	52	54	7	55	56	7	57	56	7	57
Williamsdale 132 kV Evoenergy	189	75	204	199	78	213	201	79	216	203	80	219	207	79	222	210	82	225	212	82	228	215	82	231	217	85	233	219	81	233
Yanco 33 kV	40	11	41	40	11	41	40	11	41	40	11	41	40	11	41	40	11	41	40	11	41	40	11	41	40	11	41	40	11	41
Yass 66 kV	12	-2	12	12	-2	12	12	-2	12	12	-2	12	12	-2	12	12	-2	12	12	-2	12	12	-2	12	12	-2	12	12	-2	12

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Table A2.10: Essential Energy (South) and Evoenergy bulk supply point winter maximum demand

	2025			2026			2027			2028			2029			2030			2031			2032			2033			2034		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
Albury & Finley 132 kV	98	0	98	99	0	99	100	0	100	100	0	100	100	1	100	101	0	101	101	0	101	102	0	102	102	0	102	103	0	103
Balranald 22 kV	3	-1	3	3	-1	3	3	-1	3	3	-1	3	3	-1	3	3	-1	3	3	-1	3	3	-1	3	3	-1	3	3	-1	3
Broken Hill 22 kV	35	-1	35	37	-1	37	37	-2	37	37	-2	37	37	-3	37	36	-4	37	36	-4	37	36	-5	37	36	-5	37	36	-6	37
Canberra 132 kV Evoenergy	457	54	460	479	56	482	480	73	485	484	60	488	487	59	491	489	71	495	494	58	497	494	76	500	496	76	502	496	48	498
Coleambally 132 kV	9	3	9	9	3	9	9	3	9	9	3	9	9	3	9	9	3	9	9	3	9	9	4	9	9	3	9	9	3	9
Cooma 66 kV	33	-1	33	33	-1	33	34	-1	34	34	-1	34	35	-1	35	35	-1	35	35	-1	35	36	-1	36	36	-1	36	36	-1	36
Cooma 132 kV	49	-4	49	49	-4	49	49	-4	49	49	-4	49	49	-4	49	49	-4	49	49	-4	49	49	-4	49	49	-4	49	49	-4	49
Darlington Point 132 kV	22	7	23	23	7	24	23	7	24	23	7	24	23	7	24	23	7	24	23	7	24	23	7	24	23	7	24	23	7	24
Deniliquin 66 kV	38	-1	38	38	-1	38	38	-1	38	38	-1	38	39	-1	39	39	-1	39	39	-1	39	39	-1	39	39	-1	39	39	-1	39
Finley 66 kV	13	0	13	13	0	13	13	0	13	13	0	13	13	0	13	13	0	13	13	0	13	13	0	13	13	0	13	13	0	13
Griffith 33 kV	63	3	63	64	3	64	65	3	65	65	3	65	66	3	66	66	3	67	67	3	67	68	3	68	69	3	69	69	4	69
Marulan 132 kV	56	11	57	56	11	57	56	11	57	56	11	57	56	11	57	56	11	57	56	11	57	56	11	57	56	11	57	56	11	57
Morven 132 kV	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8
Munyang 33 kV	27	8	28	27	8	28	26	9	28	26	8	28	26	8	28	26	9	27	26	9	27	26	8	27	26	8	27	26	8	27
Murrumbateman 132 kV	7	0	7	7	0	7	7	0	7	7	0	7	7	0	7	7	-1	7	7	-1	7	7	-1	7	7	-1	7	7	-1	7
Murrumburrah 66 kV	39	2	39	39	2	39	39	2	39	40	2	40	40	2	40	40	2	40	40	2	40	40	2	40	40	2	40	40	2	41
Queanbeyan 66 kV Essential Energy	69	4	69	75	6	75	81	7	81	86	9	86	92	10	92	97	11	98	102	13	103	108	14	109	116	16	117	117	17	119
Queanbeyan 66 kV Evoenergy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Queanbeyan 132 kV	13	-1	13	14	-1	14	15	-1	15	16	-1	16	17	-1	17	18	-1	18	19	-1	19	20	-1	20	20	-1	20	21	-1	21
Snowy Adit 132 kV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stockdill 132 kV Evoenergy	279	40	282	291	41	294	292	42	295	293	42	296	292	42	295	295	42	298	293	42	296	297	42	300	301	43	304	300	43	303
Tumut 66 kV	31	4	31	31	4	31	30	4	31	30	4	30	30	4	30	30	4	30	29	4	30	29	4	29	29	4	29	29	4	29
Upper Tumut (Cabramurra) 11 kV	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2
Wagga Wagga 66 kV	75	3	75	75	3	75	75	3	75	75	3	75	75	3	75	75	3	75	75	3	75	75	3	75	75	3	75	75	3	75
Wagga Wagga North 132 kV	72	-9	72	73	-9	73	73	-9	74	74	-8	75	75	-8	75	75	-8	75	76	-8	76	76	-8	76	76	-9	77	77	-8	77
Wagga Wagga North 66 kV	25	2	25	25	2	25	27	2	28	30	3	30	32	3	32	34	3	35	37	3	37	47	4	47	50	4	51	52	4	52
Williamsdale 132 kV Evoenergy	227	90	244	237	91	254	242	91	258	246	91	263	250	96	268	255	95	272	259	98	277	264	98	281	267	99	285	270	97	287
Yanco 33 kV	35	6	35	35	6	35	35	6	36	35	6	36	35	6	36	35	6	36	35	6	36	35	6	36	35	6	36	36	6	36
Yass 66 kV	15	-3	16	16	-3	16	16	-3	16	16	-3	16	16	-3	16	16	-3	16	16	-3	16	16	-3	17	16	-3	17	17	-3	17

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Table A2.11: Major industrial customers – Sum of individual summer maximum demands

	2025/26 MW	2026/27 MW	2027/28 MW	2028/29 MW	2029/30 MW	2030/31 MW	2031/32 MW	2032/33 MW	2033/34 MW	2034/35 MW
Industrial Loads	1081	1081	1166	1181	1199	1216	1233	1250	1267	1284

Table A2.12: Major industrial customers – Sum of individual winter maximum demands

	2025 MW	2026 MW	2027 MW	2028 MW	2029 MW	2030 MW	2031 MW	2032 MW	2033 MW	2034 MW
Industrial Loads	1081	1081	1081	1166	1181	1199	1216	1233	1250	1267

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Appendix 3

Trent Gillespie – Field Coordinator (Substations)
Taylor Madden – Substation Technician

How we plan

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Transgrid

Our network planning process is designed to ensure the efficient delivery of our capital program so we can facilitate the transition to a clean energy future.

A3.1.1 NSW Transmission Planning

Our current planning, coordination, operation and service provision roles

Under the National Electricity Rules (NER), Transgrid has multiple roles, including as:

- The Primary Transmission Network Service Provider (TNSP) for NSW
- The Coordinating Transmission Network Service Provider (CTNSP) for NSW
- The System Strength Service Provider and Inertia Service Provider for NSW

As a TNSP under the NER, we are subject to network planning requirements, including publishing this Report, and connections arrangements when generators, customers or other networks seek to connect to our network.

Transgrid is also a network operator for REZ Network Infrastructure Projects and Priority Transmission Infrastructure Projects under the *EII Act* and holds a transmission operator licence under the *Electricity Supply Act* 1995 (NSW).

Transgrid works closely with AEMO to develop the Integrated System Plan, which aligns with the investment needs described in this Report. We also work closely with EnergyCo, the Infrastructure Planner leading the delivery of Renewable Energy Zones (REZs) as part of the NSW Government Electricity Infrastructure Roadmap. EnergyCo produces a NSW Network Infrastructure Strategy (NIS) to coordinate the connection of new generation. The Consumer Trustee, AusEnergy Services (previously AEMO Services), independently considers these options in preparing its Infrastructure Investment Objectives (IIO) Report, which sets a 20-year development pathway for NSW generation and energy storage infrastructure.

We align our planning of the shared transmission network to support the development of REZs, taking into account the NIS and the IIO. This includes planning how a REZ will integrate with the transmission network to avoid compromising system security.

How this may change after the NSW Transmission Planning Review

The NSW Transmission Planning Review 2025[111] is looking to improve how transmission planning is coordinated across key agencies. An Interim Report released in June recommends better coordination between Transgrid, AEMO, EnergyCo and AusEnergy Services, with final recommendations due in September.

The Interim Report recommends a three-stage implementation plan with:

1. Immediate actions to accelerate planning and delivery of upcoming projects
2. Actions to clarify roles and responsibilities and enhance engagement by 2026
3. Actions to better coordinate planning across NSW by 2027

Under these draft recommendations, Transgrid will continue to have a major role in transmission planning in NSW. For example, we will continue to:

- Plan our network
- Undertake joint planning with EnergyCo, AEMO and DNSPs
- Publish our Transmission Annual Planning Report
- Be the System Strength Service Provider and Inertia Service Provider for NSW
- Plan connections to our network
- Plan interconnections with other states
- Be responsible for transmission pricing, including being CTNSP for NSW
- Undertake all of our current system security, system control and system operation functions
- Plan and deliver NER transmission projects and EII Act projects where we are the TNSP or network operator.

Transgrid strongly supports continued collaboration for transmission planning. To play our part in the new recommendations, we will preserve continuity in our core analytical functions of network planning, system strength planning, connections management and network analysis. These capabilities are critical to avoiding unnecessary delays in the energy transition and keeping costs down for consumers.

A3.1.2 National Electricity Rules

This Report has been prepared in accordance with our obligations in the NER, including its processes for developing networks and the minimum performance requirements of the network and its connections. When required, our development proposals have to pass the AER's Regulatory Investment Test – Transmission (RIT-T), which requires us to consult with registered participants and interested parties.

We also have to plan to certain standards. When the system is either in its normal state with all elements in service or following a credible contingency:

- Electrical and thermal ratings of equipment will not be exceeded
- Stable control of the interconnected system will be maintained, with system voltages maintained within acceptable levels
- The power system should remain in synchronism and be stable
- System strength and inertia levels are above required levels
- A quality of electricity supply at least to NER requirements is to be provided
- A standard of connection to individual customers as specified by Connection Agreements is to be provided
- As far as possible connection of a customer is to have no adverse effect on other connected customers
- Environmental and social objectives are to be satisfied
- Acceptable safety standards are to be maintained.

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Another obligation is to ensure the NSW electricity system is developed at the lowest cost possible while meeting the constraints imposed by the above factors. This includes providing sufficient capability in the system to allow components to be maintained in accordance with efficient asset management strategies – and reducing system energy losses where it is economic to do so.

In fulfilling our obligations, we recognise specific customer requirements as well as AEMO's role as system operator for the NEM. As a result, rather than merely complying with the NER standards, we weigh certain circumstances based on whether they deliver a greater net market benefit. For example:

- Where agreed with a distribution network owner or major directly connected end-use customer, certain levels of supply interruption can be accepted for particular single outages, before augmentation of the network is undertaken (for example, the situation with radial supplies)
- Where requested by a distribution network owner or major directly connected end-use customer and agreed with us, there will be no inadvertent loss of load (other than load which is interruptible or dispatchable) following events more onerous than N-1 such as concurrent outages of two network elements
- The transmission network should have sufficient capacity to accommodate AEMO's operating practices without inadvertent loss of load (other than load which is interruptible or dispatchable) or uneconomic constraints on the energy market. AEMO's operating practices include the re-dispatch of generation and ancillary services following a first contingency, such that within 30 minutes the system will again be in a "secure operating state" in anticipation of the next critical credible contingency.

A3.1.3 Service standard

In addition to meeting the requirements of the NER, environmental legislation and other statutory instruments, we are required to comply with the Electricity Transmission Reliability Standards 2017, administered by the Independent Pricing and Regulatory Tribunal (IPART). This standard specifies two reliability criteria for each BSP:

- The required level of network redundancy for each BSP or group of BSPs that function as a cohort
- An allowance of Minutes of Expected Unserved Energy, which is the maximum amount of energy at risk of not being supplied in a given year expressed as minutes at the average load on the BSP.

This is a planning, rather than a performance standard. It means the network needs to be planned to meet the standards over the lifecycle of the assets on average, rather than be met in every year.

Network investment may be required to ensure compliance with the standard. However, we have flexibility to promote the most efficient network or non-network solution to meet the Minutes of Expected Unserved Energy allowance. This may include changes to the transmission network, the distribution network, network support arrangements (including the use of Demand Management options), existing backup supply arrangements, or a combination of these. Transgrid's annual compliance report for 2024 found all existing BSPs are compliant with the standard.

Our planning obligations are interlinked with the reliability obligations placed on DNSPs in NSW. We must ensure that the network is adequately planned to meet these licence requirements.

A3.1.4 National planning requirements

As national transmission planner, AEMO is required to produce an ISP, which considers Transmission Network Service Providers documents, like the Transmission Annual Planning Report. In turn, the TNSPs need to take the ISP into account. Our plans in this Report are consistent with the developments in the 2024 ISP.

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A3.2 Asset management approach

Transgrid

Transgrid must maintain an Asset Management System (AMS) that complies with ISO 55001 to ensure the network is managed at the forefront of good practice asset management, delivering safe, reliable and efficient network services. Our AMS covers the entire asset lifecycle from planning through build/acquisition, operation, maintenance, renewal and decommissioning.

Figure A3.1 illustrates our AMS structure under ISO 55001.

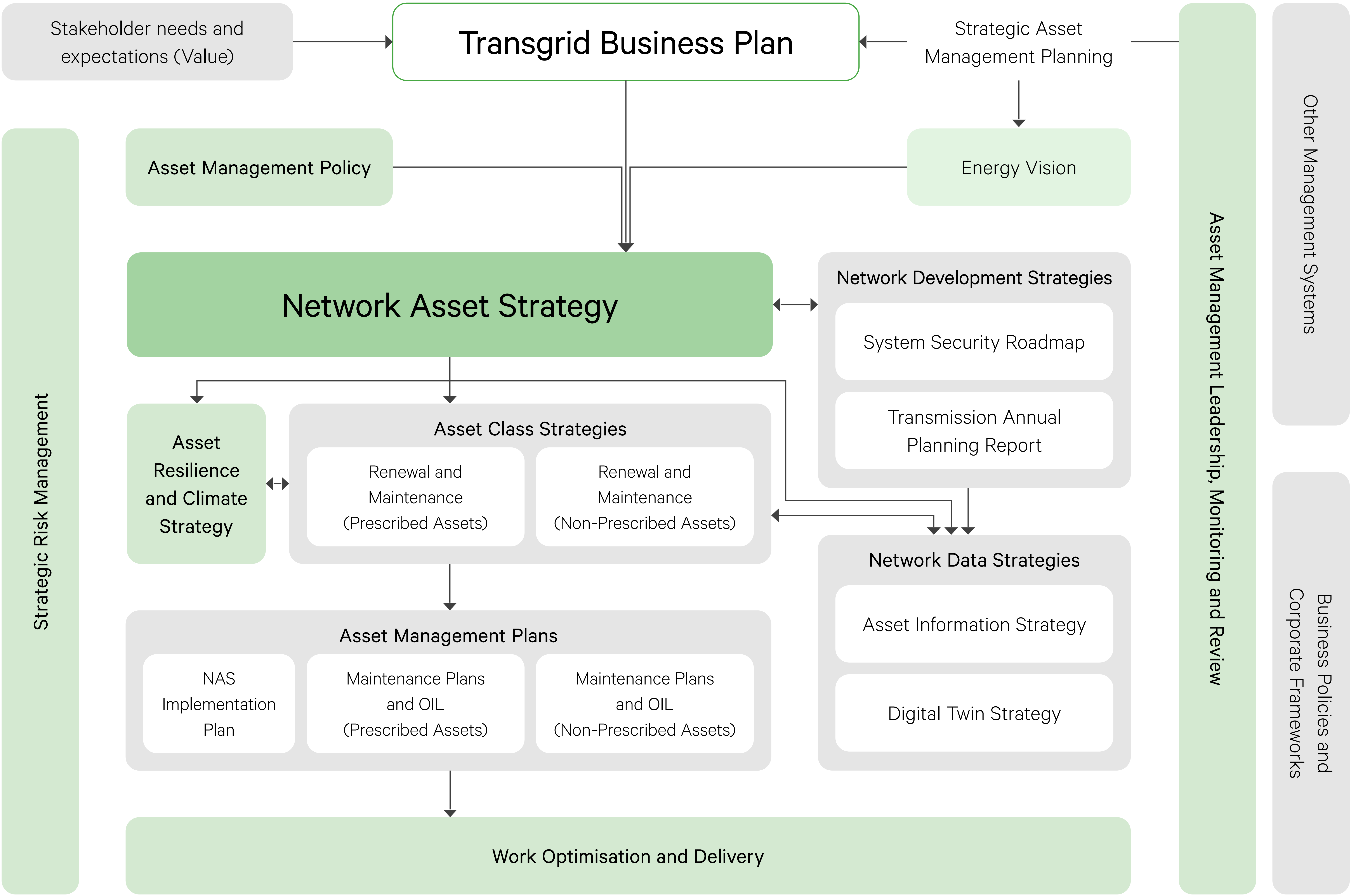
Transgrid's Network Asset Strategy (NAS) responds to the challenges of the energy transition, which require investment in the network and new technologies, changes to asset management processes and new resources and skills. The NAS identifies initiatives to meet these asset management objectives, including:

- New equipment standards for emerging technologies
- Risk-based tools for maintenance analysis
- Reliability modelling to understand how new systems will improve network reliability and security to provide balanced cost-efficient solutions

The NAS also includes an execution plan to provide appropriate levels of funding to deliver the System Security Roadmap objectives.

The Transmission Annual Planning Report is a key enabler in achieving our NAS objectives of managing risks posed by network assets and delivering value for our consumers and security holders.

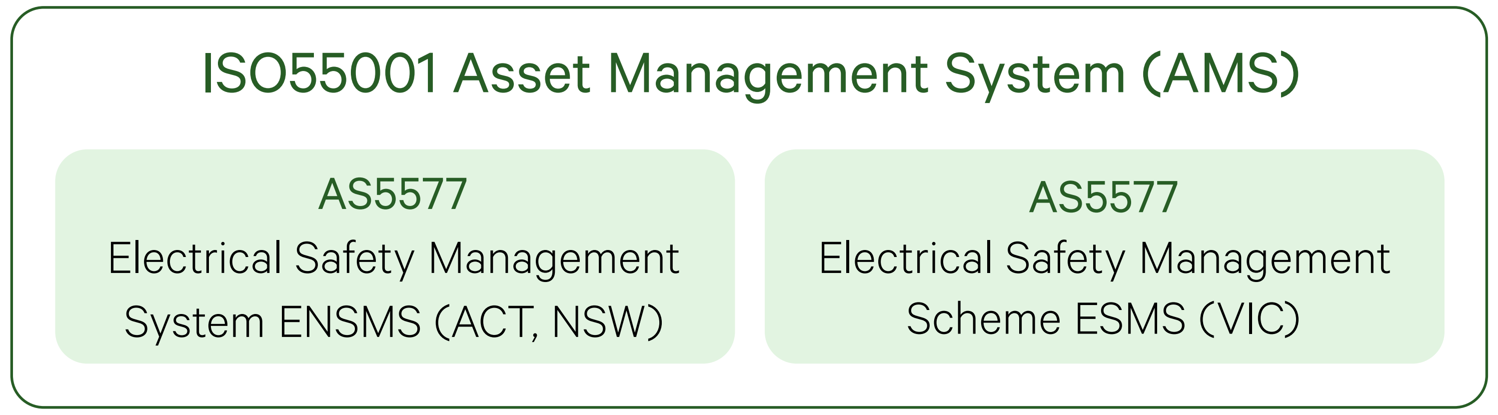
Figure A3.1: Asset Management System



Safety of our customers and community

Transgrid has two network safety management systems to ensure the management of hazards and risks arising from our electricity supply networks. One is applied to network assets located in NSW and ACT jurisdictions, the other for network assets located in Victorian Jurisdiction, as shown in Figure A3.2.

Figure A3.2: Asset and Safety Management Systems



Transgrid takes all reasonably practicable steps to ensure safety and reliability are prioritised in network planning, design, construction, commissioning, operations and decommissioning.

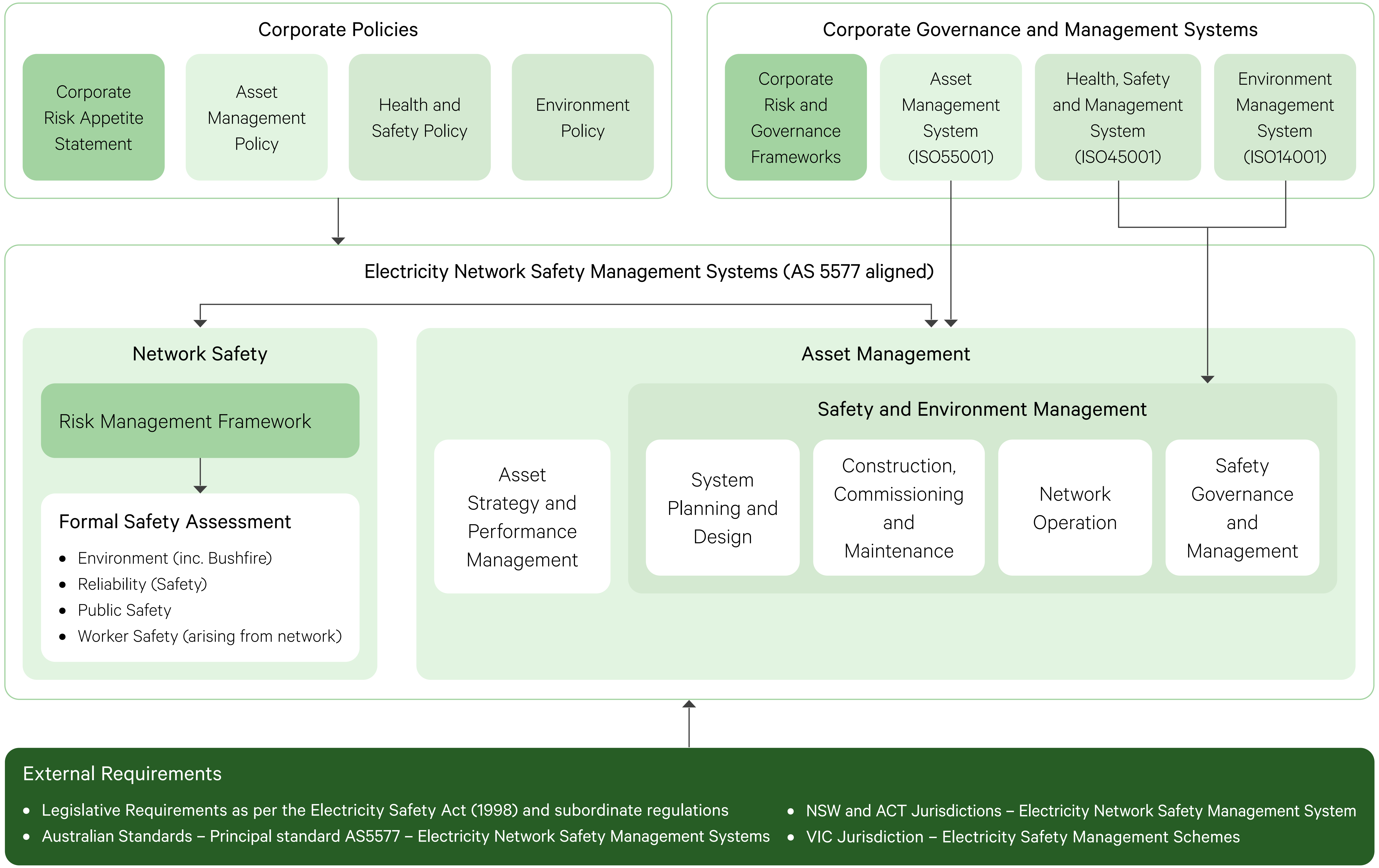
Through our AMS, ENSMS and ESMS, Transgrid seeks to:

- Demonstrate our commitment to regulatory compliance requirements
- Formalise and communicate how risk from assets is managed and reduced
- Demonstrate alignment to the requirements of AS5577 in managing the hazards and risks throughout the asset lifecycle
- Educate and gain the commitment of internal and external stakeholders.

The ENSMS and ESMS include System Planning and Design as part of the Asset Management lifecycle to meet the needs of our stakeholders, including meeting our network reliability obligations.

Our asset renewal planning uses a methodology for quantifying risk that combines the failure behaviour of an asset (the likelihood), and its consequences (the consequence). This approach ensures our asset renewal program has the most economic combination of replacement and refurbishment options.

Figure A3.3: Asset Management System



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A3.3 Network investment process

Our network investment process ensures:

- An integrated, whole-of-business approach to capital program management
- Optimised investments, operating costs and maintenance costs, while meeting augmentation and asset management requirements
- Early resolution of key risk areas, such as environmental approvals, property acquisition and scope definition in the project delivery process
- Documented options evaluations and project scoping to enhance transparency.

Stage 1

Identify need or opportunity

Transgrid planning process

- Look at demand forecasts, expected generation patterns, upcoming projects and the condition of existing assets
- Will there be a shortfall in supply if we do nothing?

Stakeholder involvement

- Sense-check forecasts with:
  - Distributors
  - Directly connected customers
  - AEMO
- Seek feedback from end users and their representatives on need assessment.

Stage 2

Review options

Transgrid planning process

Identify possible network and non-network options to fulfil the need, including:

- Demand management
- Local or distributed generation or storage
- Network infrastructure optimised to meet expected requirements
- Improved operational and maintenance regimes.

Stakeholder involvement

- Input from large energy users, service providers and experts on potential for non-network options
- Communicate with local community that may be impacted by network infrastructure.

Stage 3

Plan in detail

Transgrid planning process

Request proposals and undertake investment analysis on the most viable options.

Stakeholder involvement

- Encourage proposals from market participants for non-network options
- Engage impacted communities in network corridor selection, if relevant
- Involve end users and their representatives in final investment decision.

Stage 4

Implement solution

Transgrid planning process

- Optimise the NSW portfolio of investments
- Enter into contracts for network or non-network solutions
- Build or renew network infrastructure, if required.

Stakeholder involvement

- Work with impacted community to support best local outcomes.
- Report progress in meeting identified need to end users and their representatives.

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A3.4 Planning approach

As part of our planning process, we identify areas of the network where limitations are expected to emerge and consider both network investment and non-network solutions to address them. To identify the most economic options, we plan jointly with DNSPs, EnergyCo, directly supplied industrial customers, generators and TNSPs.

A3.4.1 The network planning process

Network planning occurs at multiple levels:

Connection planning

Planning to connect new loads and generators involves connection enquiries and formulating draft connection agreements leading to a preliminary review of the capability of connections. System Strength Assessments are undertaken following a connection enquiry. Further discussions are held with customers requiring network augmentation or new connection points.

Subsystem planning

Assessing the adequacy of 132 kV and below bulk supply transmission systems requires joint planning in conjunction with DNSPs. This ensures that development proposals meet both transmission and distribution requirements, leading to the lowest possible overall network costs to end customers. This is particularly important where the DNSPs network operates in parallel with the transmission network.

Main System planning

The main 500 kV, 330 kV and 220 kV transmission system (the Main System) is planned and developed in response to load forecasts and generation developments. It may also be influenced by interstate power transfers through interconnectors. Major network developments address emerging constraints, support the connection of new renewable generation and implement the NSW Electricity Infrastructure Roadmap.

Transgrid is supporting and working with EnergyCo to plan, develop and deliver REZs and Priority Transmission Infrastructure Projects, under the Electricity Infrastructure Investment Act 2020. Transgrid has collaborated with EnergyCo to develop its Network Infrastructure Strategy, with theaim of maintaining power system stability and security. Any proposed developments are assessed through liaison with affected NSW and interstate parties using the joint planning processes.

As a System Strength Service Provider and Inertia Service Provider, Transgrid is required to plan the system to ensure sufficient system strength and inertia to meet forecast requirements under the NER.

Inter-regional planning

Inter-regional planning focuses on coordinating interconnectivity with network operators in other states, in accordance with Clause 5.14.3 of the NER. This includes developing both interconnectors between regions and augmentations within regions that have a material effect on inter-regional power transfer capability.

Energy transition

Transgrid's Energy Vision found the role of the transmission network will be critical under every plausible scenario for the energy transition over the next 30 years. Getting the transmission network equation right and ensuring the network is secure and reliable is critical to Australia's successful transition to net zero. We are continuously looking into ways the network can facilitate a rapid and stable energy transition.

A3.4.2 Planning horizons and reporting

Transgrid is currently preparing for the 2028 to 2033 regulatory control period. The planning and network investment process supports connection planning and commitments to network developments in the context of the likely impact of emerging technologies on the electricity system. Long-term planning considers options for future major developments and provides a framework for the orderly and economic development of the transmission network and the strategic acquisition of critical line and substation sites.

As this Report looks at a 10-year horizon, the constraints that appear over long-term time frames are indicative. The timing and capital cost of possible network options to relieve them may change as system conditions evolve.

A3.4.3 Identifying network constraints and assessing possible solutions

We identify emerging constraints in the relevant horizon during various planning activities, including joint planning with EnergyCo and DNSPs. Our planning takes into account the impact of:

- Network developments undertaken by other DNSPs and TNSPs
- Network constraints raised by AEMO
- Prospective generation developments
- Constraints affecting generation dispatch in the NEM
- Changing load forecasts
- Asset renewals
- Relevant regulatory and legislative obligations.

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During the initial planning phase, we develop options for addressing the constraint or need. In accordance with NER requirements, we consult with Interested Parties to determine a range of network and non-network options and/or to refine existing network development options.

We conduct a cost-benefit analysis, comparing the economic costs and benefits of each option in accordance with Transgrid's processes and in alignment with RIT-T requirements if applicable. Cost and benefit factors may include:

- Safety and health, environmental, financial risk costs
- Avoiding unserved energy caused by either a generation shortfall or inadequate transmission capability or reliability
- Changes in Australia's greenhouse gas emissions
- Changes in ancillary services costs
- Changes in network losses
- Competition benefits
- Alleviating constraints affecting generation dispatch
- Avoiding the need for generation developments
- Introducing more efficient generation and fuel type alternatives
- Improving marginal loss factors
- Reducing future asset risk costs
- Deferring related transmission works
- Reducing operation and maintenance costs.

Options with similar net present values are assessed with respect to factors that may not be able to be quantified and/or included in the RIT-T, but nonetheless may be important from environmental or operational viewpoints. For example, these factors may include improving quality of supply above minimum requirements or operational flexibility.

When preferred options are identified for replacement and augmentation needs (including non-network alternatives), a review considers the scope of interactions across repex and augex to (a) resolve direct scope overlaps or (b) re-evaluate options to address a combined repex and augex need as relevant. The portfolio is then reviewed and phased for deliverability.

In the event of RIT-T inputs materially changing, Transgrid will be required to conduct a Material Change in Circumstances (MCC) assessment to determine if the preferred option remains the preferred option.

A3.4.4 Considering non-network alternatives

Where economic, our planning process includes considering non-network alternatives to address emerging constraints, which may defer or remove the need for some network augmentations. These opportunities are assessed on a case-by-case basis.

A3.4.5 Applying power system controls and technology

Where economic, we take advantage of the latest proven technologies in network control systems and electrical plant. For example, static VAR compensators have had a considerable impact on the power transfer capabilities of parts of the main grid, deferring or removing the need for higher cost transmission line developments.

Remedial action schemes have also been applied in several areas of the NSW system to reduce the impact of network limitations on the NEM, and to facilitate removing circuits for maintenance.

The following sections outline the broad approach to planning and consideration of these technologies, together with related issues of protection facilities, transmission line design, substation switching arrangements and power system control and communication. Transgrid's approach is in line with international practice. It provides a cost-effective means of maintaining a safe, reliable, secure and economic supply system while maintaining a responsible approach to environmental and community impacts.

A3.5 Planning criteria

Transgrid

Our planning obligations specify the minimum and general technical requirements in a range of areas, including:

- Minimum levels of credible contingency events to be considered for a specified allowance of unserved energy in a year
- The power transfer capability during the most critical single element outage. This can range from zero in the case of a single element supply to a portion of the normal power transfer capability
- Frequency variations
- Magnitude of power frequency voltages
- Voltage fluctuations, harmonics, unbalance and stability
- Synchronous stability
- System strength and inertia
- The damping of power system oscillations
- Fault clearance times
- The need for two independent high-speed protection systems
- The rating of transmission lines and equipment.

In addition to adhering to the NER and regulatory requirements, we also take into account the historical performance of NSW system components, the sensitivity of loads to supply interruption and state-of-the-art asset maintenance procedures. Planning must also support the system's orderly development, taking into account the requirement to meet future load and generation forecasts.

We apply the criteria below as a point of first review, before making a detailed assessment of each case.

A3.5.1 Main System

Power flows on the Main System are subject to overall state load patterns and the dispatch of generation within the NEM, including interstate export and import of power. AEMO applies operational constraints on generator dispatch to maintain power flows within the capability of the NSW and other regional networks. These constraints are based on the networks' ability to sustain credible contingency events, as defined in the NER, and such events mainly cover forced outages of single generation or transmission elements. However, as per NER 4.2.3A, a non-credible contingency event may be reclassified as a credible contingency event by AEMO if the likelihood of this event impacting the power system has become reasonably possible due to abnormal conditions, such as severe weather conditions, lightning or bushfires. Constraints for credible contingency events are often based on short-duration loadings on network elements, on the basis that generation can be re-dispatched to relieve the line loading within the required time frame. The rationale for this approach is that, if operated beyond a defined power transfer level, credible contingency disturbances could potentially lead to system-wide loss of load with severe social and economic impacts.

Following any transmission outage (e.g., during maintenance or following a forced line outage for which line reclosure[112] has not been possible), AEMO applies more severe constraints within a short adjustment period, in anticipation of a further contingency event. This may require:

- Re-dispatching generation and dispatchable loads
- Redistributing ancillary services
- Where there is no other alternative, shedding load (power interruption).

Transgrid's Main System Planning Criteria requires that no load will be pre-emptively shed in anticipation of the second credible contingency. However, load shedding may be needed following a second credible contingency. The impact of a second credible contingency, including non-credible contingency events that AEMO reclassifies as credible contingency events, on the Main System can be significant. The extent of post-contingency load shedding can be minimised by installing a Remedial Action Scheme.

AEMO may direct load shedding, rather than operating the network for a sustained period in a manner where overall security would be at risk of a further contingency. The risk is accepted over a period of up to 30 minutes. We consider AEMO's imperative is to operate the network in a secure manner.

Our planning for the Main System concentrates on the security of supply to load connection points under sustained outage conditions. This is consistent with the overall principle that supply to load connection points must be satisfactory after any single contingency.

The reliability of Main System components and the ability to withstand a disturbance to the system are critically important in maintaining a secure supply to NSW customers. The capital cost of this system is balanced by:

- Avoiding the large cost to the community of widespread shortages of supply
- Providing flexibility in the choice of economical generating patterns
- Allowing reduced maintenance costs through easier access to equipment
- Minimising electrical losses, which also provides benefit to the environment.

112 Transgrid lines have automatic systems to return them to service (reclose them) following a fault.

As we plan the Main System, Transgrid considers the risk of a credible contingency event coinciding with adverse conditions of load and generation dispatch scenarios. To manage this risk, we plan to augment the Main System in response to changing load forecasts and generation requirements, and the influence of interstate interconnection power transfers. Any developments are negotiated with affected NSW and interstate parties, including AEMO to maintain power flows within the capability of the NSW and other regional networks.

In general, our planning processes considers two worst-case load scenarios for maximum demand. These are scenarios with loads at or exceeding a one in two-year probability of occurrence (50% POE Maximum Load Scenario) and a one in ten-year probability of occurrence (10% POE Maximum Load Scenario).

For minimum load forecasts, we use scenarios with loads at or exceeding a one in ten-year probability of occurrence (10% POE Minimum Load Scenario), for reactive power planning purposes. The projected NSW as-generated forecasts are provided in Chapter 4.

Network planning targets

50% POE Maximum Load Scenario

- The system will be able to withstand a single credible contingency under all reasonably probable scenarios
- Provision is made for the prior outage of a single item of reactive plant
- The system will be able to be secured by re-dispatching generation without requiring pre-emptive shedding (interruption) to withstand the impact of a second credible contingency.

10% POE Maximum Load Scenario

- The system will be in a satisfied operational state under normal network conditions under a limited set of scenarios and is able to withstand a single credible contingency event (under N-1 network conditions)
- The system will be able to be re-secured by re-dispatching generation or control scheme to withstand the impact of a second credible contingency event, without pre-emptive load shedding.

10% POE Minimum Load Scenario

- The system will meet voltage level requirements under both normal and N-1 network conditions under a limited set of scenarios, assuming one reactive plant is in pre-outage status.

We use these forecasts to simulate multiple scenarios, based on the historical performance of the NEM and modelling of generation sources into the future. These scenarios take into account different generation dispatch scenarios, interconnection power flows and REZ generation.

Under all conditions, we need to achieve adequate voltage control. Traditionally, we assumed all online generators could provide reactive power support within their rated capability. However, we now align with other utilities in relying only on reactive capability given by performance standards. Reactive support beyond the performance standards may need to be procured under network support arrangements.

Supply in NSW currently depends on base-load coal-fired generation in Hunter region and hydro generation in the southern network. In future, REZs will have a significant role in the network. These generation areas are interconnected with the load centres via numerous single and double-circuit lines. Planning the NSW system requires considering AEMO's operational approach, including the risk and impact of overlapping circuit outages under probable load and generation patterns.

Our analysis of network adequacy must take into account the probable load patterns, typical dispatch of generators and loads, the availability characteristics of generators (as influenced by maintenance and forced outages), energy limitations and other factors relevant to each case.

When we consider options to address an emerging inability to meet all connection point loads, we allow for the lead time for a network augmentation solution.

Before this, we consider the costs of re-dispatching energy and ancillary services markets to manage credible contingencies. If these costs exceed those of augmentation, discussions with network load customers may lead to network or non-network solutions developed through a consultation process.

A3.5.2 Networks supplied from the Main System

Some parts of the network are primarily concerned with supply to local loads and are not significantly impacted by the dispatch of generation (although they may contain embedded generators). In determining network constraints, AEMO now has to consider the loss of a transmission element within these networks. Although ancillary services may be needed to cover load rejection in the event of a single contingency.

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A3.5.3 Supply to major load areas and sensitive loads

The NSW system contains six major load areas: Northern NSW, Newcastle and Central Coast, Greater Sydney, Central West, Southern, and South Western NSW.

Some of these load areas, including individual smelters, are supplied by limited circuits that may share double-circuit line sections. Significant individual loads and load areas must not be exposed to supply loss if multiple circuit failures occur over extended periods. Therefore, we assess the impact of contingency levels that exceed the specified level of redundancy and expected unserved energy for the respective network nodes.

We also consider outages of network elements for planned maintenance. Generally, this requires 75% of the maximum load to be supplied during the outage. While every effort is made to secure supplies should a further outage occur, this may not be always possible. In this case, our focus is on minimising the duration of the plant outage.

A3.5.4 Urban and suburban areas

Generally, urban and suburban networks are characterised by a high load density served by high-capacity underground cables and relatively short transmission lines. The connection points to the network are usually the low-voltage (132 kV) busbars of 330 kV substations. There may be multiple connection points and significant DNSP capability to transfer load between connection points, either permanently or to relieve short-time loadings on network elements after a contingency.

The focus of joint planning with DNSPs is the capability of the meshed 330/132 kV system and the capability of the existing connection points to meet expected maximum loadings. Joint planning addresses the need for augmentation to the meshed 330/132 kV system and the connection point capacity or to provide a new connection point where this is the most economic overall solution.

Consistent with good international practices, we give special consideration to supply to high-density urban and central business districts. For example, the inner Sydney metropolitan network supplies a large, critical portion of the State's load. This supply is primarily via 330 kV and 132 kV underground cables. The 330 kV cables are part of our network, while 132 kV cables belong to Ausgrid.

The criterion applied to the Inner Sydney area is consistent with that applied in the electricity supply to major cities throughout the world. Most countries use an N-2 criterion. Others apply an N-1 criterion with some selected N-2 contingencies, commonly with two cables sharing the one trench or a double-circuit line.

This is similar to the previous approach in NSW, using the probabilistic approach specified under the NSW Electricity Transmission Reliability and Performance Standard 2017. Under this standard, supply to the Inner Sydney load is required to be designed for Category 3 level of redundancy[113] and maximum unserved energy allowance corresponding to 0.6 minute per year at average demand levels.[114]

The reliability criteria (redundancy level and unserved energy allowance per year) at bulk supply points outside the Inner Sydney area are less onerous than for those inside.

A3.5.5 Non-urban areas

Generally, these areas are characterised by lower load densities and have lower reliability requirements than urban systems. The areas are sometimes supplied by relatively long, often radial, transmission systems. Connection points are either on 132 kV lines or on the low voltage busbars of 132 kV substations. While multiple connection points to a DNSP may exist, they are often widely spaced with limited transfer capacity between them. Frequently, supply limitations may apply to the combined capacity of several supply points together.

The focus of joint planning with DNSPs usually relates to:

- Augmenting connection point capacity
- Duplicating radial supplies
- Extending the 132 kV system to reinforce or replace existing lower voltage systems and to reduce losses
- Developing a higher voltage system to support major augmentations and reduce network losses.

Supply to one or more connection points may need to be augmented when the transmission network does not provide the specified redundancy level or the probability of unserved energy (i.e., the function of network failure rate, restoration duration and average load) at the end of the planning horizon exceeds the specified reliability criteria.

Based on the criteria, some radial parts of the 330 kV and 220 kV network are not able to withstand the forced outage of a single-circuit line at time of maximum load. In these cases, provision is made for under-voltage load shedding.

We also need to provide for network maintenance. Additional redundancy is required where maintenance cannot be scheduled without causing load restrictions or an unacceptable level of risk to the security of supply.

113 NSW Electricity Transmission Reliability and Performance Standard 2017 Clause 3
114 NSW Electricity Transmission Reliability and Performance Standard 2017 Clause 4

A3.5.6 Relationship with inter-regional planning

We monitor the occurrence of transmission system constraints that affects generator dispatch. Our planning therefore considers the scope for network augmentations to reduce constraints.

The capacity of interconnectors applied in market dispatch is the short-time capacity determined by the ability to maintain secure operation in the system normal state in anticipation of a single contingency. Interconnector operation at this capacity must be supported by appropriate ancillary services. AEMO does not operate on the basis that the contingency may be sustained but considers the impact of a prolonged plant outage.

For parts of the network critical to load supply, we may initiate augmentation to meet reliability requirements. Transgrid's major network development projects aim to increase transfer capabilities between NSW and QLD/VIC/SA. The planning of interconnections is undertaken in consultation with the Transmission Network Service Providers of the other states.

Under the NER, a Region may be created where constraints to generator dispatch are predicted to occur with reasonable frequency when the network is operated in the "system normal" (all significant elements in service) condition. However, Region creation does not consider the impact of contingencies on load connection points

A3.5.7 Transformer augmentation

In considering transformer augmentation, we allow for the transformer cyclic rating[115] and the practicality of load transfers between connection points. Allowance is made for the outage of a single transformer (or single-phase unit) or a transmission line that supports the load carried by the transformer.

We also provide for transformer maintenance. This has become a critical issue at a number of sites in NSW where multiple transformers are in service. To enable maintenance, additional transformer capacity may be required – or load may need to be transferred to other supply points via the lower voltage network.

A3.5.8 Consideration of low probability events

Although there is a low probability of supply interruptions as a result of system disturbances, no power system can be guaranteed to deliver a firm capability 100% of the time, particularly when subjected to disturbances that are severe or widespread. Extreme loads beyond planning allowances can also occur, typically during extreme weather events.

The NSW network contains numerous lines of double-circuit construction and, while the probability of overlapping outages of both circuits of a line is very low, the consequences could be widespread supply disturbances.

Thus, we assess the potential for low probability events to cause localised or widespread disruption to the power system. These events can include:

- Loss of several transmission lines within a single corridor, as may occur during extreme weather events
- Loss of a number of cables sharing a common trench
- Loss of more than one section of busbar within a substation, possibly following a major plant failure
- Loss of a number of generating units
- Occurrence of three-phase faults,[116] or faults with delayed clearing.

In our network, appropriate facilities and mechanisms are put in place to minimise the probability of such events and to lessen their impact. Our decision-making process considers the underlying economics of facilities or corrective actions, taking account of the low probability of the occurrence of extreme events.

We take measures, where practicable, to minimise the impact of disturbances to the power system by implementing power system control systems at minimal cost in accordance with the NER.

115 Transformer nominal ratings are based on them carrying a constant load. However, loads are often cyclic (they vary throughout the day). In these cases transformers may be able to carry more than their nominal rating for a short period around the time of the maximum load as they are loaded less heavily before and after that period. A cyclic loading takes this into account.
116 Alternating current power systems generally have three phases. Faults on those systems can involve one, two or all three of those phases. Faults involving three phases are generally the most onerous.

A3.6 Joint planning

Transgrid regularly undertakes joint planning with AEMO and Primary Transmission Network Service Providers from across the NEM. Our joint working and reference groups include:

- Executive Joint Planning Committee (EJPC)
- Joint Planning Committee
- Forecasting Reference Group
- Regulatory Working Group
- Power system modelling reference group
- System Strength Working Group.

Executive Joint Planning Committee

The Executive Joint Planning Committee coordinates effective collaboration and consultation on electricity transmission network planning issues to:

- Develop a framework for the ISP
- Continuously improve current network planning practices
- Coordinate on energy security across the NEM
- Help provide efficient services to the NEM while jointly considering planning, operations, and other activities.

The EJPC directs and coordinates the activities of the Forecasting Reference Group, and the Regulatory Working Group as outlined below. These activities ensure effective consultation and coordination between Transmission Network Service Providers, transmission system operators and AEMO on a broad spectrum of perspectives on network planning, forecasting, market modelling, and market regulatory matters to deal with the challenges of a rapidly changing energy industry.

Joint Planning Committee

The Joint Planning Committee supports the EJPC in achieving effective collaboration, consultation and coordination between jurisdictional planning bodies, transmission system operators and AEMO on electricity transmission network planning issues.

The matters to be considered by the committees include:

- Load forecasting
- Reliability and quality of supply issues
- Major plant refurbishment and retirement
- Reviewing and updating the Connection Agreement Data Book and Licence to Occupy schedules
- New and augmented major load, generator and Battery Energy Storage Systems (BESS) connections
- Data-centres, Special Activation Precincts and Renewable Energy Zones
- Demand management and embedded generation opportunities
- Network augmentation options
- Reactive plant and voltage control requirements
- System fault levels and system strength requirements
- Earthing coordination
- Network operational control coordination
- Overview of protection, metering, control and communication issues.

Forecasting Reference Group

The Forecasting Reference Group is a monthly forum with AEMO and industry forecasting specialists. The forum seeks to facilitate constructive discussion on matters relating to gas and electricity forecasting and market modelling. It is an opportunity to share expertise and explore new approaches to addressing the challenges of forecasting in a rapidly changing energy industry.

Regulatory Working Group

The Regulatory Working Group supports the EJPC in achieving effective collaboration, consultation and coordination between Transmission Network Service Providers, transmission system operators and AEMO on key areas related to the application of the regulatory transmission framework and suggestions for improvement.

Power system modelling reference group

This technical expert reference group focuses on power system modelling and analysis techniques to ensure an accurate power system model is maintained for network planning and operational analysis, and for establishing procedures and methodologies for power system analysis, plant commissioning and model validation.

System Security Working Groups

AEMO's System Strength Service Provider working group's objective is intended to support collaboration, consultation, and coordination between system strength service providers on implementing the System Strength Framework.

AEMO's Improved Security Frameworks working group's mission is to enable consistent, effective, and efficient consultation between AEMO and TNSPs to support the timely implementation of the Improving Security Framework Rule Change in the NEM.

Regular joint planning meetings

Transgrid ensures effective network planning by joint planning with:

- AEMO National Planning
- EnergyCo
- AEMO Victoria Planning
- Transmission Company Victoria
- ElectraNet
- Powerlink
- Ausgrid
- Endeavour Energy
- Essential Energy
- Evoenergy
- ACEREZ.

Joint Planning Projects

Transgrid has coordinated with other Transmission Network Service Providers, Distribution Network providers and infrastructure planners on the following projects:

- Hunter Transmission Project – joint planning with EnergyCo
- Hunter Transmission Project 2 – joint planning with EnergyCo
- Central West Orana REZ – joint planning with EnergyCo and ACEREZ
- QNI Connect – joint planning with Powerlink
- Sydney Ring South – joint planning with AEMO
- EnergyConnect – joint planning with ElectraNet and AEMO VIC Planning
- VNI West – joint planning with AEMO Victoria Planning and Transmission Company Victoria
- South West REZ – joint planning with EnergyCo
- Hunter-Central Coast REZ – joint planning with EnergyCo and Ausgrid
- New England REZ – joint planning with EnergyCo
- Illawarra REZ – joint planning with EnergyCo and Endeavour Energy
- Sydney Plan options to re-enforce Sydney area – Joint Planning with Endeavour Energy and Ausgrid
- Yass Strategic Plan – Joint planning with Essential Energy.

A3.7 Alignment with Electricity Statement of Opportunities and Integrated System Plan

As detailed in Chapter 5, unless sufficient additional firm generation capacity is developed in time, 2027/28 will bring the risk of Lack of Reserve conditions after the expected Eraring coal-fired generator retirement while a large-scale unit is out of service. Any outage of the remaining large generating units will further increase the generation adequacy gap and could result in unserved energy. This is consistent with AEMO's 2024 Electricity Statement of Opportunities (ESOO), which forecasts a reliability gap in 2027/28 when Eraring Power Station is now advised to retire, and from 2031/32.

The plans in this Report align with the 2024 Integrated System Plan. However, we have considered our own scenarios and forecasts as outlined in this document.

A3.8 Protection requirements

The NER requires that protection systems be installed so any fault can be detected by at least two fully independent protection systems. Backup protection is provided against circuit breaker failure. Provision is also made for detecting high resistance earth faults on 330 kV and above circuits.

Required protection clearance times are specified by the NER and determined by stability considerations as well as the characteristics of modern power system equipment. Where planning includes special protection facilities or speed of fault clearance, they are justified on either NER compliance or a cost-benefit basis.

All modern distance protection systems on the main network include the facility for power swing blocking (PSB), which controls the impact of a disturbance that can cause synchronous instability. At the moment, PSB is not enabled, except at locations where demonstrated advantages apply. This feature is becoming increasingly critical as the interconnected system expands and becomes more complex.

A3.9 Transient stability

In accordance with the NER, transient stability is assessed by analysing angular swings following a solid fault on one circuit at the most critical location that is cleared by the faster of the two protections (assuming intertrip schemes are in service where applicable). We determine the transient stability capability of the Main System using software calibrated against commercially available system dynamic analysis tools.

To assess transient stability at the Main System level, we apply a two phase-to-ground fault. On 132 kV systems that are to be augmented, a three-phase fault is applied. At the Main System level, we institute maintenance and operating precautions to minimise the risk of a three-phase fault.

Where transient stability is a limiting factor in the Main System, we prioritise implementing advanced system controls or high-speed protection systems before considering high-capital plant solutions.

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A3.10 Steady state stability

The NER outlines requirements for controlling steady state stability. For planning purposes, we consider steady state stability (or system damping) adequate under any given operating condition if, after the most critical credible contingency, simulations indicate that the halving time of the least damped electromechanical mode of oscillation is not more than five seconds.

We determine steady state stability performance using software calibrated against commercially available software and from data derived from the monitoring of system behaviour.

In planning the network, we make maximum use of existing plant, through the optimum adjustment of plant control system settings before consideration is given to installing high capital cost plant.

Under Clause S5.1.8 of the NER, Transgrid also considers non-credible contingency events, such as bubsar faults, and double-circuit contingencies. In situations where severe disruption is likely, Transgrid considers measures, such as Remedial Action Schemes (RAS) and design measures, to help mitigate the impact of such events on the network. Such measures would typically be assessed as part of AEMO's General Power System Risk Review (GPSRR) using economic assessment

A3.11 Power Quality

The NER specifies system standards for maintaining power quality in the network. For planning purposes, we consider the associated system standards of NER Schedule 5.1a including Voltage fluctuations, Voltage waveform distortion (Harmonics) and Voltage unbalance requirements, to ensure the quality of electricity supply to customers. The following measures are considered in planning to manage power quality:

Voltage fluctuations

- Including conditions in connection agreements in relation to the permissible variation with time of the power generated or load taken by Network Users
- Appropriately sizing reactive plant based on the location in the network, particularly considering fault levels
- Introducing management measures such as Point on Wave (POW) and Pre-Insertion Resistors (PIR) when energising transformers and reactive plant.

Voltage waveform distortion

- Including conditions in connection agreements in relation to the permissible voltage distortion by Network Users
- Introducing management measures such as filters, and de-tuning capacitor banks where required.

Voltage unbalance

- Including conditions in connection agreements in relation to the permissible negative sequence voltage levels by Network Users
- Introducing management measures such as line transpositions to balance effective impedance of the phases.

A3.12 Reactive support and voltage stability

If a single element fails at times of maximum system loading, we need to keep voltages within acceptable levels. A single element could be a generator, a single transmission circuit, a cable or single items of reactive support plant.

To cover fluctuations in system operating conditions, uncertainties of load levels, measurement errors and errors in setting control operating points, we need to maintain a margin from any operating point that may result in a loss of voltage control. A reactive power margin is maintained over the point of voltage instability or alternatively a margin is maintained with respect to the power transfer compared to the maximum feasible power transfer.

The system voltage profile is set to standard levels during generator dispatch to minimise the need for post contingency reactive power support.

Reactive power generally has a low cost relative to major transmission lines, and the incremental cost of providing additional reactive support can be relatively low. Also, reactive power can have a very high cost-benefit ratio. Consequently, the timing of reactive power installation is typically less sensitive to load changes than for other network augmentations. Even so, the aim is to make maximum use of existing reactive sources before new installations are considered.

We have traditionally assumed that all online generators can provide reactive power support within their rated capability. However, we now align with other utilities in relying only on the reactive capability given by agreed performance standards of the generator. Reactive support beyond the performance standards may need to be procured under network support agreements.

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We install reactive power to support planned power flows up to the capability defined by limit equations. This is often the critical factor determining network capability. On the Main System, we allow for a single major source of reactive power support to be unavailable in the critical area affected at times of high load, but not at the maximum load level.

To maintain control of the voltage supply to the connected loads under minimum load conditions, we determine the need for reactive plant installations based on the economic and safety imperatives to:

- Limit the voltage deviation between the pre- and post contingency operating conditions
- Ensure the post contingency operating voltage at major 330 kV busbars remain above a lower limit
- Maintain the reactive margin from the point of voltage collapse above a minimum acceptable level
- Maintain a margin between the power transmitted and the maximum feasible power transmission
- Maintain voltages during low load conditions remain within equipment voltage limits,

Following forced outages, relatively large voltage changes are accepted at some locations on the main network, and agreed with customers, providing voltage stability is not placed at risk. These voltage changes can approach, and in certain cases, exceed 10% at maximum load.

On some network sections, the possibility of loss of load due to depressed voltages following a contingency is also accepted. However, we prefer to install load shedding initiated by under-voltage so the disconnection of load occurs in a controlled manner.

When determining the allowable rating of switched reactive plant, we observe the requirements of the NER.

A3.13 Transmission line voltage and conductor sizes determined by economic considerations

Transgrid selects line design voltages within the standard nominal ranges, taking due account of transformation costs. Minimum conductor sizes are governed by losses, radio interference and field strength considerations.

We select line conductor sizes based on cost efficiency. For a line whose design is governed by economic loading limits, we determine the conductor size by assessing capital versus loss costs. This includes considering the impact of the development on generator and load marginal loss factors in the market. For other lines, the rating requirements determine the conductor requirements.

Double-circuit lines are built in place of two single-circuit lines where this is both economic and provides adequate reliability. We consider the impact of a double-circuit line failure, both over relatively short terms and for extended durations. This means that supply to a relatively large-load may require single rather than double-circuit transmission line construction where this is environmentally acceptable.

In areas prone to bushfire, any parallel single-circuit lines are preferably routed well apart to avoid the risk of simultaneous outage during a bushfire event.

A3.14 Line and equipment thermal ratings

Line thermal ratings have often traditionally been based on a fixed continuous rating and fixed short-time ratings. Transgrid's line ratings, which depend on weather conditions and line design parameters, are:

- Normal rating
- Contingency rating
- Short-time emergency rating – typically based on a load duration of 15 minutes, although the duration can be adjusted to suit the particular load pattern to which the line is expected to be exposed.

Five-minute ratings will be used under certain conditions to maintain reliable supply once coal generators retire. The duration and level of loading takes into account any requirements for re-dispatch of generation or load control.

Ambient condition monitors have been installed on several transmission lines to allow real-time line conductor ratings to be applied in the generation dispatch systems. Transgrid is implementing dynamic line ratings on additional transmission lines.

Transformers are rated according to their specification. Provision is also made for use of the short-time capability of the transformers during the outage of a parallel transformer or transmission line.

The 330 kV cables are rated according to the manufacturer's recommendations and have been checked against an appropriate thermal model of the cable. The rating of line terminal equipment is based on the manufacturer's advice.

A3.15 Autoreclosure

As most line faults are transient, our overhead transmission lines are equipped with autoreclose facilities. For most overhead circuits, this is slow speed three-pole reclosure. On the remaining overhead circuits, under special circumstances, high-speed single-pole autoreclosing may be applied.

For public safety reasons, reclosure is not applied to underground cables.

Autoreclose is inhibited following the operation of breaker fail protection.

A3.16 Short-circuit rating requirements

Substation high-voltage equipment is designed to withstand the maximum expected short-circuit duty in accordance with the applicable Australian Standard.

Operating constraints are enforced to ensure equipment is not exposed to fault duties beyond the plant ratings.

In general, the short-circuit capability of all plant is designed to match or exceed the maximum short-circuit duty at the relevant busbar. To achieve cost efficiencies when augmenting an existing substation, the maximum possible short-circuit duty on individual substation components are calculated and applied to establish the adequacy of the equipment.

Short-circuit duty calculations are based on the following assumptions:

- All main network generators that are capable of operating, as set out in connection agreements, are assumed to be in service
- All generating units that are embedded in distribution networks are assumed to be in service
- The maximum fault contribution from interstate interconnections is assumed
- The worst-case pre-fault power flow conditions are assumed
- Normally open connections are treated as open
- Networks are modelled in full
- Motor load contributions are not modelled at load substations
- Generators are modelled as a constant voltage behind sub-transient reactance.

At power station switchyards, we allow for the contribution of the motor component of loads. We analyse the impact of the motor component of loads to assess whether to include such contributions when assessing the adequacy of the rating of load substation equipment.

A3.17 Substation configurations

Transgrid adopts substation configurations (single busbar, double busbar, multiple element mesh or breaker-and-a-half) that provide acceptable reliability at minimum cost. In determining a switching arrangement, we also consider the:

- Site constraints
- Reliability expectations with respect to connected loads and generators
- Physical location of “incoming” and “outgoing” circuits
- Maintenance requirements
- Operating requirements
- Transformer arrangements.

In general, at main system locations, an up to four circuit breaker mesh or breaker-and-a-half arrangement are the preferred minimum-requirement standard configurations. Where necessary, the expected reliability performance of potential substation configurations can be compared using equipment reliability parameters derived from local and international data.

The forced outage of a single busbar zone is generally provided for. Under this condition, the main network is planned to have adequate capability although loss of load may eventuate. In general, the forced outage of a single busbar zone should not result in the outage of any baseload generating unit. Where appropriate, a 330 kV bus section breaker would ordinarily be provided to segregate “incoming” lines when a second “incoming” 330 kV line is connected to the substation.

A 132 kV bus section circuit breaker would generally be considered necessary when the maximum load supplied via that busbar exceeds 120 MW. A bus section breaker is generally provided on the low voltage busbar of 132 kV substations when supply to a particular location or area is taken over more than two low-voltage feeders.

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A3.18 Power system control and communication

In designing the network and its operation to specified power transfer levels, we use the following control facilities:

- Automatic excitation control on generators
- Power system stabilisers on generators and SVCs
- Load drop compensation on generators and transformers
- Supervisory control over main network circuit breakers
- Under-frequency load shedding
- Under-voltage load shedding
- Under and over-voltage initiation of reactive plant switching
- High speed transformer tap changing
- Network connection control
- Check and voltage block synchronisation
- Control of reactive output from SVCs
- Remedial Action Schemes.

We also use the following communication, monitoring and indication facilities where appropriate:

- Network wide SCADA and Energy Management System
- Telecommunications and data links
- Mobile radio
- Fault locators and disturbance monitors
- Protection signalling
- Load monitors
- Power Quality monitors.

We use protection signalling and communication over a range of media, including pilot wire, power line carrier, microwave links and, increasingly, optical fibres in overhead earthwires.

A3.19 Scenario planning

Scenario planning assesses network capacity for a number of NEM load and generation scenarios, taking into account AEMO's outlook stated in its latest ESOO and the scenarios considered in the ISP. The planning scenarios we develop also incorporate the following:

- Identifying possible future load growth scenarios. These are developed based on Transgrid's NSW Region forecasts, DNSPs' bulk supply point load forecasts and directly connected customer demand outlook. We consider key data for each scenario to prepare Transmission Annual Planning Report load forecasts for NSW. The forecast can also incorporate possible local developments such as new loads or the expansion or closure of existing industrial loads.
- Developing a number of generation scenarios for each load growth scenario. These generation scenarios relate to new generators and utilisation of existing generators and considers expected or possible future retirements.
- Modelling the NEM for load and generation scenarios to quantify factors affecting network performance, including generation from individual power stations and interconnector flows.
- Modelling network performance for the load and generation scenarios using the data from market modelling.

We then assess the set of scenarios over the planning horizon to establish the adequacy of the system, and assess network and non-network augmentation options.

A3.20 System Strength

Transgrid's system strength modelling methodologies, assumptions and results are referred to in Chapter 5.

The following methodologies and assumptions have been followed when producing Transgrid's system strength Project Assessment Conclusion Report (PACR), published in July 2025:

- Methodologies for assessing system strength follows AEMO's published System Strength Requirements Methodology v2.0 and System Strength Impact Assessment Guidelines (SSIAG) v2.1
- Inverter-based renewable projections, informing Transgrid's efficient level requirements, are based on an IBR forecast developed by Baringa Partners. Baringa used the same modelling methodology as AEMO in its ISP and System Strength Reports, however the updated delivery timing of New England REZ is included to reflect best available information at the commencement of PACR modelling. This results in a deviation in future IBR timing and distribution of future IBR compared to AEMO
- Transgrid has used the Available Fault Level (AFL) methodology to approximate efficient level of system strength requirements. In preparation for the PACR, Transgrid undertook an assessment of stable-voltage waveform remediation required using the AFL proxy method versus detailed PSCAD studies and concluded that AFL method represented a useful long-term planning proxy but should be validated with PSCAD studies.

- For future inverter based renewable plant where the withstand Short Circuit Ratio (SCR) is not known, an assumed value of 3.0 has been used
- An alpha factor of 1.2 has been used
- Network solutions for system strength focussed on synchronous condensers and grid-forming batteries. The PADR modelling showed that Grid-forming Static Synchronous Compensators (STATCOMs) coupled with a supercapacitor STATCOMs were not selected as part of the portfolio optimisation approach. As such, Transgrid did not consider STATCOMs as potential solution for the PACR assessment. Synchronous condensers with a rating of 200 MVA and a short circuit capacity of 1,050 MVA at their point of connection have been assumed
- Attributes of non-network options have been taken from proponent Expressions of Interest proposals, the 2023 IASR workbook, GHD's costs and technical parameter review and an independent assessment conducted by GHD.
- In line with discussions between AEMO and System Strength Service Providers, our analysis assumes that fault current contributions from minimum generating unit combinations in other states flow through to NSW until synchronous condensers can be delivered, then one unit less than the minimum combination in each sate.
- Transmission dates have been informed by AEMO's 2024 Integrated System Plan Optimal Development Pathway with updated delivery dates for the New England REZ Network Infrastructure Project.
- The proposed remediation of system strength within the Central West Orana REZ by the REZ Network Operator is documented within the NSW Government's Network Infrastructure Strategy. Transgrid have included the ACEREZ synchronous condensers intended to remediate the Central West Orana REZ in the PACR modelling with updated delivery timing provided by EnergyCo in April 2025.
- In collaboration with Baringa Partners, Transgrid conducted market modelling in PLEXOS to assess the economic feasibility of all solutions considered as part of the system strength PACR
- To account for the disadvantage that grid-forming BESS face when stable voltage waveform support is 'valued' using its fault current provision, Transgrid has introduced a 'boost factor' concept. Transgrid has used detailed PSCAD analysis to determine a ratio between the fault current contribution from a synchronous condenser to the MVA size of BESS that can support the level of stable voltage waveform, thus determining the 'boost' factor. This was performed on various inverter-supplier models and calculated with a range between 2.6 to 4.1.
- Market modelling assumed a Value of Emissions Reduction (VER) published by the AER in May 2024 consistent with the statement published by the Ministerial Council of Energy (MCE) on the interim value of greenhouse gas emissions reduction. Transgrid also ran sensitivities applying higher and lower assumed VER.

Amy Longmuir – Substation Technician Apprentice

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Appendix 4

Andrew Swaffield - Field Manager
Sam Isaac Martin - Transmission Line Apprentice

Line utilisation report

A4.1 Line utilisation report

This report sets out our transmission line utilisation for the period from 1 March 2024 to 28 February 2025.

The line loading information from 1 March 2024 to 28 February 2025 was obtained from AEMO's Operations and Planning Data Management System (OPDMS). This system produces half hourly system load flow models (snapshots) of the NEM.

For each half hour period, the utilisation (loading) of each line was calculated as a proportion of the relevant rating. The highest values of these proportions are reported here. The utilisation of each line was calculated based on two conditions:

1. With all network elements in service, referred to as the 'N utilisation'. These utilisation figures are based on normal line ratings; and

2. With the most critical credible contingency (usually an outage of another line in the area), referred to as the 'N-1 utilisation'. These utilisation figures are based on the line contingency ratings. The N utilisation and N-1 utilisation of the transmission lines in the NSW transmission network are shown in Figures A4.2 9 to A4.9. For each line, the utilisations are shown in the box placed adjacent to the line. The box shows:

A. The transmission line number;

B. The maximum N utilisation of the transmission line (%);

C. The maximum N-1 utilisation of the transmission line (%); and

D. The identity of the line that creates the critical contingency in the event of an outage.

The box layout is shown in Figure A4.1.

Figure A4.1: Key to interpreting the information shown in Figures A4.2 to A4.9

A Line number
B Maximum N Utilisation %
C Maximum N-1 Utilisation %
D Line number out for N-1

In some situations, the N-1 utilisation has been estimated to be more than 100 per cent. These situations could be because of:

- A higher level of line loading being allowed, considering the operational line overloading control schemes, runback schemes available for managing the line loadings, and generation re-dispatch capability by AEMO; and
- The predicted dispatch conditions that change over the five-minute dispatch period, causing the line loadings to increase above the predicted values.

Figure A4.2: Transgrid N and N-1 line utilisations – Sydney and Newcastle

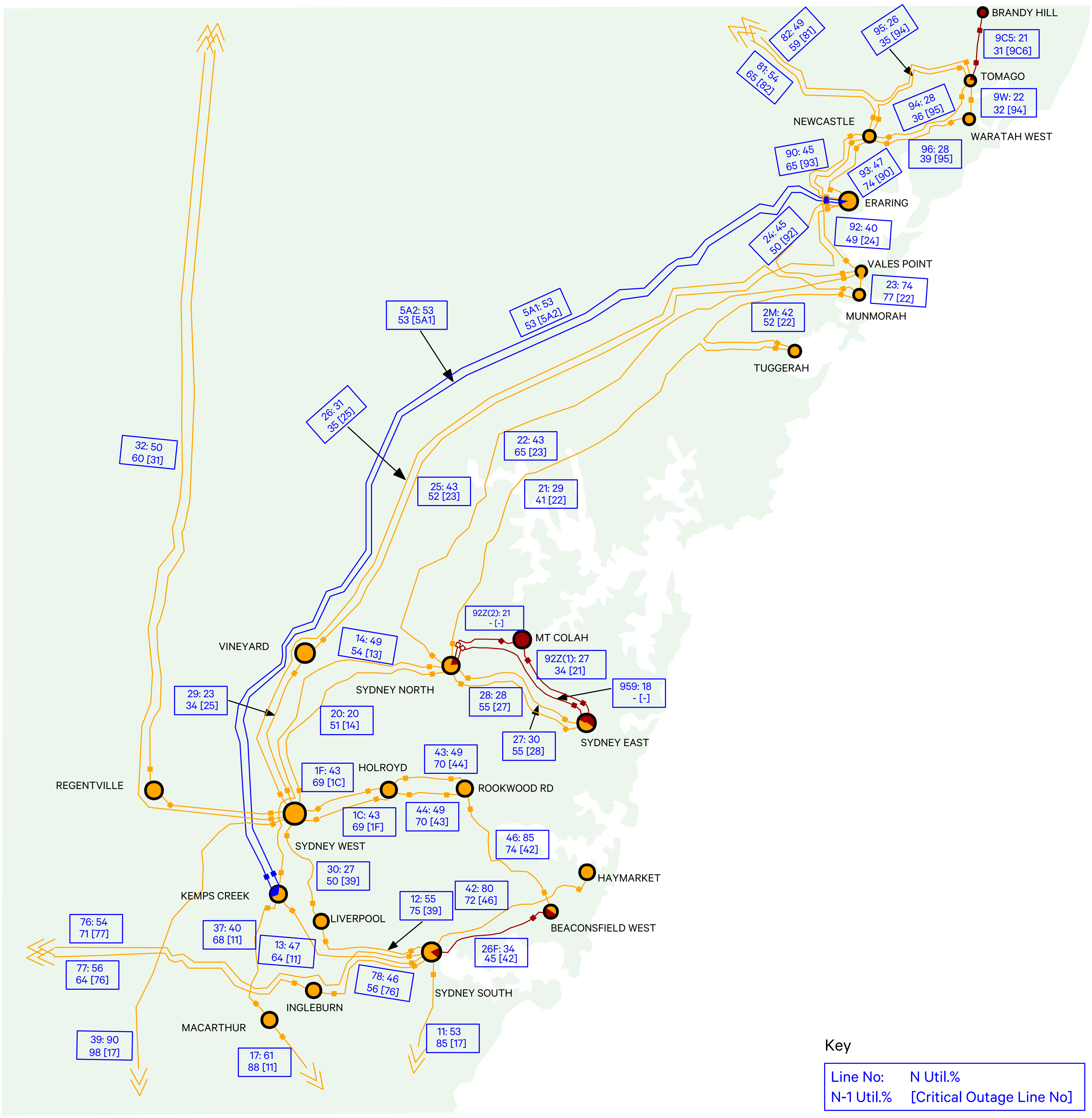

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Figure A4.3: Transgrid N and N-1 line utilisations – North East NSW and Northern NSW

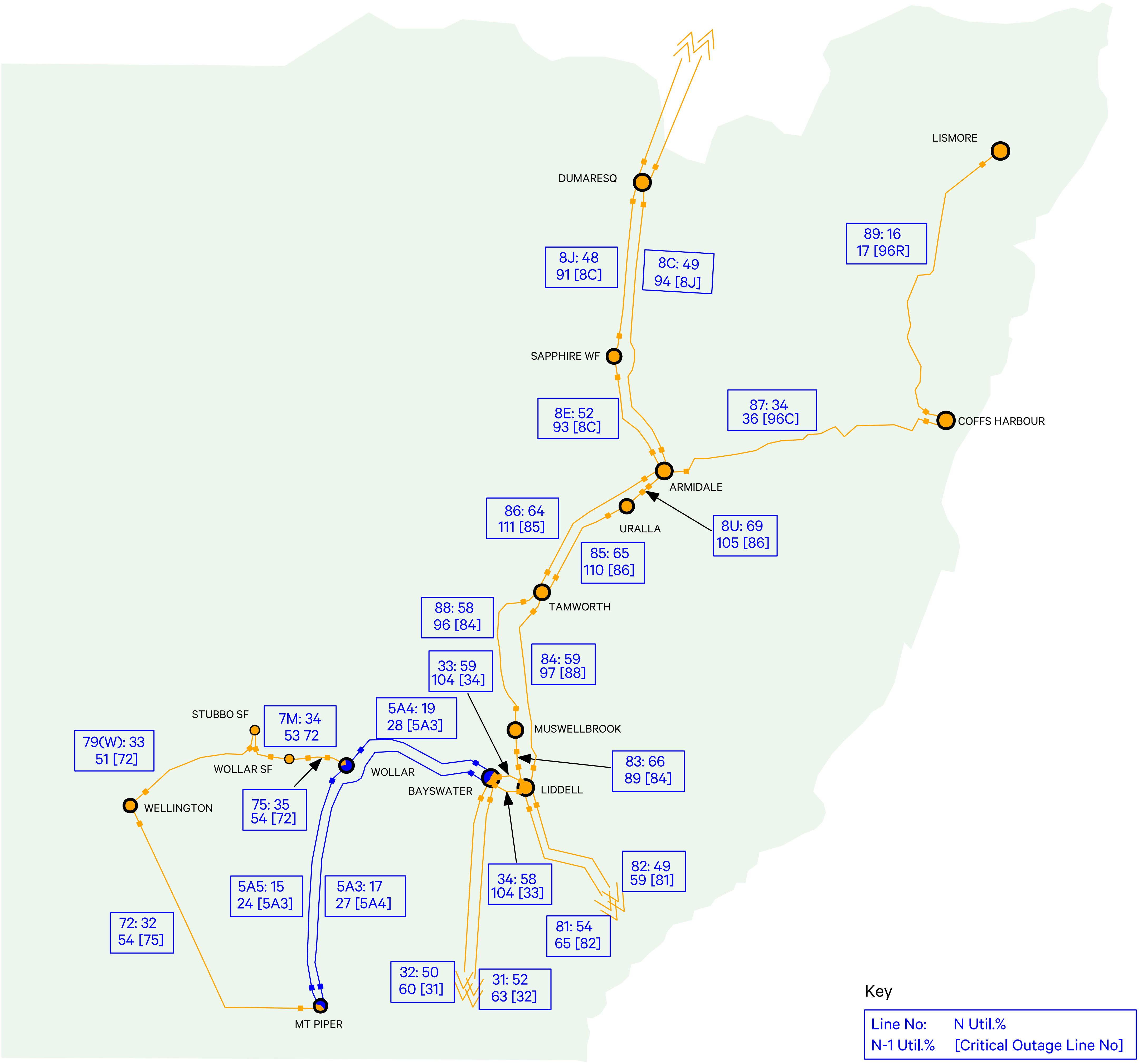

Figure A4.4: Transgrid N and N-1 line utilisations – South and South East

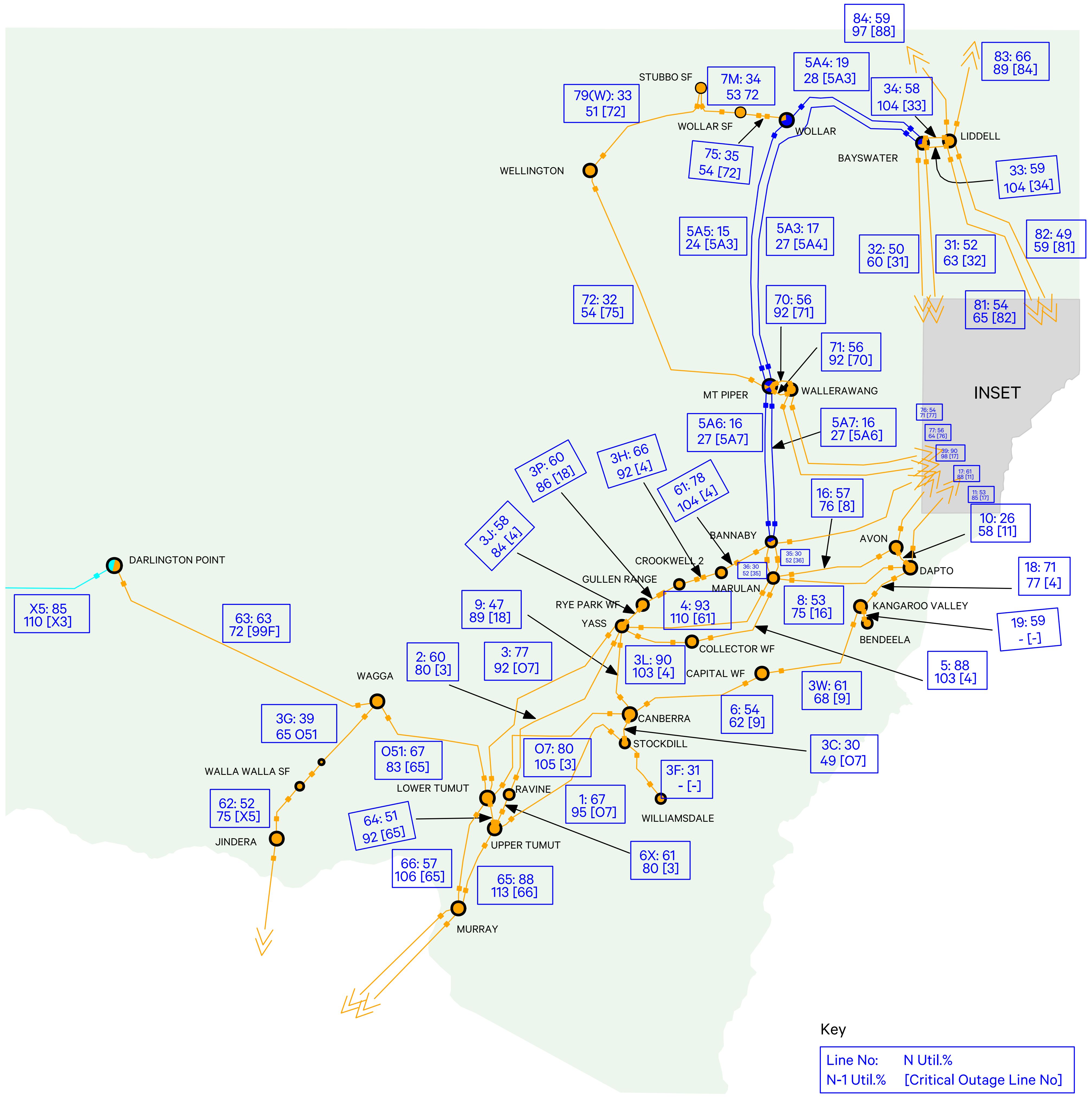

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Figure A4.5: Transgrid N and N-1 line utilisations – Far West

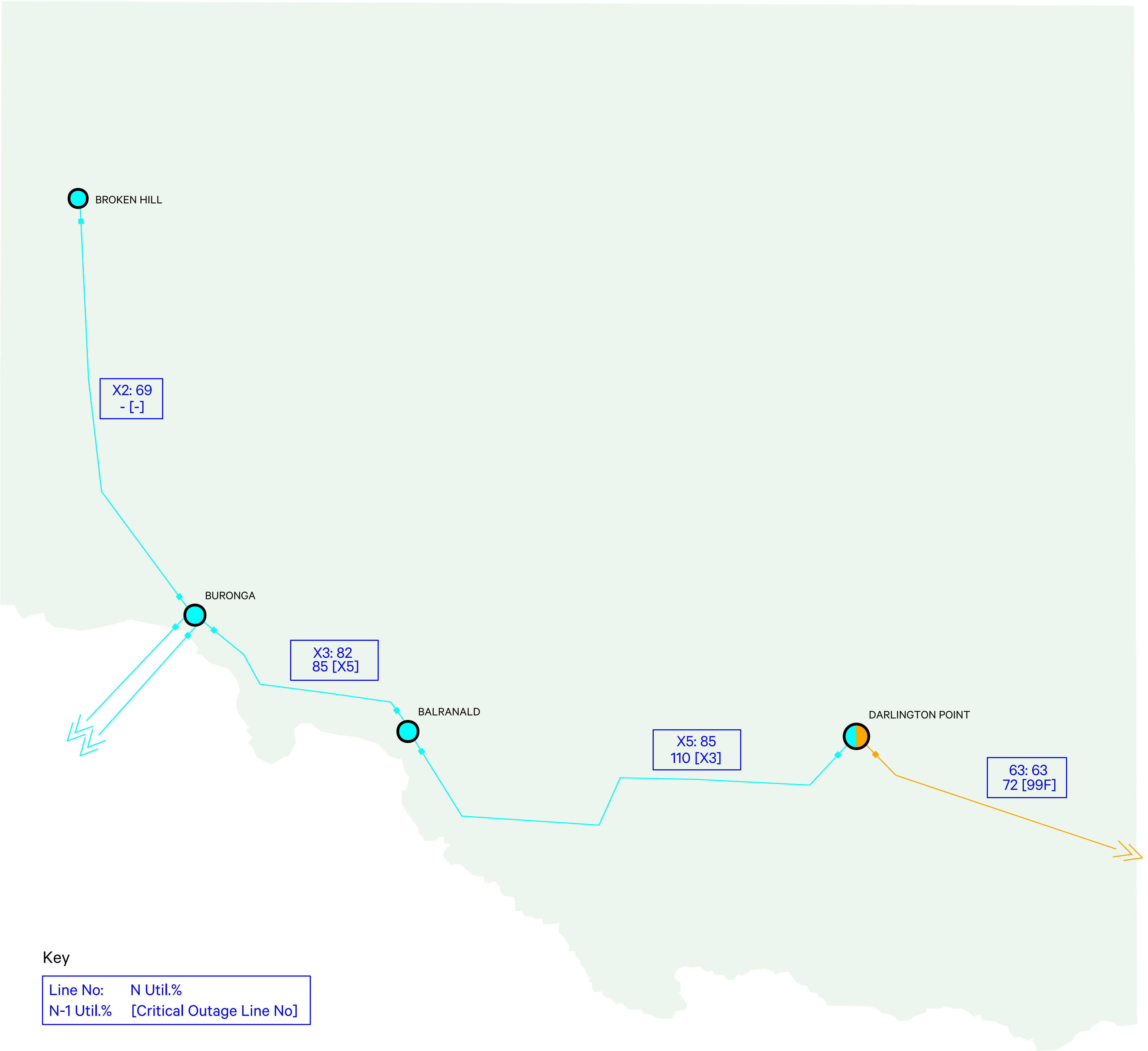

Figure A4.6: Transgrid N and N-1 line utilisations – North Coast and North West 132 kV System

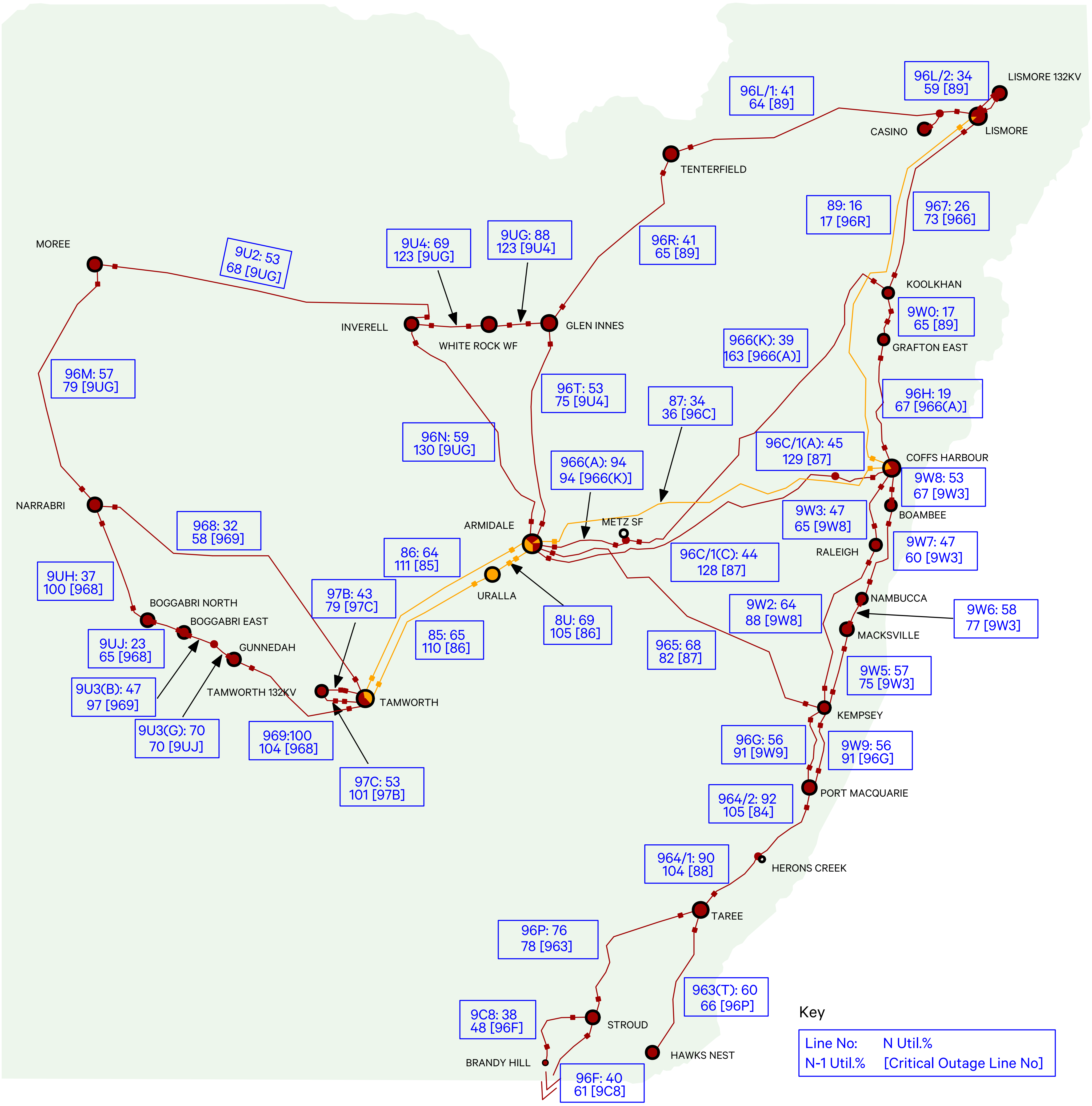

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Figure A4.7: Transgrid N and N-1 line utilisations – Central West

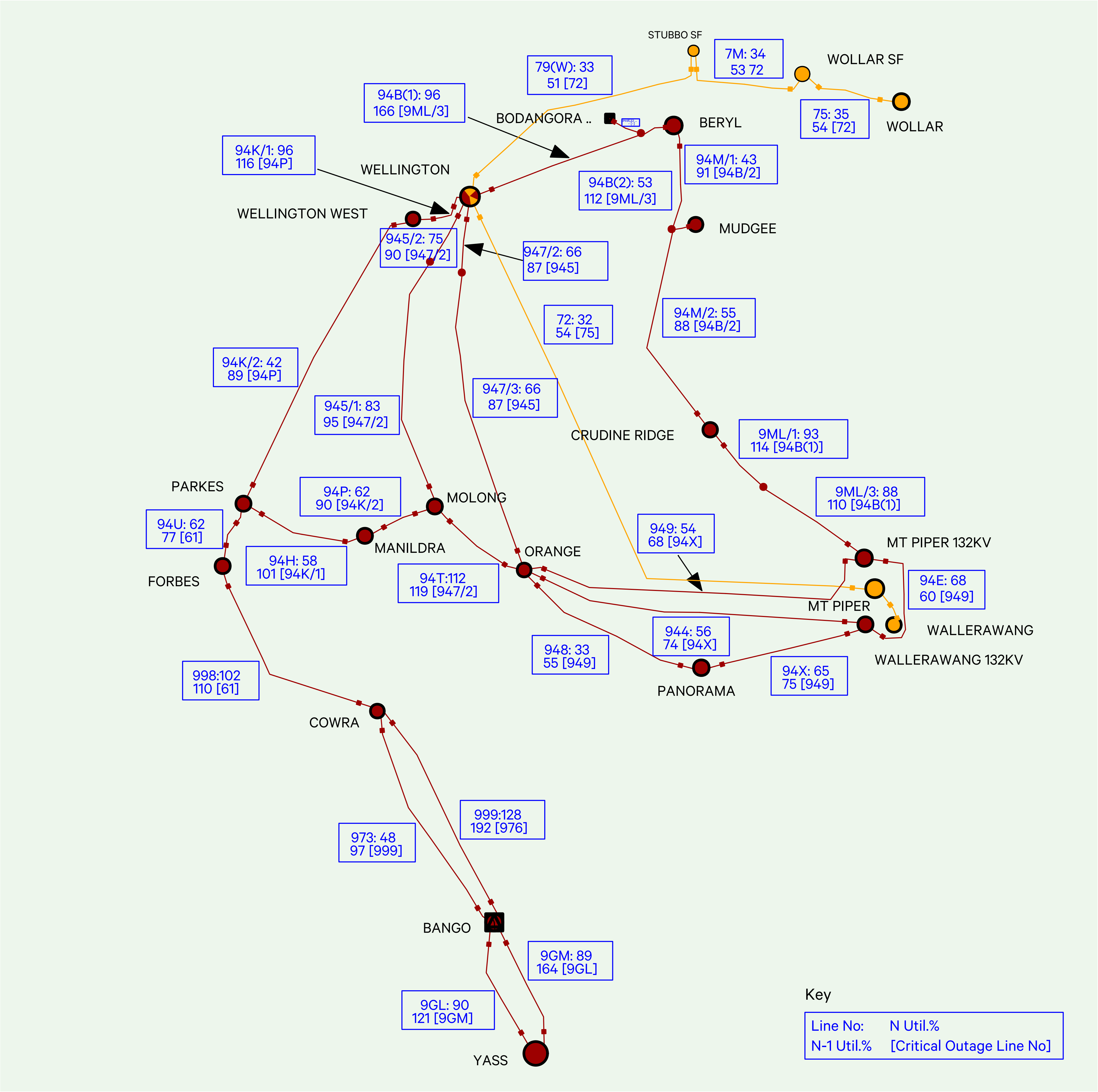

Figure A4.8: Transgrid N and N-1 line utilisations – South East

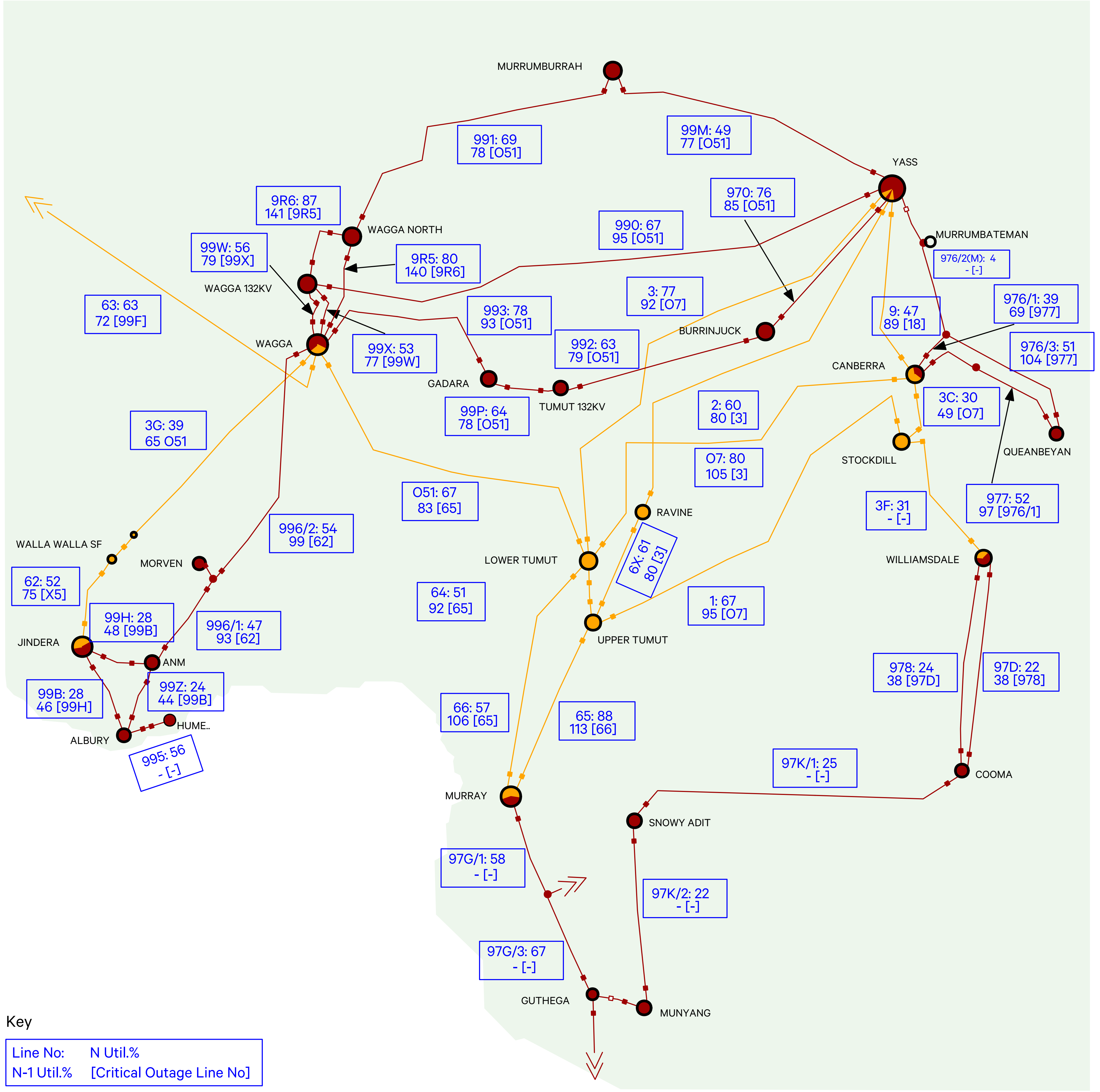

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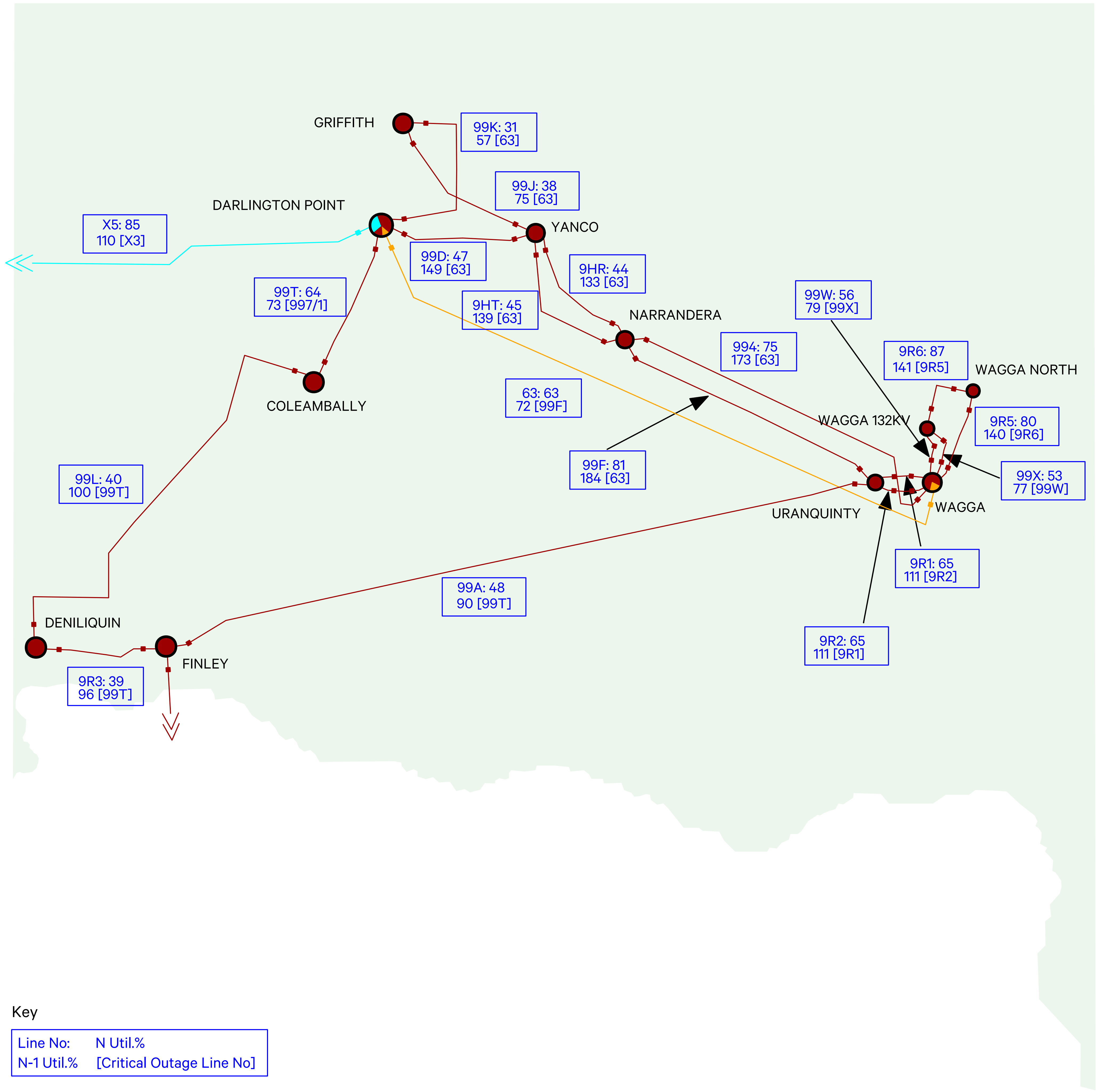
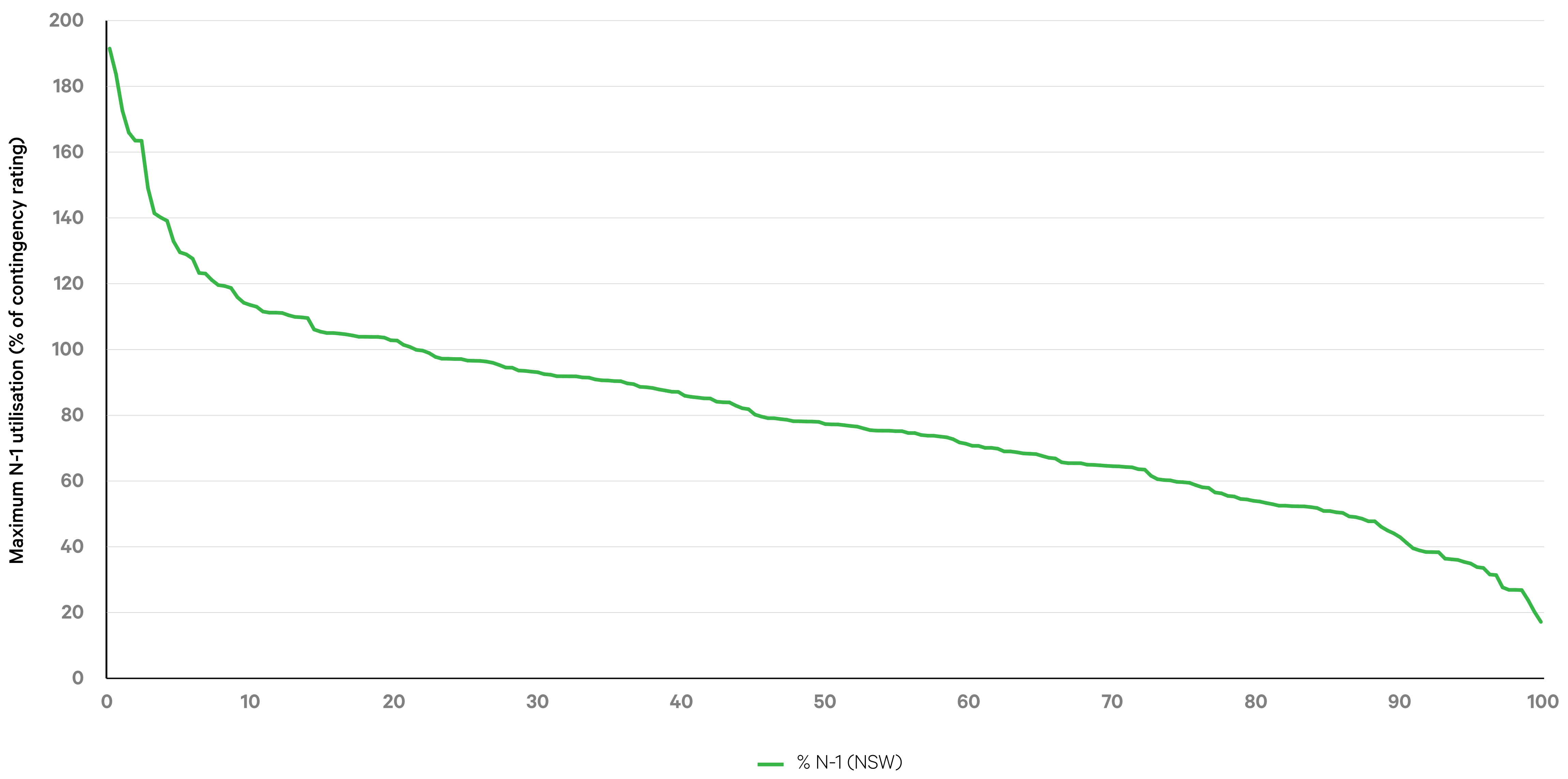
Figure A4.9: Transgrid N and N-1 line utilisations – South West



A4.1.1 Summary of the N-1 utilisation of the transmission lines in the Transgrid's network

The distribution of the N-1 utilisation of the transmission lines across our network is shown in Figure A4.10. The distribution shows that approximately 22 per cent of the transmission lines in the network are utilised at more than their installed maximum capacity and over half of the lines are utilised at more than 86 per cent of their installed capacity. The distribution of the N-1 line utilisations reflects at least 40 years of planning history of the transmission network. It is considered to be typical of a well-planned network where various parts of the network are well-established, while other parts have had recent step augmentations that will be further utilised in future years.

Figure A4.10: Distribution of Transgrid N-1 utilisations (1st March 2024–28th February 2025)



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Appendix 5

Transgrid 330 kV line
Megalong Valley, Blue Mountains

Transmission constraints

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A5.1 Introduction

This appendix shows where the power flows in our network have reached or come close to the network limits, and the assets affected.

Capacity could be limited due to the power flows reaching:

- The maximum rating of a single transmission element, such as a transmission line or a transformer
- The combined capacity of a group of transmission elements, such as several parallel transmission lines constituting inter-regional links
- The limits set by system-wide considerations such as voltage, transient or oscillatory stability.

Transgrid gives this information to AEMO to support power flow management in the transmission network. AEMO automatically adjusts the quantity of generation dispatched to maintain transmission flows under the prevailing operating conditions – and even under credible unplanned outages.

'Optimal generation dispatch' is the dispatch that minimises total cost while ensuring the capability limits of the transmission system are not violated. It is determined using the National Electricity Market Dispatch Engine (NEMDE). Capability limits are included within NEMDE as mathematical equations, which are known as the 'Constraint Equations'. Each constraint equation has a unique identifier, and information including the capability limit and its determining factors, such as power flow in a transmission line or generator power outputs.

The constraints reported here cover the transmission system capability limitation experienced from 1 March 2024 to 28 February 2025.

Judith van der Eyk – Risk Officer

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A5.2 Transmission system performance – Binding duration

Table A5.1 summarises the top 20 constraints where higher cost generation may have been dispatched because some transmission elements or parts of the transmission network have reached their maximum capability. The table shows the constraint identifier, its description, type of limitation addressed by the constraint equation, and length of time the transmission element was operated at its maximum capability from 1 March 2024 to 28 February 2025.

Transgrid reviews the constraints in Table A5.1 to fully understand their nature, and to provide possible solutions to reduce their market impact. The solutions for highly ranked constraints impacting the generators, NSW-QLD and VIC-NSW interconnectors are included in our proposed major developments and in the subsystem developments described in Chapters 2.1 and 2.3 respectively.

Table A5.1: Constraints operating at the capability limit

Rank	Constraint ID	Total duration (dd:hh:mm)	Type	Impact	Reason
1	N>NIL_94T	73:23:20	Thermal	NSW Generation	Avoid overload of Molong to Orange North (94T) line with no trip
2	N>NIL_969	50:22:45	Thermal	NSW Generation	Avoid overload of Gunnedah to Tamworth (969) line with no trip
3	N>NIL_9R6_991	41:22:50	Thermal	NSW Generation	Avoid overload of Wagga Wagga North to Wagga Wagga 132 (9R6) line on trip of Wagga Wagga North to Murrumburrah (991) line
4	N_X_MBTE_3A	34:09:55	Unit Zero	Terranora Interconnector	No flow on Directlink, all three cables out
5	N>>NIL_964_84_S	26:19:45	Thermal	NSW Generation + Interconnectors	Avoid overload of Port Macquarie to Taree (964) line on trip of Tamworth to Liddell (84) line
6	N>NIL_9R6_9R5	22:15:45	Thermal	NSW Generation	Avoid overload of Wagga Wagga North to Wagga Wagga 132 (9R6) line on trip of Wagga Wagga North to Wagga Wagga 330 (9R5) line
7	N>Q-NIL_757_758	21:11:45	Thermal	Terranora Interconnector	Avoid overload of Terranora to Mudgeeraba (757 or 758) line on trip of the other
8	V^^N_MNYS_1	19:09:45	Voltage Stability	Vic – NSW Interconnector + Generators	Avoid voltage collapse around Murray on loss of all APD potlines, Marulan to Yass (4 or 5) line out
9	N>NIL_94K_1	18:09:55	Thermal	NSW Generation	Avoid overload of Suntop Tee to Wellington (94K/1) line with no trip
10	N^^V_CTMN_1	17:04:05	Voltage Stability	Vic – NSW Interconnector + Generators	Avoid voltage collapse in southern NSW on trip of largest Vic generator, when Marulan to Yass (4 or 5) line out of service
11	N>>BDBU_970_051	16:21:25	Thermal	NSW Generation + Interconnectors	Avoid overload of Burrinjuck to Yass (970) on trip of Wagga Wagga to Lower Tumut (051) line, when Bundey to Buronga (6F) line out of service
12	N>NIL_901	14:14:15	Thermal	NSW Generation	Avoid overload of West Wyalong to Temora (901) with no trip
13	N>NIL_PKTX_LV	14:08:45	Thermal	NSW Generation	Avoid overload of either Parkes 132/66 kV Transformer with no trip
14	V^^N_NIL_1	13:05:40	Voltage Stability	Vic – NSW Interconnector + Generators	Avoid voltage collapse around Murray on loss of all APD potlines
15	N>NIL_9R4_99A	11:12:00	Thermal	NSW Generation	Avoid overload of Finley to Mulwala (9R4) line on trip of Finley to Uranquinty (99A) line
16	N^^V_NIL_1	11:06:250	Voltage Stability	Vic – NSW Interconnector + Generators	Avoid voltage collapse in southern NSW on trip of largest Vic generator
17	N_X_MBTE_3B	9:01:50	Unit Zero	Terranora Interconnector	No flow on Directlink, all three cables out
18	N^^N_NIL_X5_BESH	8:18:50	Voltage Stability	NSW Generation + Interconnectors	Limit power flow on Balranald to Darlington Point (X5) line to avoid voltage collapse at Balranald on trip of Bendigo to Shepparton line
19	N>>NIL_966/1	8:18:10	Thermal	NSW Generation + Interconnectors	Avoid overload of Metz Tee to Armidale (966/1) line with no trip
20	N>>NIL_990_051	8:16:05	Thermal	NSW Generation + Interconnectors	Avoid overload of Wagga Wagga to Yass (990) line on trip of Wagga Wagga to Lower Tumut (051) line

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A5.3 Transmission system performance – Market impact

Table A5.2 summarises the top 20 constraints with the highest market impacts, measured by the marginal value. The table shows the constraint identifier, its description, type of limitation addressed by the constraint equation, the sum of the marginal values of the constraint binding and length of time the transmission element was operated at its maximum capability from 1 March 2024 to 28 February 2025.

Table A5.2: Constraints operating at the capability limit

Rank	Constraint ID	Sum of Marginal Values ($m)	Total duration (dd:hh:mm)	Type	Impact	Reason
1	N>NIL_94T	$37.710	73:23:00	Thermal	NSW Generation	Avoid overload of Molong to Orange North (94T) line with no trip
2	N>NIL_999	$18.364	0:05:15	Thermal	NSW Generation	Avoid overload of Bango to Cowra (999) line with no trip
3	N>NIL_969	$14.293	50:22:45	Thermal	NSW Generation	Avoid overload of Gunnedah to Tamworth (969) line with no trip
4	N>>BDBU_970_051	$11.467	16:21:25	Thermal	NSW Generation + Interconnectors	Avoid overload of Burrinjuck to Yass (970) line on trip of Wagga Wagga to Lower Tumut (051) line, when Bundey to Buronga (6F) line out of service
5	N>NIL_9R6_991	$9.984	41:22:50	Thermal	NSW Generation	Avoid overload of Wagga Wagga North to Wagga Wagga 132 (9R6) line on trip of Wagga Wagga North to Murrumburrah (991) line
6	N>>NIL_970_051	$4.583	7:23:50	Thermal	NSW Generation + Interconnectors	Avoid overload of Burrinjuck to Yass (970) line on trip of Wagga Wagga to Lower Tumut (051) line
7	N>NIL_94K_1	$4.163	18:09:55	Thermal	NSW Generation	Avoid overload of Suntop Tee to Wellington (94K/1) line with no trip
8	N>NIL_9R6_9R5	$3.972	22:15:45	Thermal	NSW Generation	Avoid overload of Wagga Wagga North to Wagga Wagga 132 (9R6) line on trip of Wagga Wagga North to Wagga Wagga 330 (9R5) line
9	N>NIL_9R5_9R6_N	$3.038	0:21:20	Thermal	NSW Generation	Avoid overload of Wagga Wagga North to Wagga Wagga 132 (9R5) line on trip of Wagga Wagga North to Wagga Wagga 330 (9R6) line
10	N>NIL_901	$2.712	14:14:15	Thermal	NSW Generation	Avoid overload of West Wyalong to Temora (901) line with no trip
11	N>NIL_9R4_99A	$2.205	11:12:00	Thermal	NSW Generation	Avoid overload of Finley to Mulwala (9R4) line on trip of Finley to Uranquinty (99A) line
12	N>NIL_PKTX_LV	$2.172	14:08:45	Thermal	NSW Generation	Avoid overload of either Parkes 132/66 kV transformer with no trip
13	N>79_998_72	$1.805	1:08:00	Thermal	NSW Generation	Avoid overload of Cowra to Forbes North (998) line on trip of Mt Piper to Wellington line (72) when Wollar West to Wellington (79) line out of service
14	N>976_977_NIL_1	$1.803	0:09:50	Thermal	NSW Generation	Avoid overload of Canberra to Queanbeyan (976) line on no trip, when Canberra to Queanbeyan (976/1 or 977/1) line out of service
15	N>9ML_94T	$1.766	3:07:45	Thermal	NSW Generation	Avoid overload of Molong to Orange North (94T) line with no trip, when Mount Piper to Crudine Ridge (9ML) line out of service
16	N::N_CTYS_2	$1.756	2:05:25	Transient Stability	NSW Generation + Interconnectors	Snowy to NSW stability limit for critical fault on one 330 kV line between Yass and Bannaby/ Marulan, when Collector to Yass (3L) line out of service
17	N>NIL_BHTX_SF_TTS	$1.682	1:02:00	Thermal	NSW Generation	Avoid overload of Broken Hill 220/22 kV transformer on trip of Broken Hill solar farm
18	N>NIL_977_976	$1.662	0:09:00	Thermal	NSW Generation	Avoid overload of Canberra to Queanbayan (976 or 977) line on trip of the other
19	N::N_CTMN_2	$1.619	3:21:20	Transient Stability	NSW Generation + Interconnectors	Snowy – NSW stability limit for fault on 330 kV line between Yass and Bannaby/ Marulan, when Collector – Marulan (4) line out of service
20	N^^N_NIL_X5_BESH	$1.481	8:18:50	Voltage Stability	NSW Generation + Interconnectors	Limit power flow on Balranald to Darlington Point (X5) line to avoid voltage collapse at Balranald on trip of Bendigo to Shepparton line

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A5.4 Possible future transmission system performance

Table A5.3 summarises the maximum demand event for each of NSW, Queensland and Victoria that were analysed for the constraints that were binding (or violating) and the 10 constraints that were closest to binding at the time of the maximum demand in the period 1 March 2024 to 28 February 2025. The constraints that were close to binding were assessed to identify possible future transmission system limitations.

Table A5.3: Maximum demand event in NSW, Queensland and Victoria

Region	Max demand	Date and time
NSW	12,550 MW	Tuesday 17 December 2024, 16:00
QLD	11,159 MW	Wednesday 22 January 2025, 17:45
VIC	9,887 MW	Monday 16 December 2024, 17:00

A5.4.1 Maximum demand event in NSW

Figure A5.1 shows a NEM overview map on the maximum demand event day in NSW. It summarises the power flow directions when the maximum demand occurred on Tuesday 17 December 2024 at 16:00.

Figure A5.1: NEM overview map on Tuesday 17 December 2024, 16:00

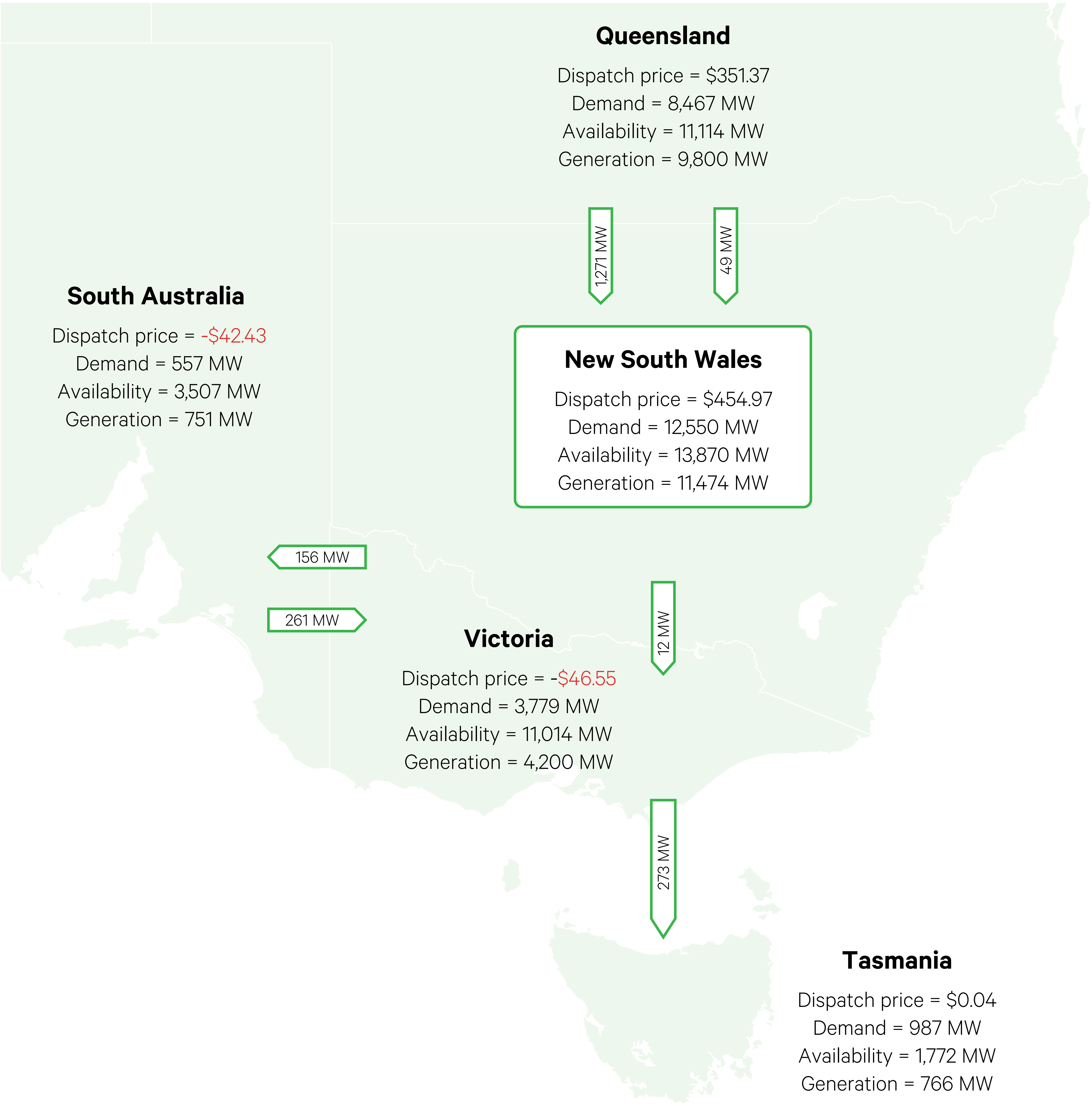

Table A5.4 summarises the NSW binding constraints on the maximum demand day in NSW (Tuesday 17 December 2024 at 16:00).

Table A5.4: NSW binding constraints on Tuesday 17 December 2024, 16:00

Constraint ID	Type	Impact	Reason
N>>BDBU_970_051	Thermal	NSW Generation + Interconnectors	Avoid overload Burrinjuck to Yass (970) line on trip of Wagga Wagga to lower Tumut (051) line, when Bundey to Buronga (6F) line out of service

Table A5.5 summarises the NSW constraints that were close to binding on the maximum demand day of Tuesday 17 December 2024 at 16:00.

Table A5.5: NSW constraints that were close to binding on Tuesday 17 December 2024, 16:00

Rank	Constraint ID	Headroom (MW)[117]	Type	Impact	Reason
1	N>>NIL_970_051	0.1	Thermal	NSW Generation + Interconnectors	Avoid overload of Burrinjuck to Yass (970) line on trip of Wagga Wagga to Lower Tumut (051) line
2	N>NIL_9R5_9R6_N	1	Thermal	NSW Generation	Avoid overload of Wagga Wagga North to Wagga Wagga 330 (9R5) line on trip of Wagga Wagga North to Wagga Wagga 132 (9R6) line
3	N>NIL_94T	3	Thermal	NSW Generation	Avoid overload of Molong to Orange North (94T) line with no trip
4	N>NIL_9R6_9R5	3	Thermal	NSW Generation	Avoid overload of Wagga Wagga North to Wagga Wagga 132 (9R6) line on trip of Wagga Wagga North to Wagga Wagga 330 (9R5) line
5	N>NIL_COTX_LV	5	Thermal	NSW Generation	Avoid overload of Corowa 132/22 kV transformer with no trip
6	N>NIL_94T_79	14	Thermal	NSW Generation	Avoid overload of Molong to Orange North (94T) line on trip of Wellington to Wollar (79) line
7	N>NIL_94T_947	18	Thermal	NSW Generation	Avoid overload of Molong to Orange North (94T) line on trip of Wellington to Orange North (947) line
8	N>NIL_9R4_99A	19	Thermal	NSW Generation	Avoid overload of Finley to Mulwala (9R4) line on trip of Finley to Uranquinty (99A) line
9	N>NIL_997/2_99A	24	Thermal	NSW Generation	Avoid overload of Mulwala to Corowa (997/2) line on trip of Finley to Uranquinty (99A) line
10	N>N-NIL_JUTX_LV	33	Thermal	NSW Generation	Avoid overload of Junee 132/66 kV transformer with no trip

117 Constraint equations are directional on energy flow. Hence if flow is in the opposite direction of the constraint equation then headroom can be greater than the element rating.

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A5.4.2 Maximum demand event in QLD

Figure A5.2 shows a NEM overview map on the maximum demand event day in QLD. It summarises the power flow directions when the maximum demand occurred on Wednesday 22 January 2025 at 17:45.

Figure A5.2: NEM overview map on Wednesday 22 January 2025, 17:45

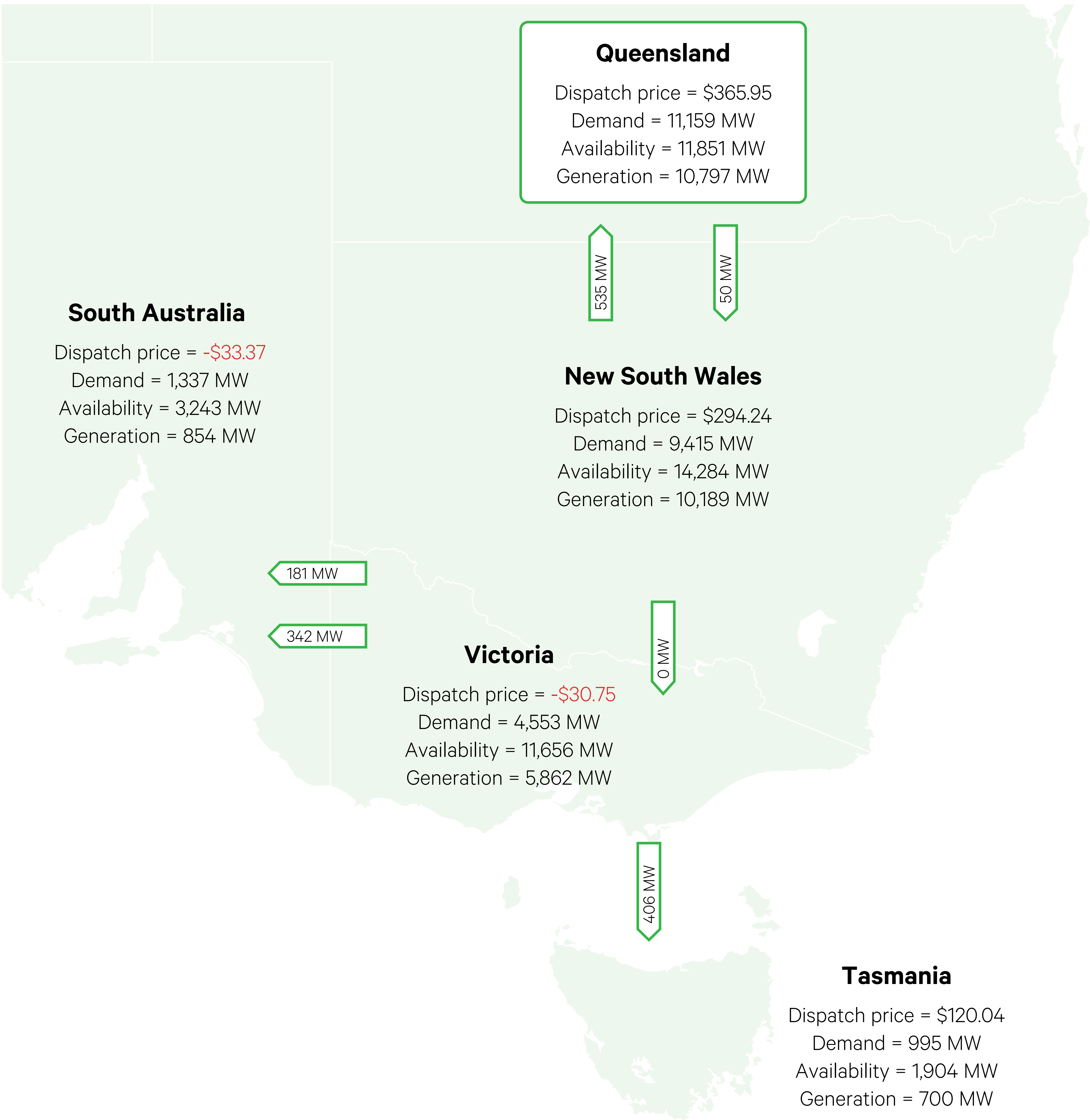

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Table A5.6 summarises the NSW binding constraints on the maximum demand day in Queensland (Wednesday 22 January 2025 at 17:45).

Table A5.6: NSW binding constraints on Wednesday 22 January 2025, 17:45

Constraint ID	Type	Impact	Reason
N>>BDBU_970_051	Thermal	NSW Generation + Interconnectors	Avoid overload Burrinjuck to Yass (970) line on trip of Wagga Wagga to lower Tumut (051) line, when Bundey to Buronga (6F) line out of service
N::N_CTYS_2	Transient Stability	NSW Generation + Interconnectors	Snowy to NSW stability limit for critical fault on one 330 kV line between Yass and Bannaby/ Marulan, when Collector to Yass (3L) line out of service

Table A5.7 summarises the NSW constraints that were close to binding on the maximum demand day in Queensland (Wednesday 22 January 2025 at 17:45).

Table A5.7: NSW constraints that were close to binding on Wednesday 22 January 2025, 17:45

Rank	Constraint ID	Headroom (MW)[118]	Type	Impact	Reason
1	N>>NIL_970_051	0.2	Thermal	NSW Generation + Interconnectors	Avoid overload of Burrinjuck to Yass (970) line on trip of Wagga Wagga to Lower Tumut (051) line
2	N>N-NIL_JUTX_LV	10	Thermal	NSW Generation	Avoid overload of Junee 132/66 kV transformer with no trip
3	N^^Q_LS_SVC_KPP_1	22	Voltage Stability	QNI Interconnector + Directlink	Avoid voltage collapse on loss of Kogan Creek, when Lismore SVC out of service
4	N>NIL_COTX_LV	27	Thermal	NSW Generation	Avoid overload of Corowa 132/22 kV transformer with no trip
5	N>NIL_LSDU	28	Thermal	Terranora Interconnector	Avoid overload of Lismore to Dunoon (9U6 or 9U7) line on trip of the other
6	N>>NIL_990_051	34	Thermal	NSW Generation + Interconnectors	Avoid overload of Wagga Wagga to Yass (990) line on trip of Wagga Wagga to Lower Tumut (051) line
7	N>NIL_9R49R3	37	Thermal	NSW Generation	Avoid overload of Finley to Mulwala (9R4) line on trip of Finley to Deniliquin (9R3) line
8	N>NIL_BHTX_SF	40	Thermal	NSW Generation	Avoid overload of Broken Hill 220/22 kV transformer on trip of Broken Hill solar farm
9	N>>BDBU_990_051	41	Thermal	NSW Generation + Interconnectors	Avoid overload of Wagga Wagga to Yass (990) line on trip of Wagga Wagga to Lower Tumut (051) line, when Bundey to Buronga (6F) line out of service
10	N>NIL_9R4_99A	56	Thermal	NSW Generation	Avoid overload of Finley to Mulwala (9R4) line on trip of Finley to Uranquinty (99A) line

118 Constraint equations are directional on energy flow. Hence if flow is in the opposite direction of the constraint equation, then headroom can be greater than the element rating.

A5.4.3 Maximum demand event in Vic

Figure A5.3 shows a NEM overview map on the maximum demand event day in Vic. It summarises the power flow directions when the maximum demand occurred on Monday 16 December 2024 at 17:00.

Figure A5.3: NEM overview map on Monday 16 December 2024, 17:00

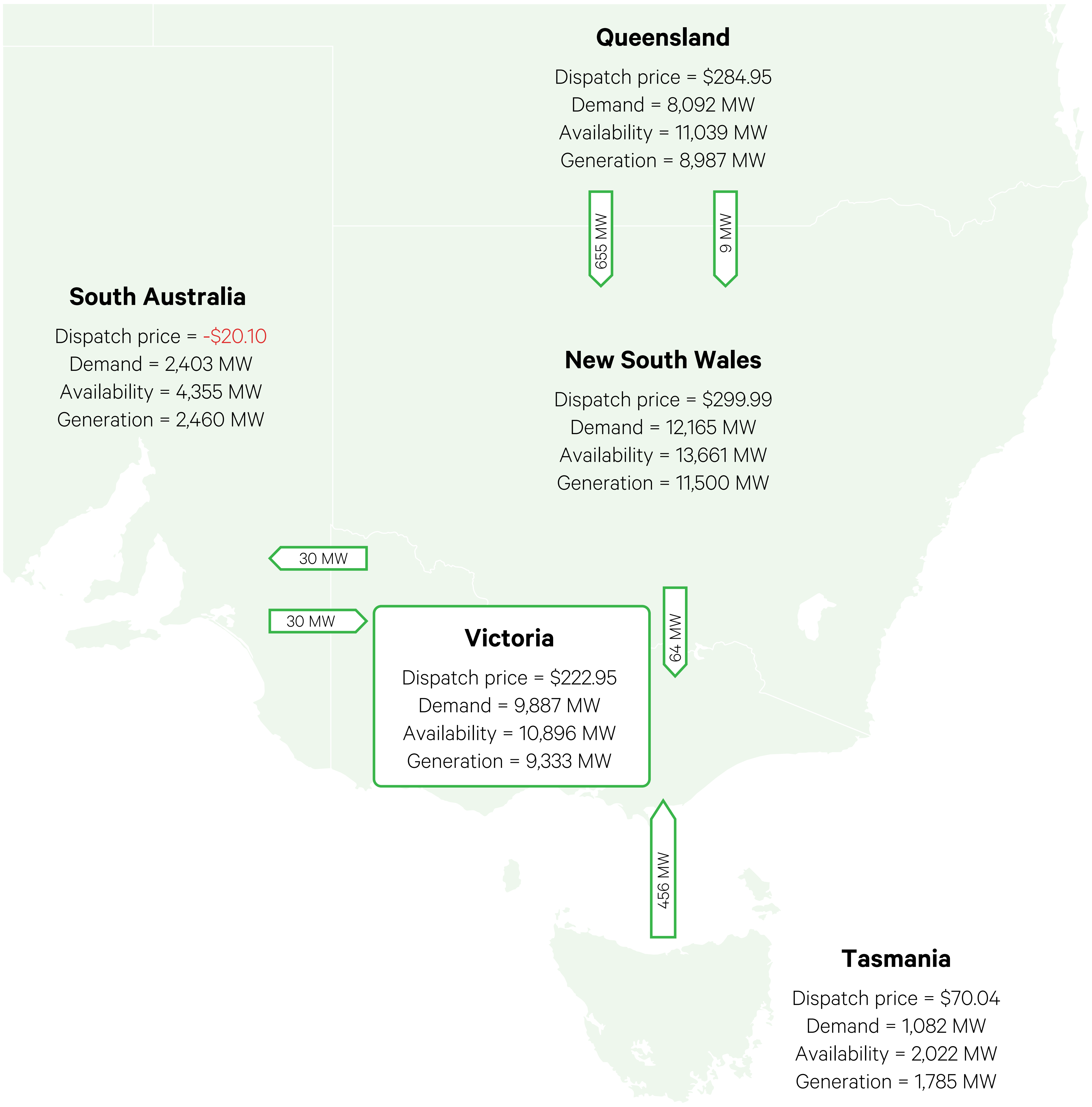

Table A5.8 summarises the NSW binding constraints on the maximum demand day in Victoria (Monday 16 December 2024 at 17:00).

Table A5.8: NSW binding constraints on Monday 16 December 2024, 17:00

Constraint ID	Type	Impact	Reason
N>>BDBU_970_051	Thermal	NSW Generation + Interconnectors	Avoid overload Burrinjuck to Yass (970) line on trip of Wagga Wagga to lower Tumut (051) line, when Bundey to Buronga (6F) line out of service
N>NIL_94T	Thermal	NSW Generation	Avoid overload of Molong to Orange North (94T) line with no trip
N>NIL_9R6_991	Thermal	NSW Generation	Avoid overload of Wagga Wagga North to Wagga Wagga 132 (9R6) line on trip of Wagga Wagga North to Murrumburrah (991) line
N>>NIL_85_86_S	Thermal	NSW Generation + Interconnectors	Avoid overload of Uralla to Tamworth (85) line on trip of Armidale to Tamworth (86) line

Table A5.9 summarises the NSW constraints that were close to binding on the maximum demand day in Victoria (Monday 16 December 2024 at 17:00).

Table A5.9: NSW constraints that were close to binding on Monday 16 December 2024, 17:00

Rank	Constraint ID	Headroom (MW)[119]	Type	Impact	Reason
1	N>>NIL_970_051	0.1	Thermal	NSW Generation	Avoid overload of Burrinjuck to Yass (970) line on trip of Wagga Wagga to Lower Tumut (051) line
2	N>N-NIL_JUTX_LV	16	Thermal	NSW Generation	Avoid overload of Junee 132/66 kV transformer with no trip
3	N>NIL_901	17	Thermal	NSW Generation	Avoid overload of West Wyalong to Temora (901) line with no trip
4	N>NIL_94K_1	17	Thermal	NSW Generation	Avoid overload Suntop Tee to Wellington (94K/1) line with no trip
5	N>NIL_94T_947	24	Thermal	NSW Generation	Avoid overload of Molong to Orange North (94T) line on trip of Wellington to Orange North (947) line
6	N>NIL_966/1	24	Thermal	NSW Generation	Avoid overload of Metz Tee to Armidale (966/1) line with no trip
7	N>NIL_BHTX_SF	26	Thermal	NSW Generation	Avoid overload of Broken Hill 220/22 kV transformer on trip of Broken Hill solar farm
8	N>>BDBU_996_6Y	27	Thermal	NSW Generation + Interconnectors	Avoid overload of Wagga Wagga to ANM (996) line on trip of Wagga Wagga to Walla Walla (6Y) line, when Bundey to Buronga (6F) line out of service
9	N>NIL_COTX_LV	32	Thermal	NSW Generation	Avoid overload of Corowa 132/22 kV transformer with no trip
10	N>>NIL_996_6Y	37	Thermal	NSW Generation + Interconnectors	Avoid overload of Wagga Wagga to ANM (996) line on trip of Wagga Wagga to Walla Walla (6Y) line

119 Constraint equations are directional on energy flow. Hence if flow is in the opposite direction of the constraint equation, then headroom can be greater than the element rating.

Appendix 6

Christian Johane – Substation Technician

Glossary

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Term	Explanation/Comments
AEMC	The Australian Energy Market Commission, who develops the National Electricity Rules by which the markets must operate
AEMO	The Australian Energy Market Operator. Responsible for operation of the NEM and has the role of Victorian Jurisdictional Planning Body (JPB)
AER ('the regulator')	The Australian Energy Regulator; who monitors performance and compliance with the rules
As generated	Generation measured at the generator terminals
Assets	Transgrid's 'towers and wires', all the substations and electricity transmission lines that make up the network
Augmentation	Expansion of the existing transmission system or an increase in its capacity to transmit electricity
BESS	Battery Energy Storage System
Bulk supply point (BSP)	A point of supply of electricity from a transmission system to a distribution system
CAGR	Compound Annual Growth Rate
Committed	New generation projects assessed to have a 'Committed' status as described in the System Strength Impact Assessment Guidelines.[120] Transgrid further defines committed projects as those where AEMO has been notified as per 5.3.7(g) of the NER
Connection point	The agreed point of supply established between the network service provider and another registered participant or customer
Cooling degree days (Appendix 1)	Cooling degree days are the addition of cooling degrees for all days in a given period. Cooling degrees, or CDs, are temperature deviations above or below the human comfort threshold of 21˚C. If, for a given temperature, t, measured on any particular day $t \le 21^\circ C$, CD = 0, or $t > 21^\circ C$, CD = t - 21
Constraint (limitation)	An inability of a transmission system or distribution system to supply a required amount of electricity to a required standard
Consumers	Any end user of electricity including large users, such as paper mills, and small users, such as households

Term	Explanation/Comments
Demand	The total amount of electrical power that is drawn from the network by consumers. This is talked about in terms of 'maximum demand' (the maximum amount of power drawn throughout a given period) and 'total energy consumed' (the total amount of energy drawn across a period)
Demand, Native	Operational demand as above plus small Non-Scheduled generation. Non-inclusion of this generation may significantly distort past electricity usage trends in NSW
Demand, Operational	A measure of electricity use based on half-hourly measurements of all Scheduled, Semi-Scheduled and significant Non-Scheduled generation within the region, plus net imports into the region. Importantly, operational demand does not include demand met by rooftop solar, which is "behind the meter"
Demand management (DM)	A set of initiatives that are put in place at the point of end-use to reduce the total and/or maximum consumption of electricity
Direct customers	Transgrid's customers are those directly connected to our network. They are either Distribution Network Service Providers, directly connected generators, large industrial customers, customers connected through interregional connections or potential new customers
Distribution Network Service Provider, DNSP (Distributor)	An organisation that owns, controls or operates a distribution system in the National Electricity Market. Distribution systems operate at a lower voltage than transmission systems and deliver power from the transmission network to households and businesses
Easement	A designated area in which Transgrid has the right to construct, access and maintain our assets, while ownership of the property remains with the original land owner
Term	Explanation/Comments
Elasticity	A unit-less measure of responsiveness of demand to either price or income. For example, an own price elasticity of -0.5 means that a 1% increase in own price reduces demand by 0.5%

120 AEMO, System Strength Impact Assessment Guidelines

Term	Explanation/Comments
Electricity services (Appendix 1)	This concept is used in Transgrid's energy modelling and refers to an underlying, primary need to use appliances that happen to be powered by electricity. It includes both residential electricity services and non-residential electricity services. Residential electricity services are constructed as the addition of residential grid supplied energy, residential rooftop solar generation and estimated above-trend residential energy efficiency savings. Non-residential electricity services are constructed as the addition of non-residential native energy (minus major industrial loads), non-residential rooftop solar generation, and an estimate of out-of-trend non-residential energy efficiency savings
Electricity Statement of Opportunities (ESOO)	A document produced by AEMO that focuses on electricity supply demand balance in the NEM
Embedded generation	A generating unit connected to the distribution network, or connected to a distribution network customer (not a transmission connected generator)
Energy	Measures the capacity for work to be done by electricity that is supplied to consumers, expressed in GWh per year
EnergyCo	The Energy Corporation of New South Wales, that leads the delivery of renewable energy zones (REZ)
Generator	An organisation that produces electricity. Power can be generated from various sources, e.g. coal-fired power plants, gas-fired power plants, solar and wind farms
Heating degree days (Appendix 1)	Heating degree days are the addition of heating degrees for all days in a given period. Heating degrees, or HDs, are temperature deviations above or below the human comfort threshold of 18˚C. If, for a given temperature, t, measured on any particular day, t ≤ 18°C, CD = 0, or t > 18°C, CD = 18- t
Hybrid	A power system that generates electricity from two or more renewable sources, sharing a single network connection point
IBR	Inverter-based resource
Interconnection	The points on an electricity transmission network that cross state boundaries
IPART	Independent Pricing and Regulatory Tribunal
ISP	Integrated System Plan

Term	Explanation/Comments
Jurisdictional Planning Body (JPB)	The organisation nominated by a relevant minister as having transmission system planning responsibility in a jurisdiction of the NEM
Load	The amount of electrical power that is drawn from the network
Load factor	The ratio of average demand to maximum demand. This can relate to maximum demand and energy via the formulation: Load factor = 1000 × GWh energy/ (MW maximum demand × 8760)
Local generation	A generation or co-generation facility that is located on the load side of a transmission constraint
Major industrial load	Electricity usage by a defined group of large electricity customers with whom Transgrid has a direct relationship and who are not significantly responsive to price or temperature
Maximum demand	Measures the highest rate, within a defined period such as summer or winter, at which energy is absorbed by the network, generally expressed in this report by the measure of MW averaged over a half hour
Minimum demand	Measures the lowest rate, within a defined period such as spring or autumn, at which energy is absorbed by the network, generally expressed in this report by the measure of MW averaged over a half hour
'N – 1' reliability	The system is planned for no loss of load on the outage of a single element such as a line, cable or transformer
National Electricity Law	Common laws across the states which comprise the NEM, which make the NER enforceable
Term	Explanation/Comments
National Electricity Market (NEM)	The National Electricity Market, covering Queensland, New South Wales, Victoria, South Australia and Tasmania
National Electricity Rules (NER or 'the Rules')	The rules that govern the NEM. The Rules are administered by the AEMC
Native energy (demand)	Energy (demand) that is inclusive of scheduled, semi-scheduled and non-scheduled generation

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Term	Explanation/Comments
Non-network options	Alternatives to network augmentation which address a potential shortage in electricity supply in a region, e.g. demand response or local generation
NSCAS	Network Support and Control Ancillary Services. Services used by AEMO that are essential for managing power system security, facilitating orderly trading, and ensuring electricity supplies are of an acceptable quality
NSW Region	With respect to energy consumption and demand, the term 'NSW Region' refers to the combined NSW and ACT electricity loads
Outage	An outage is when part of the network is switched off. This can be either planned (i.e. when work needs to be done on the line) or unplanned
PACR	Project Assessment Conclusions Report. The PACR is the final deliverable of the RIT-T
PADR	Project Assessment Draft Report. The PADR is a deliverable of the RIT-T
POE	Probability of Exceedance. This is the probability a forecast would be met or exceeded, e.g. a 50% POE demand implies there is a 50% probability of the forecast being met or exceeded
PSCR	Project Specification Consultation Report. The PSCR is the first deliverable of the RIT-T
PTIP	Priority Transmission Infrastructure Project
PV	Photovoltaic
RAS	Remedial Action Scheme. RAS is used to take action on the HV Network during special operating conditions
Reliability	Reliability is a measure of a power system's capacity to continue to supply sufficient power to satisfy customer demand, allowing for the loss of generation capacity
RET	Renewable Energy Target
RIT-T	Regulatory Investment Test for Transmission
Secondary system	Equipment used to control, automate, protect and monitor the network
Sent-out	Generation measured at the point of connection with the transmission network

Term	Explanation/Comments
Small non-scheduled generation	Non-Scheduled generation that is not included in Operational Demand
Spot Load	Spot loads are step (one-shot) increases in load for a BSP due to new commercial/housing developments or large industrial customer connections. There could be spot load decreases in cases where there are withdrawals of large-load customers from the grid
Substation	A secure area designated for HV switchgear, secondary systems, and other Transgrid assets other than transmission lines
Summer	In this report, all days from 16 November to 15 March
SVC	Static VAr Compensator. An electrical device installed on the high-voltage transmission system to provide fast acting voltage control to regulate and stabilise the system
Term	Explanation/Comments
TAC	Transgrid's Advisory Council
TBD	To be determined. Data is not available at the time of this report being issued
Transmission Annual Planning Report (TAPR)	This document that sets out issues and provides information to the market that is relevant to transmission planning in NSW
Transmission line	A high-voltage power line running at 500 kV, 330 kV, 220 kV or 132 kV. The high-voltage allows delivery of bulk power over long distances with minimal power loss
Transmission Network Service Provider (TNSP)	A body that owns, controls and operates a transmission system in the NEM
VER	Value of Emissions Reduction
Winter	In this report, all days in a particular year from 16 May to 31 August

Transgrid

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