Draft Network Infrastructure Strategy

Appendices

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Cover image Image courtesy of iStock. Town from a hill.

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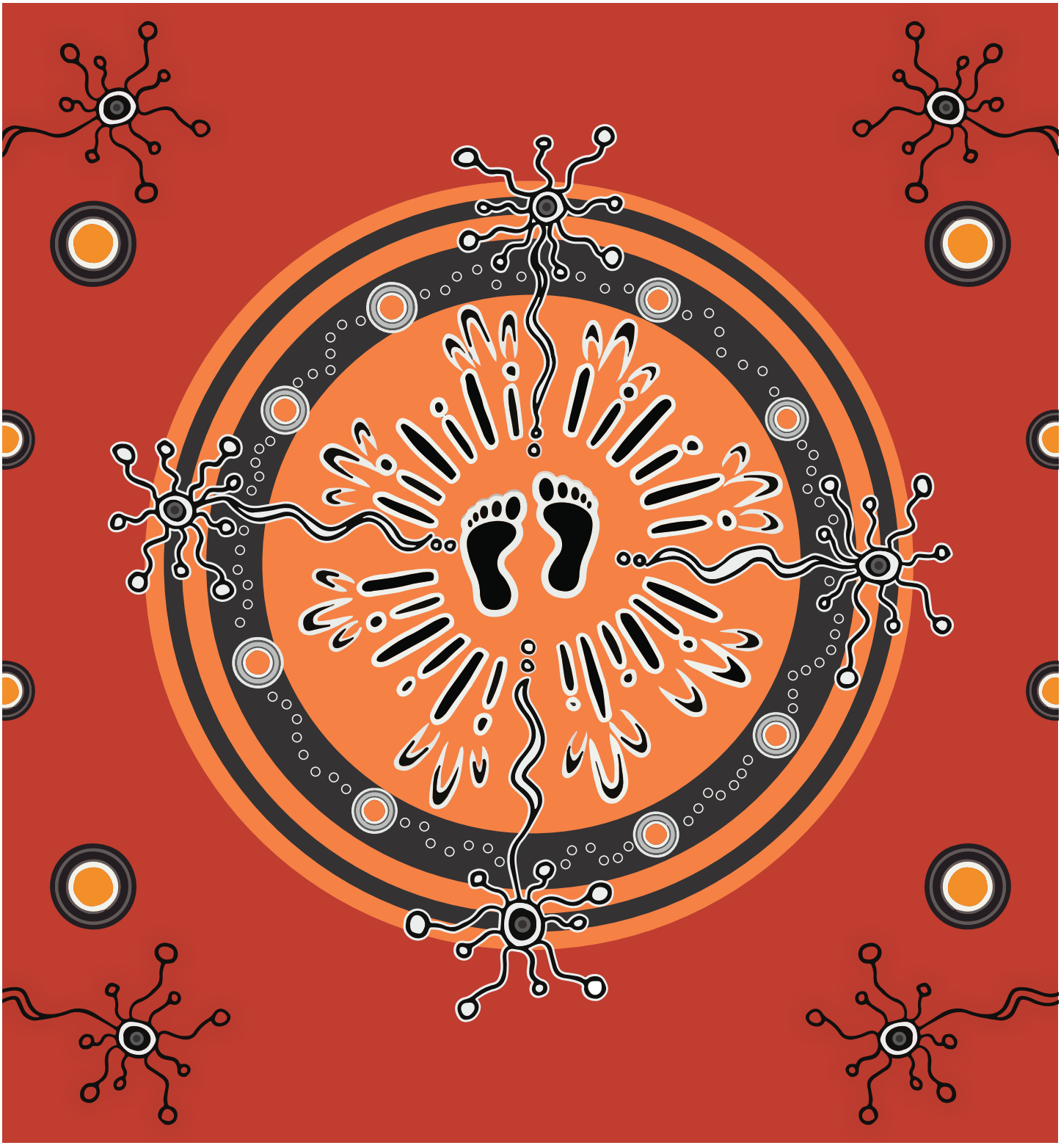

Acknowledgement of Country

The Energy Corporation of NSW acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

Image courtesy of Getty. Woman walking next to solar panels.

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Appendix A: Shortened forms

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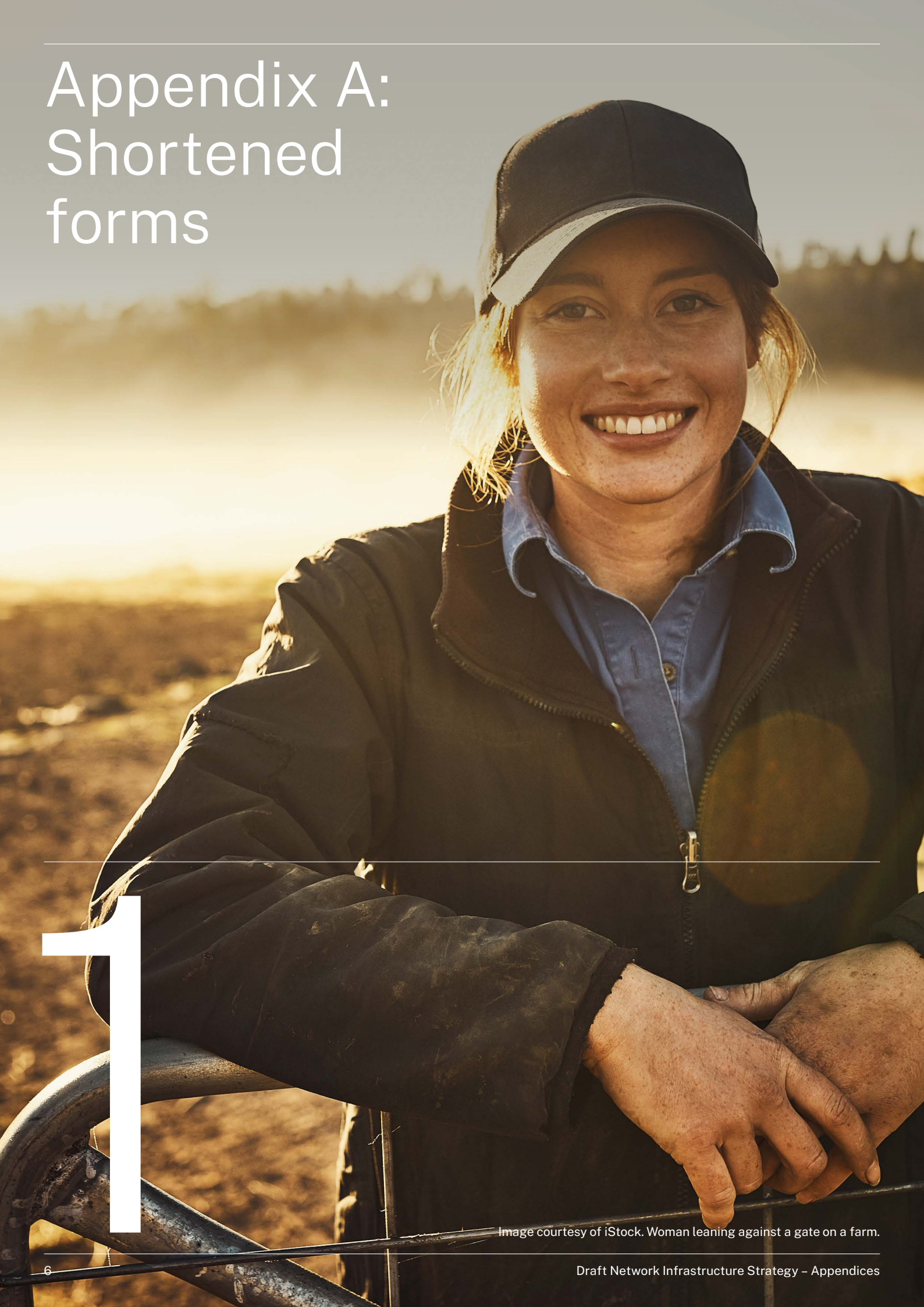

Image courtesy of iStock. Woman leaning against a gate on a farm.

Abbreviation	Long form
AEMO	Australian Energy Market Operator
CWO REZ	Central-West Orana Renewable Energy Zone
DAPR	Distribution Annual Planning Report
DNSP	Distribution network service provider
EII Act	*Electricity Infrastructure Investment Act 2020*
EnergyCo	Energy Corporation of New South Wales
ESOO	Energy Statement of Opportunities
HCC REZ	Hunter-Central Coast Renewable Energy Zone
IIO Report	Infrastructure Investment Objectives Report
ILW REZ	Illawarra Renewable Energy Zone
IP	Infrastructure Planner
LTESA	Long-term Energy Service Agreements
NE REZ	New England Renewable Energy Zone
NEM	National Electricity Market
Net Zero Plan	NSW Net Zero Plan Stage 1: 2020-2030
NIS	Network Infrastructure Strategy
OSW	Offshore Wind
Roadmap	NSW Electricity Infrastructure Roadmap
PTIP	Priority Transmission Infrastructure Project
REZ	Renewable Energy Zone
RIT-T	Regulatory Investment Test – Transmission
RNIP	REZ network infrastructure project
SW REZ	South-West Renewable Energy Zone
TAPR	Transmission Annual Planning Report
TET	Transmission Efficiency Test

Appendix B: Key terms

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Image courtesy of iStock. Farmer watching over cattle on farm.

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

Downstream augmentations: As each of the REZs grow in hosting capacity, additional downstream network augmentations are required to enable the stable, unconstrained flow of power to the major load centres. These augmentations are both upgrades to existing transmission infrastructure, to maximise the utility of these assets, but also new infrastructure to create the required additional capacity.

Infrastructure Investment Objectives (IIO): The EII Act establishes minimum objectives for the construction of specified amounts of generation and long-duration storage infrastructure by the end of 2029; and overall objectives to construct additional generation, long-duration storage, and firming infrastructure to minimise costs to NSW electricity consumers and meet the NSW energy security target and reliability standard.

Long Duration Storage (LDS): Any form of energy storage that can dispatch at its rated capacity for 8 hours or more.

Maximum theoretical transfer capacity: The potential transfer capacity that can be unlocked for each REZ, provided that all optimal network augmentations and investments are undertaken.

National Framework: The National Electricity Rules and National Electricity Law which regulate the development of in the NEM.

Network Infrastructure Options (Options): A forward-looking series of technical options for expanding the NSW transmission network over the coming years. These options serve not only to deliver the required network capacity for renewable energy zones under the NSW Electricity Infrastructure Roadmap, but also to establish a strong foundation to meet NSW's changing energy requirements. The options inform the Consumer Trustee's preparation of an optimised 20-year Development Pathway for electricity infrastructure in NSW.

NSW Framework: The new legislative Framework set out to regulate the development of the electricity sector in NSW under the *Electricity Infrastructure Investment Act 2020*.

Option rich approach: The NIS develops potential network options that can be expanded readily, at lower costs and with minimised community impacts. These projects maximise future optionality and ensure that the power system is robust to withstand future uncertainties and deliver lower long-term prices and risks to NSW consumers.

Priority Transmission Infrastructure Project (PTIP): Network infrastructure to address a breach in the NSW Energy Security Target (must be identified in the ISP). The Minister can authorise or direct a Network Operator to carry out a PTIP.

Renewable Energy Zone (REZ): Renewable Energy Zones (REZs) are modern-day power stations. They combine renewable energy generation such as wind and solar, storage such as batteries, and high-voltage towers and wires to deliver energy to the homes, businesses and industries that need it.

REZ Network Infrastructure Project (RNIP): Network infrastructure to support generation and storage within a declared REZ and consists of network infrastructure of a class prescribed by the EII Act. The Infrastructure Planner for a REZ must recommend options for RNIPs to the Consumer Trustee to authorise a network operator. The Minister may also direct a Network Operator to construct a RNIP if a recommendation has been made by the Consumer Trustee.

The Roadmap: The Roadmap is the NSW Government's plan to transform the NSW electricity sector and deliver a modern electricity system that is affordable, reliable, and clean for consumers. It sets out a coordinated framework to construct electricity infrastructure to replace NSW's coal-fired power stations as they progressively retire.

Transmission Efficiency Test: A regulatory assessment carried out by the Australian Energy Regulator (AER) to determine whether the capital costs proposed by the Network Operator are prudent, efficient and reasonable.

Appendix C: Methodologies

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Image courtesy of iStock. Wind turbines.

A detailed explanation of the current working methodologies for cost, schedule and generation build out estimation can be found in this appendix. These methodologies synthesise EnergyCo's learnings and current market insight from the development activities carried out to date.

Note that all of these methodologies are currently still in development. As part of the Interim Network Infrastructure Report release, we are actively seeking feedback on the robustness of these processes to help ensure the best representations of each project is estimated.

Cost Estimation

Overview

A standardised process for estimating the cost of identified augmentations was developed to allow for fair cost/benefit evaluation of different augmentations in the modelling process. This cost estimate is intended to be used for comparison of options in the early stages of conceptualisation and as such the granularity of the estimation process reflects this early development stage. Additionally, this estimation process is intended to reflect the additional real world costs that are incurred in delivering these types of projects that traditionally are not encapsulated within the National Framework – to better reflect the actual delivery cost.

The cost estimation process is carried out in two stages. **Stage one** utilises the AEMO's Transmission Cost Database (TCD) with a standardised set of inputs appropriate for the types of network augmentations being proposed and is representative of the delivery cost under the National Framework.

Stage two then applies additional cost factors which represent additional considerations, such as specific land user payments or establishment of a special procurement vehicle for a contestable process, that are unique to a project being delivered under the Roadmap. These additional costs are reflective of the non-CAPEX components of transmission project delivery that are crucial to successful delivery and actively incorporated under the Roadmap, but traditionally are not considered under the National Framework as project delivery cost.

Early phase project cost estimates will be used for a number of purposes:

1. A comparison of project options and selection of preferred options.
2. Assessment of the project by the consumer trustee.
3. Project management actions.
4. Communication with stakeholders (management, community, etc.).
5. Progressing through to the next project phase.

Limitations

This cost estimation process is only fit for purpose for a class 5b or equivalent cost estimation. If project definition and scope has moved beyond this level, use of this process is no longer appropriate and the estimate should be developed with the support of a technical adviser, a tenderer or a contractor. Refer to Table 1, which sets out a guide for the level of detail that each class estimate corresponds to. This is used to determine whether this process is appropriate for the scope being estimated.

Whist derived from current experience; it is still only the first instance of a project being delivered under the Roadmap. As such, the assumptions behind each line item are still a work in progress and subject to change as more experience is gained developing and delivering under the Roadmap.

Cost Delineation

The overall project delivery cost is broken up into four broad categories:

1. **REZ Network Infrastructure**: which covers all contestable and non-contestable infrastructure.
2. **Roadmap Additional Costs**: which covers additional roadmap costs and savings created due to delivery under the Roadmap.
3. **Generator Shared Costs**: which covers cost born by the generators connecting to a REZ for shared services (e.g. system strength).
4. **Financing Costs**: cost of debt to deliver the project.

The costs have been classified in these categories to highlight the components that make up the overall delivery cost of a given augmentation and bring clarity on who is paying for each item. The format for this cost breakdown is illustrated in Table 1.

Table 1. Overall cost estimate format

	Source/Approach	REZ Network Infrastructure ($ million)	Roadmap additional costs ($ million)	Generator shared costs ($ million)	Financing costs ($ million)
Transmission Lines					
Line 1	AEMO Cost Database - Class 5b	$			
Line 2	AEMO Cost Database - Class 5b	$			
Line 3	AEMO Cost Database - Class 5b	$			
Non-contestable	AEMO Cost Database - Class 5b	$			
Energy Hubs					
Hub 1	AEMO Cost Database - Class 5b	$		$	
Hub 2	AEMO Cost Database - Class 5b	$		$	
Hub 3	AEMO Cost Database - Class 5b	$		$	
Non-contestable	AEMO Cost Database - Class 5b	$		$	
Indirect Costs					
Project Development	AEMO Cost Database - Class 5b	$			
Works Delivery	AEMO Cost Database - Class 5b	$			
Land and Environment	AEMO Cost Database - Class 5b	$			
Stakeholder and Community Engagement	AEMO Cost Database - Class 5b	$			
Procurement Costs	AEMO Cost Database - Class 5b	$			
Insurance	AEMO Cost Database - Class 5b	$			
Other Capex and Adjustments					
Social procurement	First Nations, local content, training, accommodation (calculated % that is applied to all other projects)		$		
Upfront & SPV costs	Including bid cost recovery		$		
Property	Roadmap approach to property		$		
Biodiversity offsets	Additional to costs already in AEMO database		$		
Client costs in delivery	Additional costs for EnergyCo oversight under roadmap approach		$		
Client contingency			$		
EnergyCo DEVEX			$		
Other NO Costs					
Capitalised interest and financing costs	Construction debt				$
DSRA	6 months debt service				$
Total Cost (Real 2021 $ million)		**$**	**$**	**$**	**$**

Table 2. Association for the advancement of cost engineering project definition and cost estimation

	Primary characteristic	Secondary Characteristic			
Estimate class	**Level of project definition** Expressed as % of complete definition	**End usage** Typical purpose of estimate	**Methodology** Typical estimating method	**Expected accuracy range** Typical variation in low and high ranges (a)	**Preparation effort** Typical degree of effort relative to least coast index of 1 (b)
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment or analogy	L:-20% to-50% H: +30% to +100%	1
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L:-15% to-30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, authorisation or control	Semi-detailed unit costs with assembly level line items	L:-10% to-20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L:-5% to-15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L:-3% to-10% H: +3% to +15%	5 to 100

Notes: (a) The state of process technology and availability of applicable reference cost data affect the range markedly. The +/-value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

(b) If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimation data and tools.

The information contained in Table 1 is provided to assist the estimator in determining the appropriate estimate costs.

Image courtesy of iStock. Female windfarm engineer.

Stage 1 – Use of AEMO's TCD

The process for using AEMO's TCD for the initial cost estimate is as follows:

1. Develop the project scope using appropriate technical and cost estimator subject matter experts (SMEs).
2. Use the Database to develop the initial cost estimate:

- Use the level of scope definition to decide whether the estimate should be Class 5b or Class 5a.
- Ensure all the appropriate factors, risks and indirect costs are reviewed and included. (Refer to the Table 3 - 9 to assist in determining the appropriate risk factors and the appropriate estimate class. At Class 5b most/all of the factors, risks, costs will be BAU; if there is sufficient knowledge of factors and risks to adjust away from BAU this would suggest the Class 5a is more relevant).

3. 'Test' the scope and estimate by appropriate SMEs.

The AEMO TCD is used for both the REZ Network Infrastructure and Generation Shared Cost estimation in Table 1.

All estimators must read the Database – User Manual before undertaking an estimate. It is recommended that estimators also review the AEMO 2021 Transmission Cost Report before undertaking an estimate.

The AEMO 2021 Transmission Cost Report contains information and tables that will assist in deciding on the appropriate class of estimate.

Standardised Inputs and Assumptions

A standardised set of Project Factors, Known Risks and Unknown Risks was determined for lines and stations as well as for Indirect Project Factors, based on the experience developing the CWO REZ and best represents current market conditions. These standardised factors are to be applied across all options, where appropriate, and are aimed at enabling as even comparison of project costs as possible.

Line Project Factors

These are the factors applied to all transmission line portions of a given scope. They have been selected to broadly represent the likely experience of developing and delivering a transmission line in NSW. All factors are constant across different scopes, except for 'Project network element size' and 'Greenfield or brownfield', which were selected appropriately depending on the line item.

Table 3. Line Project Attributes

Line Project Attributes	Selection	Justification
Project network element size	**As appropriate**	Based on conceptual scope
Jurisdiction	NSW	-
Land Use	Grazing	High possibility of encountering grazing land
Greenfield or brownfield	**As appropriate**	Some augmentations will be new and some will impact existing infrastructure
Proportion of environmentally sensitive areas	50%	Intended design of alignment will aim to avoid environmentally sensitive areas where practical
Location (regional/distance factors)	Regional	Based on geographical position of REZs
Location wind loading zones	Non-cyclone region	Appropriate for all of NSW
Delivery timetable	Tight	Given the amount of activity in this industry domestically and globally
Contract delivery model	EPC contract	Likely method of delivery
Terrain	Hilly/undulating	To account for worst scenario

Table 4. Line Project Known Risks

Line Project Known Risks	Selection	Justification
Macroeconomic influence	BAU	-
Market activity	Tight	Given the amount of activity in this industry domestically and globally
Project complexity	Partly complex	Mix of well-established and novel configurations/equipment being proposed
Compulsory acquisition	BAU	May be required for certain projects
Environmental offset risks	BAU	Given the added attention drawn to this under the Roadmap
Geotechnical findings	BAU	-
Outage restrictions	Low	Augmentations will likely be constructable in parallel to existing infrastructure
Weather delays	BAU	-
Cultural heritage	BAU	-

Table 5. Line Project Unknown Risks

Line Project Unknown Risks	Selection	Justification
Scope and technology risks	Class 5b	Early stage nature of all designs
Productivity and labour cost risks	Class 5b	
Plant procurement cost risks	Class 5b	
Project overhead risks	Class 5b	

Note: If known risks are assessed and adjusted from BAU the unknown risks should be adjusted to Class 5a.

Station Project Factors

These are the factors applied to all substation or switching station portions of a given scope. They have been selected to broadly represent the likely experience of developing and delivering a substations or switching stations line in NSW. All factors are constant across different scopes, except for 'Project network element size' and 'Greenfield or brownfield', which were selected appropriately depending on the line item.

Table 6. Station Project Unknown Risks

Station Project Attributes	Selection	Justification
Project network element size	**As appropriate**	Based on conceptual scope
Jurisdiction	NSW	
Land Use	Grazing	High possibility of encountering grazing land
Greenfield or brownfield	**As appropriate**	Some augmentations will be new and some will impact existing infrastructure
Proportion of environmentally sensitive areas	50%	Intended design of alignment will aim to avoid environmentally sensitive areas where practical
Location (regional/distance factors)	Regional	Based on geographical position of REZs
Delivery timetable	As appropriate	Given the amount of activity in this industry domestically and globally
Contract delivery model	EPC contract	Likely method of delivery

Table 7. Station Project Known Risks

Station Project Known Risks	Selection	Justification
Macroeconomic influence	BAU	-
Market activity	Tight	Given the amount of activity in this industry domestically and globally
Project complexity	Partly complex	Mix of well-established and novel configurations/equipment being proposed
Compulsory acquisition	BAU	May be required for certain projects
Environmental offset risks	BAU	Given the added attention drawn to this under the Roadmap
Geotechnical findings	BAU	-
Outage restrictions	Low	Augmentations will likely be constructable in parallel to existing infrastructure
Weather delays	BAU	-
Cultural heritage	BAU	-

Table 8. Station Project Unknown Risks

Station Project Unknown Risks	Selection	Justification
Scope and technology risks	Class 5b	Early stage nature of all designs
Productivity and labour cost risks	Class 5b	
Plant procurement cost risks	Class 5b	
Project overhead risks	Class 5b	

Note: If known risks are assessed and adjusted from BAU the unknown risks should be adjusted to Class 5a.

Indirect Project Factors

These are the factors applied to the overall scope of the project, and is calculated after all line items have been totalled. These additional costs represent modifications to the indirect cost of delivery of a given scope.

Table 9. Indirect Project Factors Risks

Indirect Project Factor	Selection	Justification
Greenfield	As appropriate	Note that appropriate combination of greenfield/partly brownfield/brownfield and total scope value would be selected for each option
Partly brownfield	As appropriate	
Brownfield	As appropriate	
Stakeholder and community sensitive region	Sensitive	It is expected that with the volume of development occurring that stakeholders would require additional engagement and management
Contract delivery model	EPC contract	Likely method of delivery

Image courtesy of iStock. City at dusk.

Stage 2 – Roadmap Additional Costs

AEMO's TCD represents the likely cost of delivery of a given transmission project under the National Framework, however the options presented in the Interim NIS would be delivered under the NSW Framework (EII Act 2020). This differs from the National Framework in that there are additional considerations, such as added social licence costs or contestable delivery cost savings, that aren't traditionally captured in the delivery cost estimates.

Other CAPEX and Adjustments

Project delivery under the Roadmap is structured differently from the National Framework and as such different cost factors need to be accounted for. The points of differentiation between the delivery frameworks are:

- Additional and early consideration for social licence requirements, including additional administrative costs
- Coordination of projects with NSW Government property and biodiversity programs to ensure fair land use payments and environmental sensitivity
- Administrative costs for a contestable approach to project delivery
- Subsequently, potential delivery cost savings.

EnergyCo is currently investigating what these Other CAPEX and Adjustment costs may look like and how they can be represented in future estimations.

Table 10. Indirect Project Factors Risks

Item	Value	Justification
Social procurement	TBC	Additional consideration for social licence in project delivery cost
Property	TBC	Reflects additional consideration for landowner benefit payments
Biodiversity offsets	TBC	Reflects additional consideration for environmental impact payments
Upfront & Special Procurement Vehicle (SPV) costs	TBC	Cost associated with a contestable approach
Client costs in delivery	TBC	Cost of EnergyCo managing delivery
Client contingency	TBC	Risk contingency
EnergyCo DEVEX	TBC	Increased indirect cost of delivery due to coordination with other NSW Roadmap programs

Other Network Operator Costs

It is anticipated that the financing cost of delivering a project under the Roadmap maybe different from that known under the National Framework given that it is a new process. EnergyCo is currently investigating what this risk profile may appear as to the market, to better understand the expected delivery complexity of a project under the Roadmap.

Table 11. Indirect Project Factors Risks

Item	Value	Justification
Capitalised interest & financing costs	TBC	These values have yet to be determined, as there is still an on-going tender for the Network Operator for CWO
DSRA	TBC	

Image courtesy of iStock. A group of farmers discussing in the field.

Schedule Estimation

Overview

A standardised process for estimating the delivery schedule of identified augmentations was developed to allow for fair cost/benefit evaluation of different augmentations in the modelling process. This schedule estimate is intended to be used for comparison of options in the early stages of conceptualisation and as such the granularity of the estimation process reflects this early development stage. This estimation process is intended to reflect the additional real world delays often experienced by such large transmission projects.

In line with the Central, Early Coal Exit and Transmission Delayed modelling scenarios in Chapter 3 of the Interim NIS, a standardised delivery time frame was created for a project entering under one of these three timeframes. These standard delivery timeframes were estimated based on the current understanding of lead times on labour and materials, which has been informed from market investigations as part of the development of CWO REZ.

Limitations

This cost estimation process is only fit for purpose for projects of a class 5b or equivalent cost estimation. If project definition and scope has moved beyond this level, use of this process is no longer appropriate and the estimate should be developed with the support of a technical adviser, a tenderer or a contractor. Refer to Table 1, which sets out a guide for the level of detail that each class estimate corresponds to. This is used to determine whether this process is appropriate for the scope being estimated.

Schedules

Central Schedule

A standard delivery schedule was estimated based on the required activities listed in Table 12. The number of activities, sequence and duration of each activity was derived from the current learnings from the development of CWO REZ, and reflect the current view on lead times under business as usual conditions.

Table 12. Central Scenario – Standard Schedule

Activity	Duration (weeks)
Procurement of NO	
RFP to market. Tender preparation by proponents.	23
Tender evaluation by EnCo and BAFO	21
Execution of commitment deed. NO work under commitment deed.	23
Planning Approvals	
Conformance of EnCo planning approval documentation	20
Exhibition of EIS	6
Submissions report and determination	24
CEMP – preparation and approval	24
Property Acquisitions	
Acquisition of Property	84
Delivery	
Mobilisation	16
Construction	96
Global commissioning	16
Total	212 weeks (~4 years)

Early Coal Exit and Transmission Delayed Schedules

An Early Coal Exit and a Transmission Delayed Schedule was also estimated to reflect the delivery timeframe in the event that program acceleration was required or if compounding delays pushed out delivery times. Like with the Central schedule, these two schedules were derived from the current learnings from developing CWO REZ and represent plausible program accelerations and delays.

Under an Early Coal Exit schedule, it was estimated that only approximately three months could be reasonably reduced off the Central schedule.

These savings came from optimisations in the construction phase (out of hours work, site establishment as early works and a higher value Commitment Deed enabling construction earlier).

Under a Transmission Delayed schedule, it was estimated that an additional year would be added onto the Central Schedule. This came from potential delays in the EIS phase (approximately by three months) and construction (nine months collectively) due to scope changes or supply chain constraints worsening.

Table 13. Early Coal Exit and Transmission Delayed Schedules

Scenarios	
Central	4 years
Early Coal Exit	3.75 years
Transmission Delayed	5 years

Image courtesy of iStock. Technician working on solar panels.

Appendix D: Detailed Network Infrastructure Options

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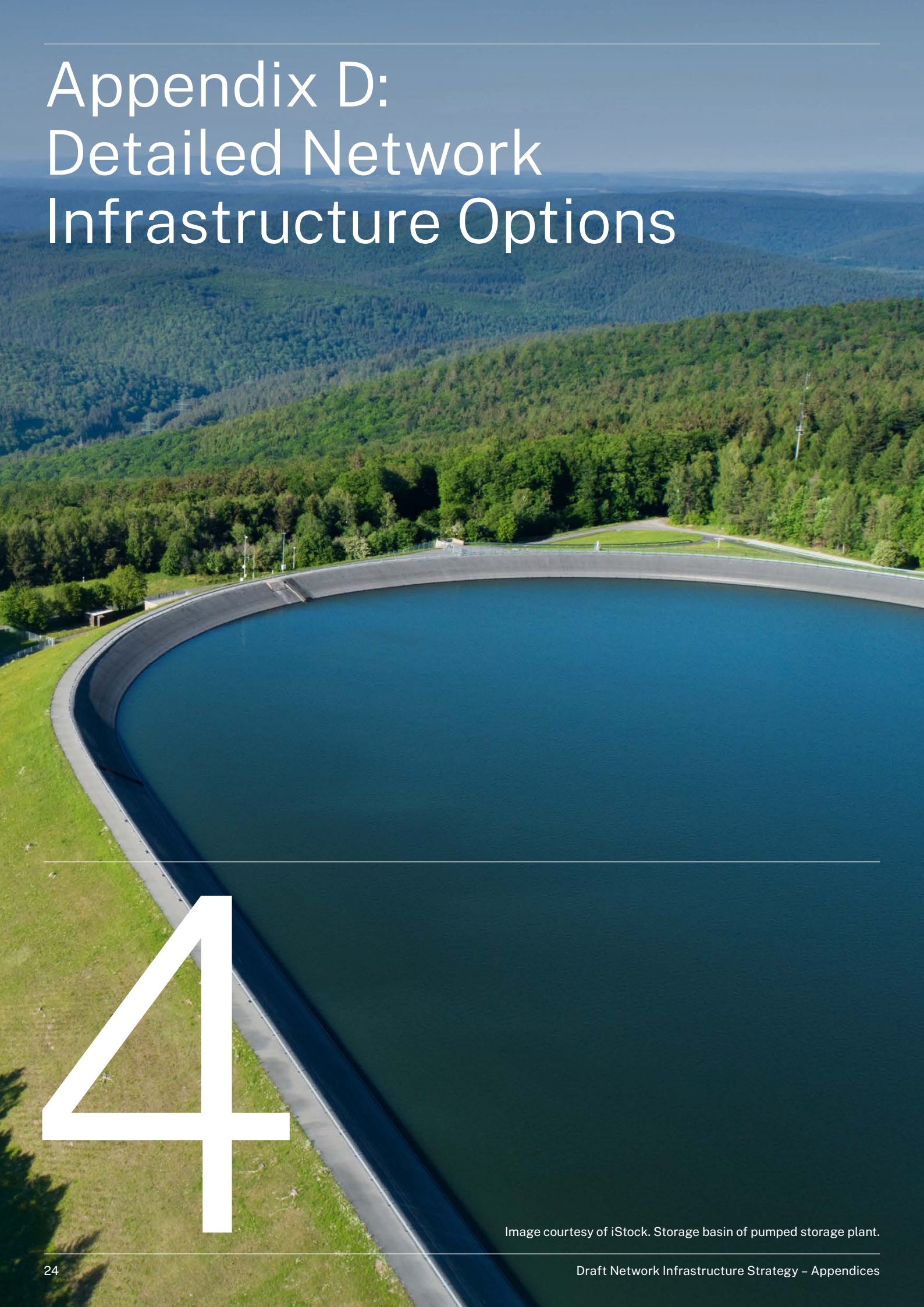


Image courtesy of iStock. Storage basin of pumped storage plant.

This appendix contains the complete list of potential network augmentations, within REZ's and within the shared network, that would likely be required in order to practically expand the generation hosting capacity of the REZ's across the state.

This includes the potential expansions within the Central-West Orana, New England, South West and Hunter Central Coast REZ's and the downstream augmentations that could be required to deliver this additional generation to the load centres along the east coast.

Limitations

These augmentations are conceptual in nature, and are informed by preliminary power system analysis only. They represent a potential future network configuration based on theoretical maximum generation in the identified REZs. Detailed design, planning and further technical analysis will be required to determine not only the feasibility of each option, but also what the detailed solution would be. All of these options are subject to change, and neither EnergyCo nor the Consumer Trustee are bound to any particular option presented.

Considerations

On 9 November 2020, the NSW Government released the NSW Electricity Infrastructure Roadmap to secure cheaper, cleaner and more reliable electricity for NSW households and businesses. The NSW Electricity Infrastructure Investment Act defines long duration storage as storage with a registered capacity that can be dispatched for at least eight hours and stipulates a minimum objective of 2 GW (excluding the Snowy 2.0 project) to be constructed by the end of 2029.

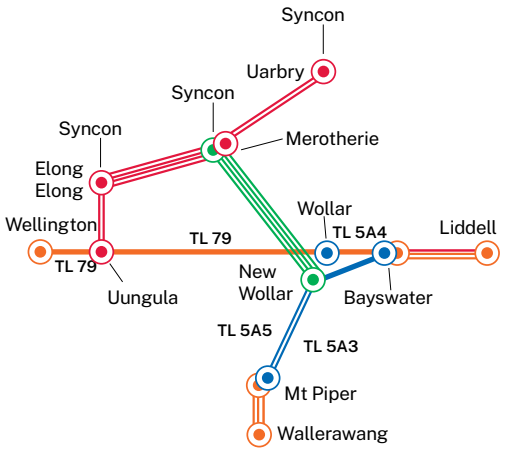
In addition to planning for future expansions to the currently identified REZ's, the network infrastructure options identified are cognisant of potential opportunities to enable pumped hydro energy storage (PHES) projects with future network expansions. Where potential for enabling PHES projects has been identified, it has been detailed in the Notes column. Whilst each of these network augmentations aren't explicitly required for the project to connect, they have been associated together as in combination, there are opportunities to leverage the synchronous generation to release broader network benefits.

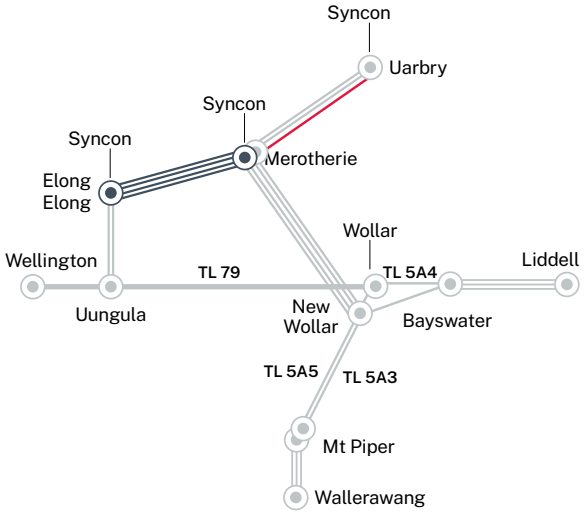
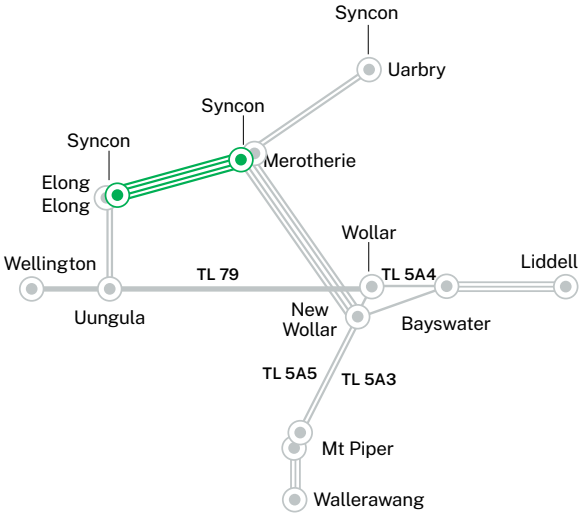
Image courtesy of iStock. Farmers recording details of each cow.

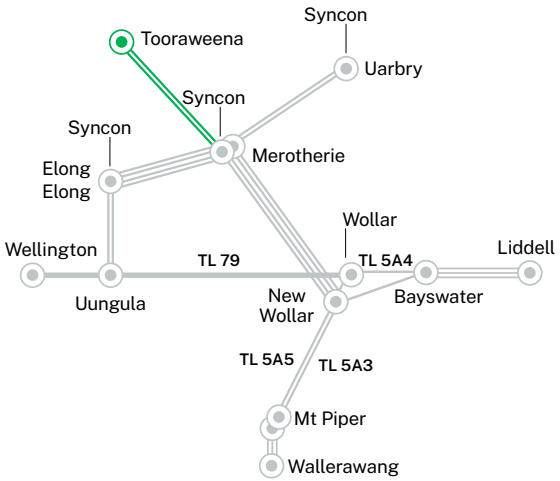
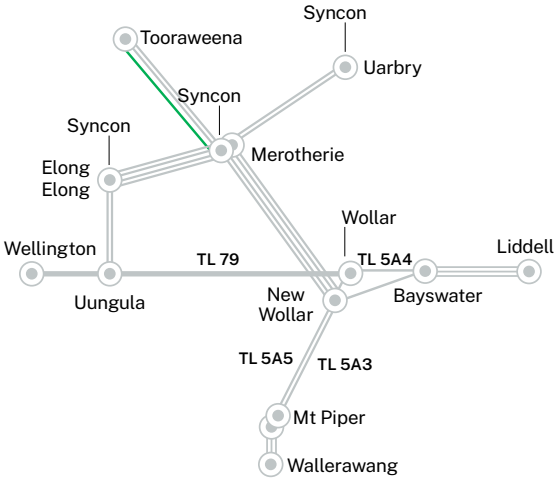
REZ Augmentations

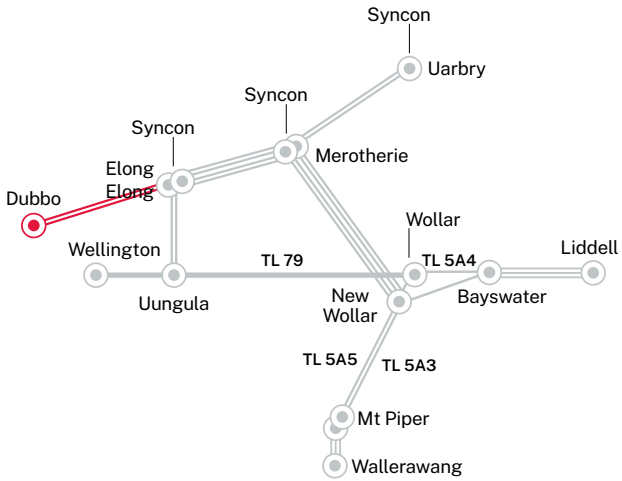
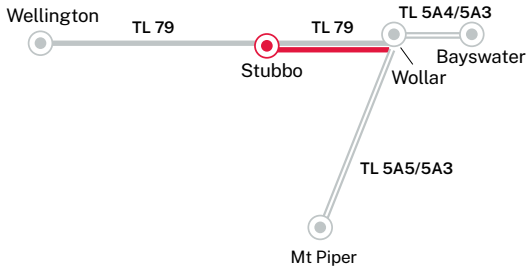
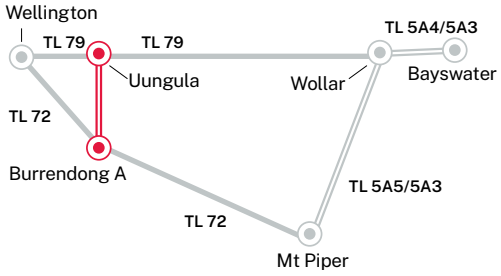
CWO Augmentations

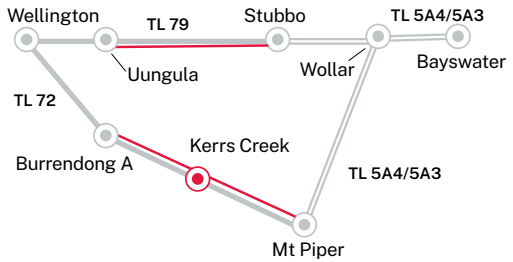
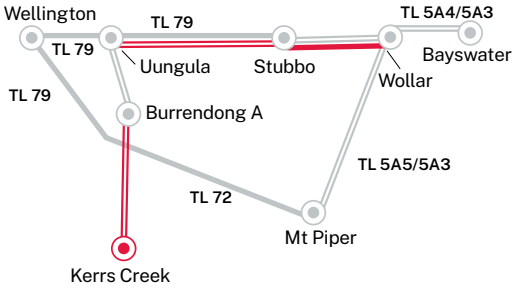
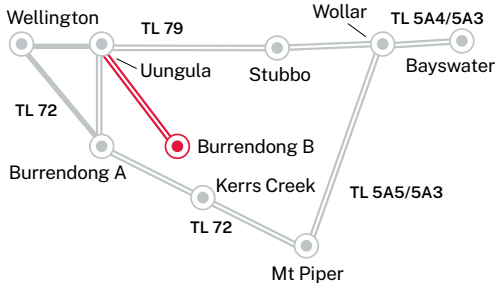
Table 14. Network augmentation options for Central-West Orana REZ

Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	System Strength Remediation	Notes
Option 1 (reference scope)	(Pre-requisite: none) • New Merotherie 500/330 kV substation with 3 x 500/330/33 kV 1,500 MVA transformers • New 330 kV Uarbry, Elong Elong switching stations • New 500 kV Wollar switching station • New 330 kV Uungula switching station and cut into Line 79 Wellington – Wollar • 2 x 500 kV DCST line from Wollar to Merotherie with Quad Orange conductor • 1 x 500 kV DCST and initially operated at 330 kV from Merotherie to Uarbry with Quad Orange conductor • 2 x 500 kV DCST and initially operated at 330 kV from Merotherie to Elong Elong with Quad Orange conductor • 1 x 330 kV DCST from Elong Elong to Uungula with Twin Olive conductor • 5 x 100 MVAr synchronous condensers at Elong Elong switching station • 5 x 100 MVAr synchronous condensers at Merotherie substation • 5 x 100 MVAr synchronous condensers at Uarbry switching station • Provision of switchbays for future generator connections • An additional 330 kV SCST line from Bayswater to Liddell • An additional 330 kV SCST line from Mt Piper to Wallerawang		3,000	AEMO TCD	Included as part of network build (will be updated based on detailed power system study)	

Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	System Strength Remediation	Notes
Option 2A (Uarbry expansion)	(Pre-requisite: CWO REZ Option 1) • An additional 330 kV SCST line from Uarbry to Merotherie with Twin Olive conductor • Augment 330 kV Uarbry switching station • Provision of switchbays for future generator connections *Note: Hunter Transmission Project will be required when the total network capacity is greater than 3 GW as pre-requisite. Cost is not included.*		1,000	AEMO TCD		
Option 2B (Elong Elong expansion)	(Pre-requisite: CWO REZ Option 1) • Expand Elong Elong substation with 3 x 500/330/33 kV 1,500 MVA transformers • Operate lines between Elong Elong and Merotherie to 500 kV *Note: Hunter Transmission Project will be required when the total network capacity is greater than 3 GW as pre-requisite. Cost is not included.*		1,500	AEMO TCD		

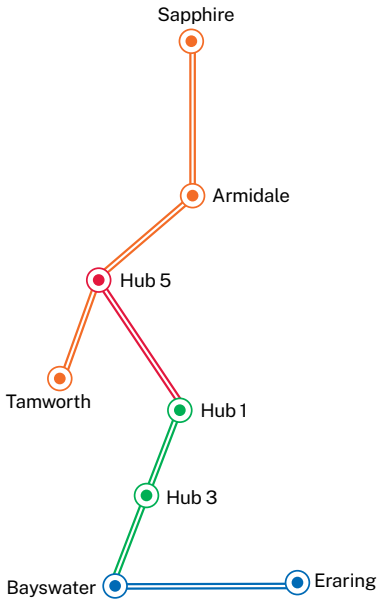
Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	System Strength Remediation	Notes
Option 3A (Tooraweenah expansion)	(Pre-requisite: CWO REZ Option 1) • New Tooraweenah 500/330 kV substation with 3 x 500/330/33 kV 1,500 MVA transformers • New 500 kV DCST line from Tooraweenah to Merotherie with Quad Orange conductor • Augment Merotherie substations • Provision of switchbays for future generator connections		3,000	AEMO TCD		
Option 3B (Tooraweenah further expansion)	(Pre-requisite: CWO REZ Option 3A) • Expand Tooraweenah 500/330 kV substation with 1 x 500/330/33 kV 1,500 MVA transformer • An additional 500 kV SCST line from Tooraweenah to Merotherie with Quad Orange conductor • Augment Merotherie substations • Provision of switchbays for future generator connections		1,500	AEMO TCD		

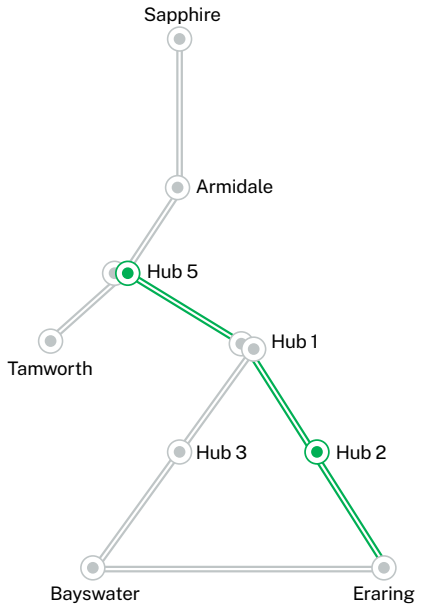
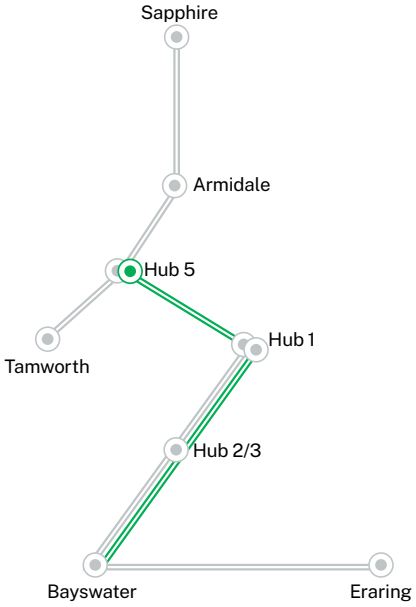
Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	System Strength Remediation	Notes
Option 3C (Dubbo expansion)	(Pre-requisite: CWO REZ Option 2B) • Expand Dubbo as 330/132 kV substation with 3 x 330/132 kV 375 MVA transformers • An additional 330 kV DCST line from Dubbo to Elong Elong with Twin Mango conductor • Provision of switchbays for future generator connections *Note: Hunter Transmission Project will be required when the total network capacity is greater than 3 GW as pre-requisite. Cost is not included.*		500	AEMO TCD		
Option 4 (Stubbo expansion)	(Pre-requisite: none) • New 330 kV Stubbo switching station and cuts into Line 79 Wellington – Wollar • New 330 kV SCST line between Wollar and Stubbo with Twin Olive conductor • Expand Wollar substation with 330 kV busbar and 1 x 500/300/33kV 1,500 MVA transformer • Provision of switchbays for future generator connections		500	AEMO TCD		
Option 5A (Burrendong expansion 1)	(Pre-requisite: none) • New 330 kV Burrendong switching station and cuts into Line 72 Wellington – Mt Piper • New Uungula switching station and cuts into Line 79 Wollar – Wellington • New 330 kV DCST line from Burrendong switching station to Uungula with Twin Mango conductor		500	AEMO TCD		This option would allow up to 500 MW of PHES to connect and the power system to benefit from ancillary services it can provide

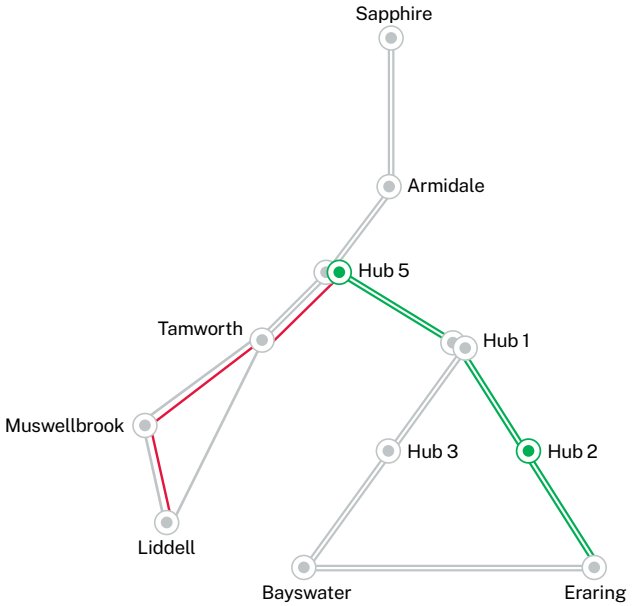
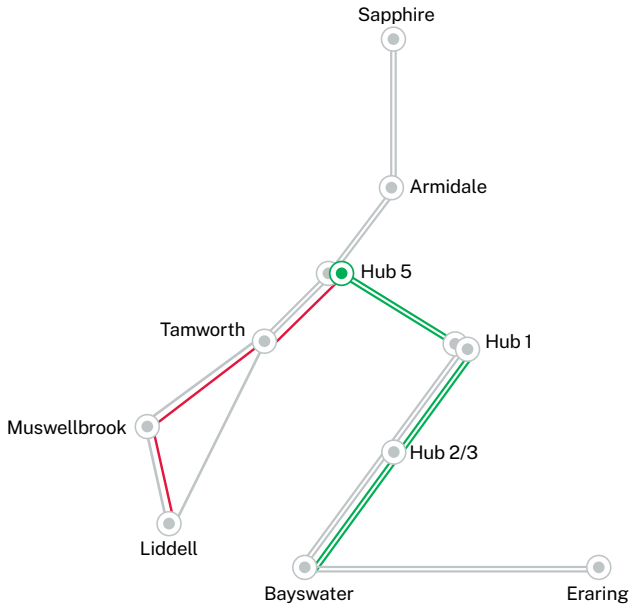
Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	System Strength Remediation	Notes
Option 5B (Kerr's Creek expansion 1)	(Pre-requisite: Option 4 and 5A) • New 330 kV Kerr's Creek switching station and cuts into Line 72 and new parallel section between Mt Piper - Burrendong • New 330 kV SCST line between Burrendong and Mt Piper with Twin Olive conductor • New 330 kV SCST line between Uungula and Stubbo with Twin Olive conductor • New 2 x 330 kV 60 MVAr line shunt reactors at Burrendong and 2 x 330 kV 60 MVar line shunt reactors at Mt Piper		800	AEMO TCD		This option would allow up to 310 MW of PHES to connect and the power system to benefit from ancillary services it can provide (alternative to option 5C)
Option 5C (Kerr's Creek expansion 2)	(Pre-requisite: Option 4 and 5A) • New 330 kV Kerr's Creek switching station • New 330 kV DCST line from Kerr's Creek to Burrendong switching station with Twin Mango conductor • New 330 kV DCST line between Uungula and Stubbo with Twin Olive conductor • New 330 kV SCST line between Stubbo and Wollar with Twin Olive conductor		800	AEMO TCD		This option would allow up to 310 MW of PHES to connect and the power system to benefit from ancillary services it can provide (alternative to option 5B)
Option 5D (Burrendong WF expansion 1)	(Pre-requisite: Option 5B or 5C) • New 330 kV Burrendong WF switching station • New 330 kV DCST line from Burrendong WF switching station to Uungula switching station with Twin Mango conductor		500	AEMO TCD		

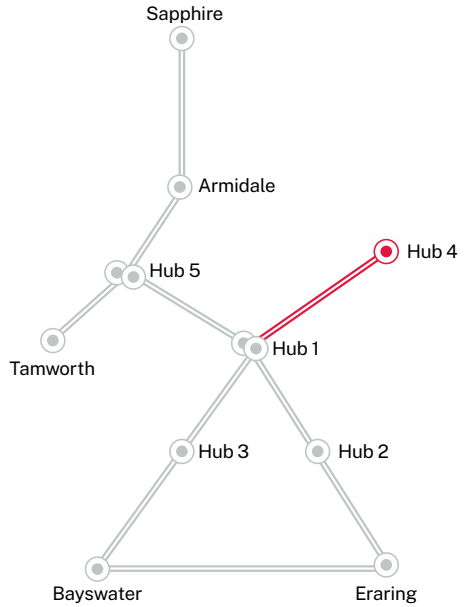
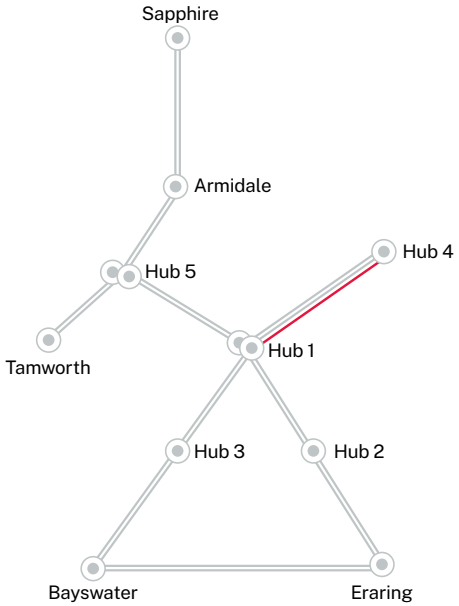
NE Augmentations

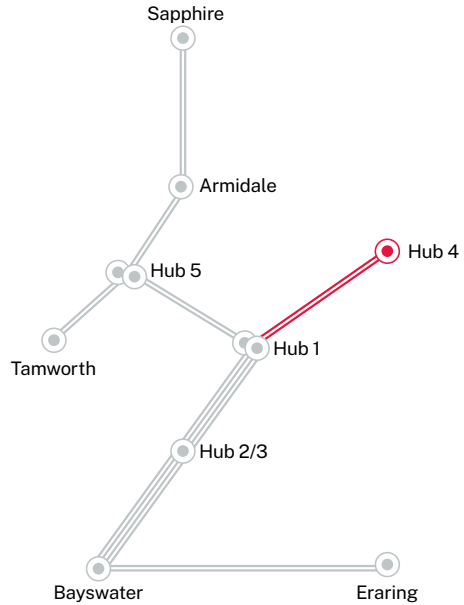
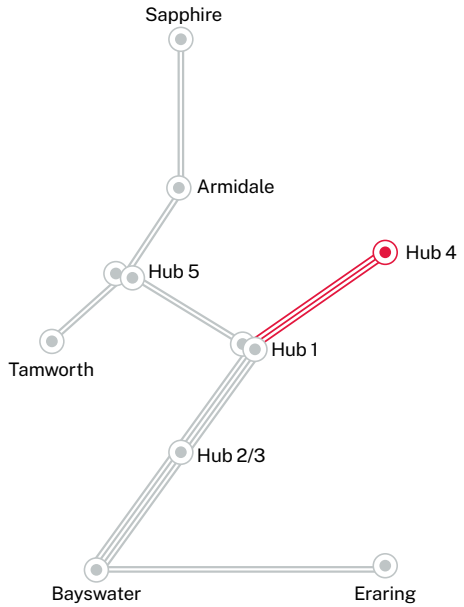
Table 15. Network augmentation options for New England REZ

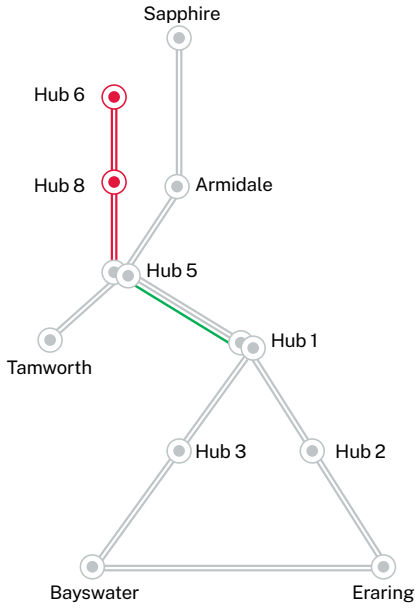
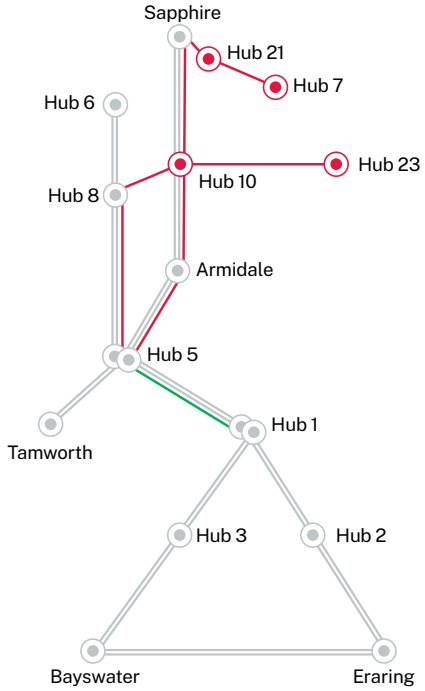
Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 1 (reference scope 1)	(Pre-requisite: none) • New Hub 1 500/330 kV substation with 3 x 500/330/33 kV 1,500 MVA transformers • New Hub 3 500/330 kV substation with 2 x 500/330/33 kV 1,500 MVA transformers • New Hub 5 330 kV switching station and cut into the existing lines between Tamworth and Armidale • New 500 kV built and initially 330 kV operated DCST line from Hub 5 to Hub 1 with Quad Orange conductor • New 500 kV DCST line between Hub 1 and Hub 3 with Quad Orange conductor • New 500 kV DCST line between Hub 3 and Bayswater with Quad Orange conductor • 4 x 500 kV 150 MVAr line shunt reactors (in total) are required for 500 kV DCST line between Hub 3 and Bayswater		3,000	AEMO TCD	This option will increase the NNSW – CNSW and/or NNSW – SNW Cut set limit. Please refer to Table 19 for more detail

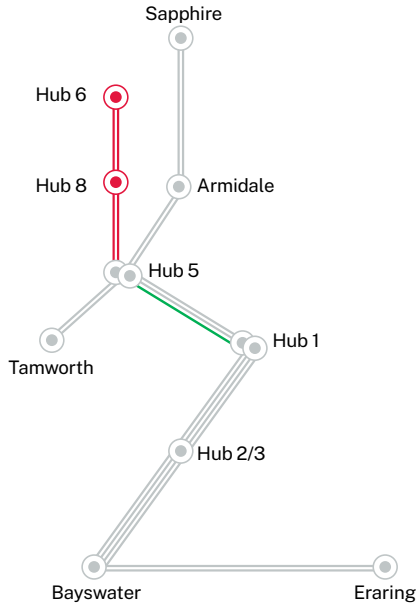
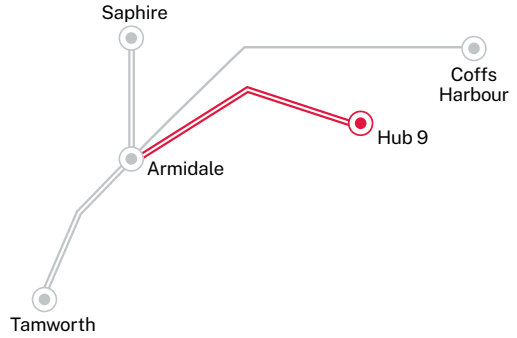
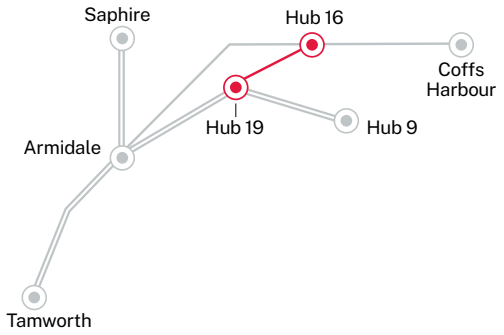
Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 2A	(Pre-requisite: NE REZ Option 1) • Expand Hub 5 switching station to 500/330 kV substation with 3 x 500/330/33 kV 1,500 MVA transformers • Operate line between Hub 5 and Hub 1 to 500 kV • New Hub 2 500/330 kV substation with 2 x 500/330/33 kV 1,500 MVA transformers • New 500 kV DCST from Hub 1 to Eraring via Hub 2 with Quad Orange conductor • 4 x 500 kV 150 MVAr line shunt reactors (in total) are required for 500 kV DCST line between Hub 2 and Eraring • New 6 x 330 kV 200 MVA phase shifting transformers at Hub 6 • Augment Hub 1 and Eraring to accommodate additional lines		3,000	AEMO TCD	This option will increase the NNSW – CNSW and/or NNSW – SNW Cut set limit. Please refer to Table 19 for more detail
Option 2B	(Pre-requisite: NE REZ Option 1) • Expand Hub 5 switching station to 500/330 kV substation with 3 x 500/330/33 kV 1,500 MVA transformers • Operate line between Hub 5 and Hub 1 to 500 kV • New 500 kV DCST from Hub 1 to Bayswater via Hub 2/3 (combine Hub 2 and Hub 3 in Option 3A together) with Quad Orange conductor • 4 x 500 kV 150 MVAr line shunt reactors (in total) are required for 500 kV DCST line between Hub 2/3 and Bayswater • New 6 x 330 kV 200 MVA phase shifting transformers at Hub 6		3,000	AEMO TCD	This option will increase the NNSW – CNSW and/or NNSW – SNW Cut set limit. Please refer to Table 19 for more detail

Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 2C	(Pre-requisite: NE REZ Option 1) • Expand Hub 5 switching station to 500/330 kV substation with 3 x 500/330/33 kV 1,500 MVA transformers • Operate line between Hub 5 and Hub 1 to 500 kV • New Hub 2 500/330 kV substation with 2 x 500/330/33 kV 1,500 MVA transformers • New 500 kV DCST from Hub 1 to Eraring via Hub 2 with Quad Orange conductor • 4 x 500 kV 150 MVAr line shunt reactors (in total) are required for 500kV DCST line between Hub 2 and Eraring • Rebuild portion of Line 86 from Hub 6 to Tamworth as 330 kV double circuit line • Rebuild Line 88 Tamworth – Muswellbrook and Line 83 Liddell – Muswellbrook as 330 kV double circuit line • Augment Hub 1,Eraring, Hub 5, Tamworth, Muswellbrook and Liddell to accommodate additional lines		3,500	AEMO TCD	This option will increase the NNSW–CNSW and/or NNSW–SNW Cut set limit. Please refer to Table 19 for more detail
Option 2D	(Pre-requisite: NE REZ Option 1) • Expand Hub 5 switching station to 500/330 kV substation with 3 x 500/330/33kV 1,500 MVA transformers • Operate line between Hub 5 and Hub 1 to 500 kV • New 500 kV DCST from Hub 1 to Bayswater via Hub 2/3 (combine Hub 2 and Hub 3 in Option 3A together) with Quad Orange conductor • 4 x 500 kV 150 MVAr line shunt reactors (in total) are required for 500 kV DCST line between Hub 2/3 and Bayswater • Rebuild portion of Line 86 from Hub 6 to Tamworth as 330 kV double circuit line • Rebuild Line 88 Tamworth – Muswellbrook and Line 83 Liddell - Muswellbrook as 330 kV double circuit line • Augment Hub 5, Hub 1, Hub 2/3, Bayswater, Tamworth, Muswellbrook and Liddell to accommodate additional lines		3,500	AEMO TCD	This option will increase the NNSW–CNSW and/or NNSW–SNW Cut set limit. Please refer to Table 19 for more detail

Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 3A	(Pre-requisite: NE REZ Option 2A) • New Hub 4 330 kV switching station • Expand Hub 1 with 1 x 500/330/33 kV 1,500 MVA transformer • New 330 kV DCST line from Hub 4 to Hub 1 with Twin Olive conductor • Augment Hub 1 to accommodate additional lines from Hub 4		1,500	AEMO TCD	
Option 3B	(Pre-requisite: NE REZ Option 3A) • New 330 kV SCST line from Hub 4 to Hub 1 with Twin Olive conductor • Augment Hub 1 to accommodate additional lines from Hub 4 • New 500/330/33 kV 1,500 MVA transformer at Hub 1		500	AEMO TCD	

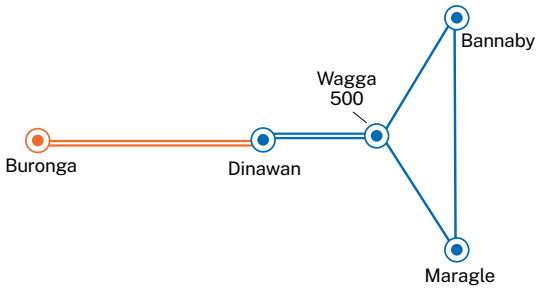
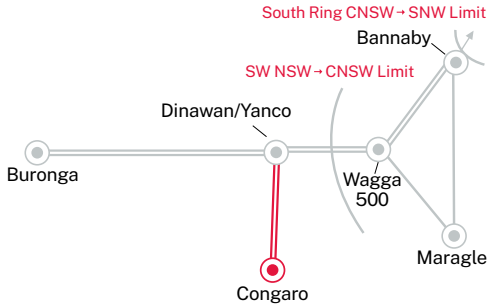
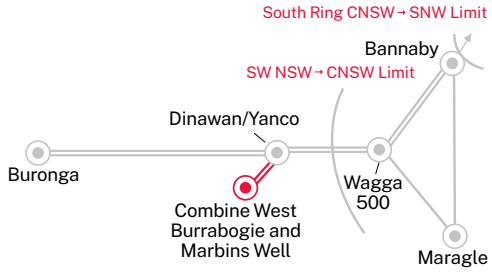
Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 3C	(Pre-requisite: NE REZ Option 2B) • New Hub 4 330 kV switching station • Expand Hub 1 with 1 x 500/330/33 kV 1,500 MVA transformer • New 330 kV DCST line from Hub 4 to Hub 1 with Twin Olive conductor • Augment Hub 1 to accommodate additional lines from Hub 4		1,500	AEMO TCD	
Option 3D	(Pre-requisite: NE REZ Option 2C) • New 330 kV SCST line from Hub 4 to Hub 1 with Twin Olive conductor • Augment Hub 1 to accommodate additional lines from Hub 4 • New 500/330/33 kV 1,500 MVA transformer at Hub 1		500	AEMO TCD	

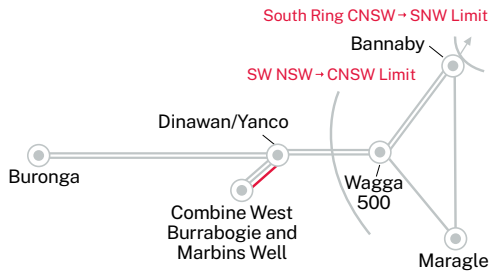
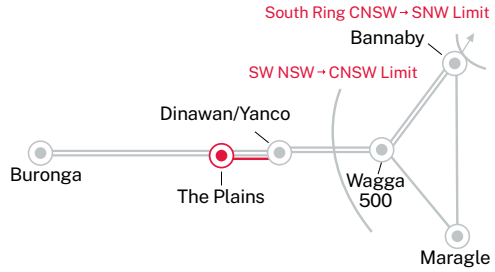
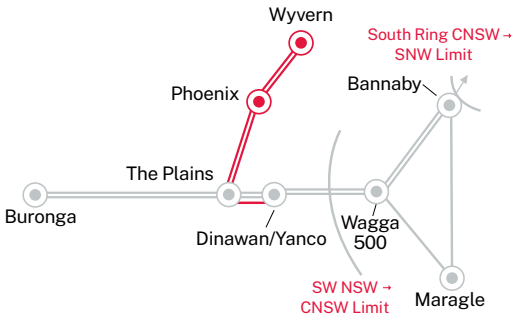
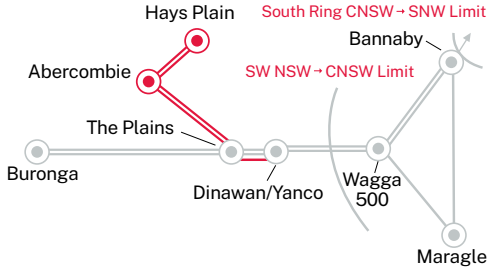
Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 4A	(Pre-requisite: NE REZ Option 2A) • New Hub 6 and Hub 8 330 kV switching station • New 330 kV DCST line from Hub 6 to Hub 8 with Twin Olive conductor • New 330 kV DCST line from Hub 8 to Hub 5 with Twin Olive conductor • New 500 kV DCST and strung on one side SCST line from Hub 5 to Hub 1 with Quad Orange conductor • Augment Hub 5 to accommodate additional lines and 1 x 500/330/33 kV 1,500 MVA transformers		1,400	AEMO TCD	
Option 4B	(Pre-requisite: NE REZ Option 4A) • New Hub 7, Hub 21 and Hub 23 330 kV switching station • Sapphire cuts into existing Armidale – Tamworth line • New Hub 10 switching station and cuts into existing 330 kV lines between Sapphire and Armidale • New 330 kV DCST line from Hub 7 to Hub 21 with Twin Olive conductor • New 330 kV DCST line from Hub 21 to Sapphire with Twin Olive conductor • New 330 kV SCST line from Hub 23 to Hub 10 with Twin Mango conductor • New 330 kV SCST line from Sapphire to Armidale via Hub 10 with Twin Olive conductor • New 330 kV DCST line from Hub 10 to Hub 8 with Twin Olive conductor • New 330 kV SCST line from Hub 8 to Hub 5 with Twin Olive conductor • New 330 kV SCST line from Armidale to Hub 5 with Twin Olive conductor • Augment Hub 5 to accommodate additional lines and 1 x 500/330/33 kV 1,500 MVA transformers		1,600	AEMO TCD	

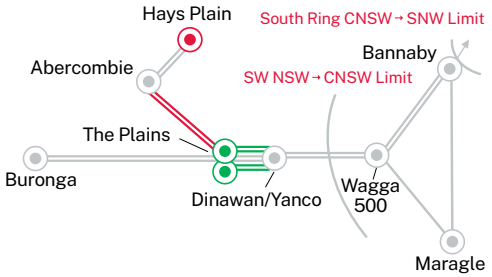
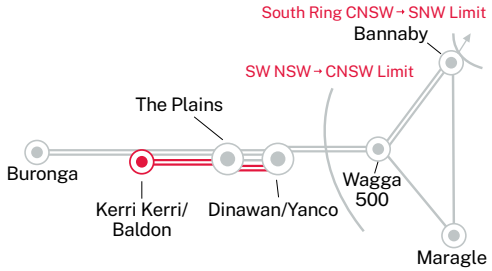
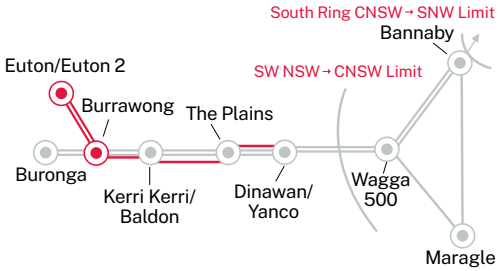
Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 4C	(Pre-requisite: NE REZ Option 2B) • New Hub 6 and Hub 8 330 kV switching station • New 330 kV DCST line from Hub 6 to Hub 8 with Twin Olive conductor • New 330 kV DCST line from Hub 8 to Hub 5 with Twin Olive conductor • New 500 kV DCST and strung on one side SCST line from Hub 5 to Hub 1 with Quad Orange conductor • Augment Hub 5 to accommodate additional lines and 1 x 500/330/33 kV 1,500 MVA transformers		1,400	AEMO TCD	
Option 5A	(Pre-requisite: none) • New Hub 9 switching stations • Establish a new Lower Creek 330/132 kV substation with 1 x 330/132 kV 375 MVA transformer • Rebuild part of Line 965 as 330 kV DCST from Armidale to Lower Creek with Twin Olive conductor • Relocate existing 132 kV 200 MVA phase shift transformer on Line 965 from Armidale to Lower Creek • New 330 kV DCST from Lower Creek to Hub 9 with Twin Mango conductor		800	AEMO TCD	This option would allow up to 900 MW of PHES to connect and the power system to benefit from ancillary services it can provide
Option 5B	(Pre-requisite: NE REZ Option 5A) • New Hub 16 switching station and cuts into existing Line 87 from Armidale to Coffs Harbour • New Hub 19 switching station and cuts into the line from Armidale to Lower Creek • New 330 kV SCST line from Hub 16 to Hub 19 with Twin Mango conductor		300	AEMO TCD	

SW Augmentations

Table 16. Network augmentation options for South-West REZ

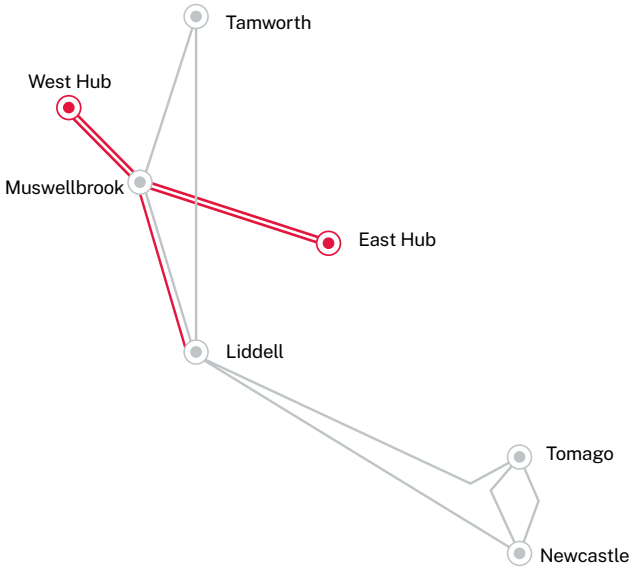
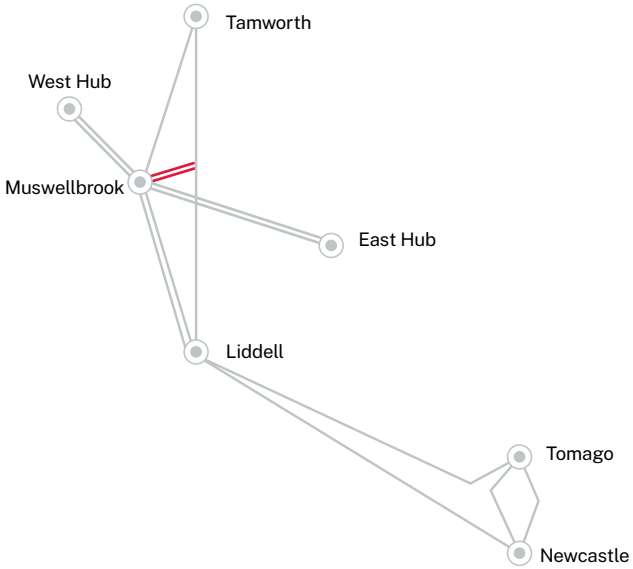
Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 1 (reference scope)	(Pre-requisite: EnergyConnect and HumeLink) • Expand Dinawan 330 kV switching station to 500/330 kV substation with 3 x 500/330/33 kV 1,500 MVA transformers • Operate 500 kV build and 330 kV operated DCST line from Dinawan to Wagga500 to 500 kV		2,500	AEMO TCD	
Option 2	(Pre-requisite: SW REZ Option 1) • New Congaro 330 kV switching station • New 330 kV DCST line from Congaro to Dinawan with Twin Mango conductor		800	AEMO TCD	
Option 3A	(Pre-requisite: SW REZ Option 1) • New Mabin's Well 330 kV switching station • New 330 kV DCST line from Mabin's Well to Dinawan with Twin Olive conductor		1,400	AEMO TCD	

Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 3B	(Pre-requisite: SW REZ Option 3A) • New 330 kV SCST line from Mabins Well to Dinawan with Twin Olive conductor		1,400	AEMO TCD	
Option 4	(Pre-requisite: SW REZ Option 1) • New The Plains 330 kV switching station • New 330 kV DCST line and strung on one side from The Plains to Dinawan with Twin Olive conductor		1,400	AEMO TCD	
Option 5	(Pre-requisite: SW REZ Option 4) • New Phoenix 330 kV switching station • New Wyvern 330 kV switching station • New 330 kV DCST line from Wyvern to Phoenix with Twin Mango conductor • New 330 kV DCST line from Phoenix to The Plain with Twin Olive conductor • String the other side of 330 kV line from The Plain to Dinawan		1,400	AEMO TCD	
Option 6A	(Pre-requisite: SW REZ Option 4) • New Hays Plain 330 kV switching station • New Abercrombie 330 kV switching station • New 330 kV DCST line from Hays Plain to Abercrombie with Twin Mango conductor • New 330 kV DCST line from Abercrombie to The Plain with Twin Olive conductor • String the other side of 330 kV line from The Plain to Dinawan		1,400	AEMO TCD	

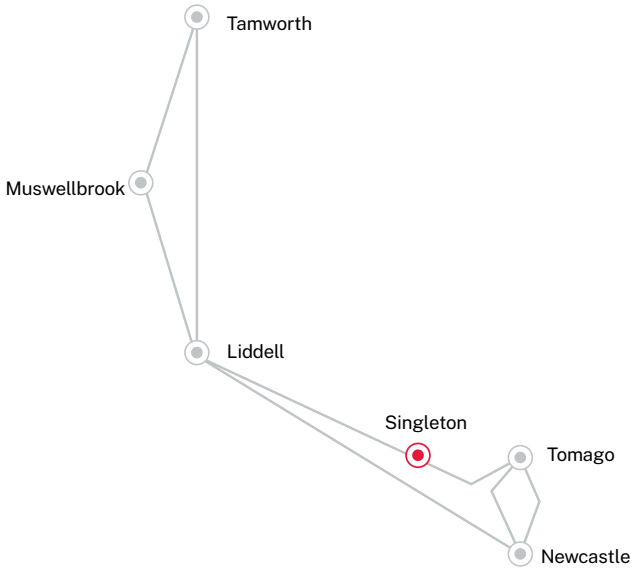
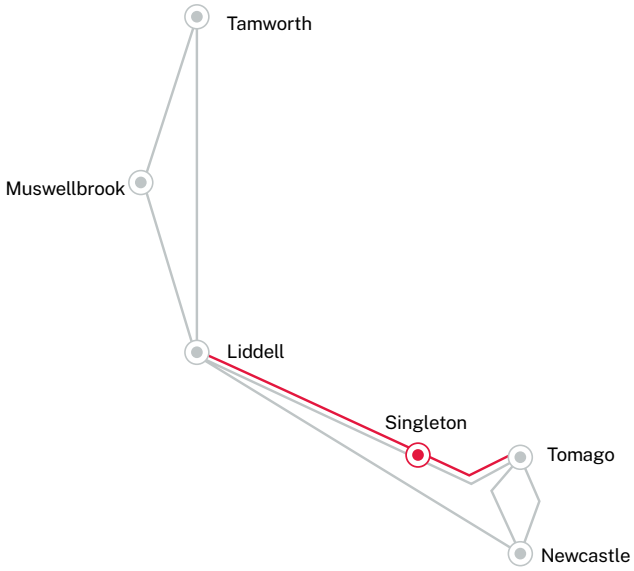
Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 6B	(Pre-requisite: SW REZ Option 6A) • New 330 kV DCST line from Abercrombie to The Plain with Twin Olive conductor • Rebuild 4 x 330 kV lines between The Plain and Dinawan to 500 kV with Quad Orange Conductor • New 4 x 500/330/33kV 1,500 MVA transformers at The Plains		2,800	AEMO TCD	
Option 7A	(Pre-requisite: SW REZ Option 4) • New Kerri Kerri switching station • New 330 kV DCST line from Kerri Kerri to The Plains with Twin Olive conductor • New 330 kV DCST line from The Plains to Dinawan with Twin Olive conductor • 4 x 330 kV 60 MVAr line shunt reactors (in total) are required for 330kV DCST line between Kerri Kerri and The Plains		2,000	AEMO TCD	
Option 7B	(Pre-requisite: SW REZ Option 7A) • New Euston switching station • New Burrawong switching station and cuts into lines between Buronga and Kerri Kerri switching station • New 330 kV DCST line from Euston to Burrawong with Twin Mango conductor • New 330 kV SCST line from Burrawong to Kerri Kerri with Twin Olive conductor • New 330 kV SCST line from Kerri Kerri to The Plain with Twin Olive conductor • New 330 kV SCST line from The Plain to Dinawan with Twin Olive conductor		1,400	AEMO TCD	

HCC Augmentations

Table 17. Network augmentation options for Hunter-Central Coast REZ

Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 1 (reference scope)	(Pre-requisite: None) • Rebuild the existing Line 83 Liddell – Muswellbrook as 330 kV double circuit line with Twin Conductor (17.68 km) • 1 x 330 kV DCST from East Hub to Muswellbrook • 1 x 330 kV DCST from West Hub to Muswellbrook		950[1]	AEMO TCD	This option would allow up to 250 MW of PHES to connect and the power system to benefit from ancillary services it can provide
Option 2	(Pre-requisite: HCC REZ Option 1) • Cut Muswellbrook into parallel Line 84 Liddell – Tamworth (1 x 330 KV DCST around 4 km from Muswellbrook to Line 84)		700[1]	AEMO TCD	

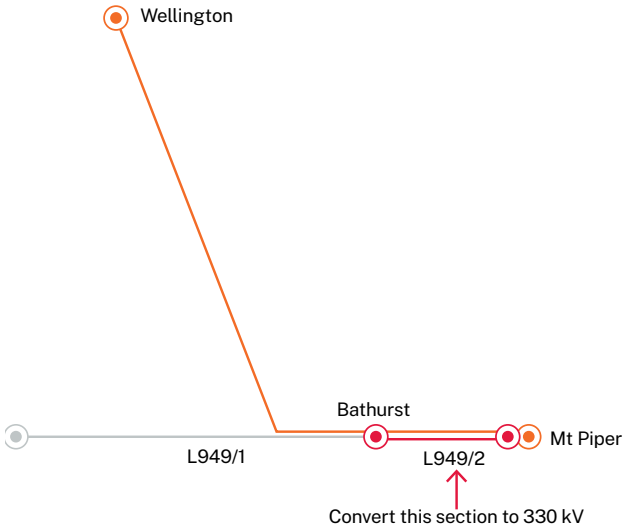
1. Note that the total available downstream capacity for this and CWO REZ combined is approximately 3,000 MW until Hunter Transmission Project is commissioned. The Waratah Super Battery could provide approximately 300 MW additional capacity if paired with new generation near Muswellbrook, before Hunter Transmission Project is commissioned. Post Hunter Transmission Project, the proposed indicative transfer improvement will be achieved.

Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Option 3	(Pre-requisite: None) • New 330 kV Singleton switching station and cuts into line 82 Liddell – Tomago		500[2]	AEMO TCD	
Option 4	(Pre-requisite: HCC REZ Option 3) • Rebuild Line 82 Liddell – Tomago via Singleton as 330 kV double circuit line		800[2]	AEMO TCD	

2. Note that the total available downstream capacity for this, Upper Hunter connection and CWO REZ combined is approximately 3,000 MW until Hunter Transmission Project is commissioned.
Post Hunter Transmission Project, the proposed indicative transfer improvement will be achieve.
Post Hunter Transmission Project+NEREZ, the total downstream capacity for this, Upper Hunter connection, CWO REZ and NE REZ combined is approximately 7,400 MW.

Shared Network Augmentations to Leverage System Benefits from Long Duration Storage

Table 18. Network augmentation options that could leverage system benefits from long duration storage

Option	Descriptions	Network Configuration Diagrams	Additional network capacity (MW)	Estimate source	Notes
Pumped hydro near Bathurst	• Establish a new Bathurst 330/132 kV substation with 1 x 330/132 kV 375 MVA transformer • Works at the Mt Piper and Bathurst ends of L949/2 to convert it to 330 kV operation		325	AEMO TCD	This option would allow up to 325 MW of PHES to connect and the power system to benefit from ancillary services it can provide

Downstream Augmentations

CNSW – NNSW

Table 19. Improvements to the CNSW – NNSW cut set are encompassed by the augmentations within the NE REZ

	Transfer Increase NNSW - CNSW (MW)	Transfer Increase NNSW – SNW
Option 1	3,000	-
Option 2A	-	3,000
Option 2B	3,000	-
Option 2C	500	3,000
Option 2D	3,500	-

CNSW – SNW

Table 20. Downstream network augmentations that impact the CNSW – SNW flow path

Development path	Development driver	Option name	Augmentation description	Forward direction power flow	Notional transfer level increase (MW)[3]		Cost estimate source
					Forward direction	Reverse direction	
Northern side of Sydney	Retirement of coal-powered generation in New South Wales	CNSW-SNW Option 1 From IASR 2022	SNW Northern 500 kV loop: • A new 500 kV double circuit line between Eraring and Bayswater substations • Two 500/330 kV 1,500 MVA transformers either at Eraring substation or new substation near Eraring	CNSW to SNW	5,000[4]	NA	AEMO (TCD)
Northern side of Sydney	CWO REZ Development	CNSW-SNW Option 4	(Pre-requisite: CNSW-SNW Option 1) • A new 500 kV Wollar South substation • Divert 3 lines from Merotherie to Wollar, to Wollar South • A new 500 kV double circuit line between Wollar South and Eraring substation with Quad Orange conductor • Two 500/330 kV 1,500 MVA transformers either at Kemps Creek • 1 x 330 kV SCST line between Vales Pt and Eraring • 1 x 330 kV SCST line between Vales Pt and Munmorah • Thermal upgrade for Line 24 Vales Pt – Eraring and 92 Newcastle – Vales Point • 1 x 330 kV SCST line between Liddell – Newcastle • 1 x 330 kV SCST line between Eraring – Newcastle	CNSW to SNW	6,000	N/A	AEMO (TCD)

3. Same increase applies to all transfer limit conditions (Peak demand, Summer typical and Winter reference).
4. This capacity increase for accommodation of additional new generation from North of Bayswater and 2/3 generation from Central West NSW accommodation of additional new generation from North of Bayswater and 2/3 generation from Central West NSW.

Development path	Development driver	Option name	Augmentation description	Forward direction power flow	Notional transfer level increase (MW)[3]		Cost estimate source
					Forward direction	Reverse direction	
Northern side of Sydney	Retirement of coal-powered generation in New South Wales + NE REZ + CWO REZ development	CNSW-SNW Option 6	(Pre-requisite: CNSW-SNW Option 1) • A new 500 kV double circuit line between substation near Eraring and Bayswater substation. • Two 500/330 kV 1,500 MVA transformers either at Eraring substation or new substation near Eraring • Two 500/330 kV 1,500 MVA transformers either at Kemps Creek • 1 x 330 kV SCST line between Vales Pt and Eraring • 1 x 330 kV SCST line between Vales Pt and Munmorah • Thermal upgrade for Line 24 Vales Pt – Eraring and 92 Newcastle – Vales Point • 1 x 330 kV SCST line between Liddell – Newcastle • 1 x 330 kV SCST line between Eraring – Newcastle	CNSW to SNW	6,000	NA	AEMO (TCD)
Southern side of Sydney	Retirement of coal-powered generation in New South Wales.	CNSW-SNW Option 2 From IASR 2022	SNW Southern 500 kV loop: • A new 500 kV double circuit line from the Bannaby substation to a new Overhead/Underground Transition site • 8 km of tunnel installed underground 500 kV cables from Transition site to new substation in the locality of South Creek • Establish 500/330 kV substation in the locality of South Creek • Cut-in both Eraring - Kemps Creek 500 kV circuits at the new substation in the locality of South Creek • Two new 500/330 kV 1,500 MVA transformers at the new substation in the locality of South Creek • Replace a section of existing Bannaby-Sydney West 330 kV to double circuit line between the locality of South Creek and Sydney West • Uprate the existing line between Bannaby and the locality of South Creek from 85 degrees to 100 degrees operating temperature • Cut-in Bayswater - Sydney West 330 kV line at South Creek • Cut-in Regentville - Sydney West 330 kV line at South Creek	CNSW to SNW	4,500 (This capacity increase for accommodation of additional new generation from South of Bannaby and 1/3 generation from Central West NSW)	NA	AEMO (TCD)

3. Same increase applies to all transfer limit conditions (Peak demand, Summer typical and Winter reference).

Development path	Development driver	Option name	Augmentation description	Forward direction power flow	Notional transfer level increase (MW)[3]		Cost estimate source
					Forward direction	Reverse direction	
Northern and Southern sides of Sydney	Retirement of coal-powered generation in New South Wales	CNSW-SNW Option 3	Both SNW Northern 500 kV loop and SNW Southern 500 kV loop: • CNSW-SNW Option 1 • CNSW-SNW Option 2	CNSW to SNW	5,600 (No restriction to generation dispatch from north, south and west of SNW)	NA	AEMO (TCD)
Southern side of Sydney	SW REZ Development	CNSW-SNW Option 5B	(Pre-requisite: CNSW-SNW Option 2) • A new 500 kV DCST from the Bannaby substation to the substation in the locality of South Creek • Expand Kemps Creek substation with 4 additional 500/330 kV transformers • A new 500 kV DCST from the South Creek substation to Kemps Creek • A new 330 kV DCST between Kemps Creek and Sydney South • A new 330 kV DCST between Kemps Creek and Sydney North • A new 330 kV DCST between South Creek and Sydney West	CNSW to SNW	6,000	NA	AEMO (TCD)
Bayswater to Newcastle	Hydrogen scenario – To provide access to port near Newcastle.	H-Newcastle From IASR 2022 (This is not an alternative option to supply SNW)	• Three new 500 kV lines from Bayswater to Newcastle • Four new 500/330 kV transformers at Newcastle • Line shunt reactors at each of the new 500 kV lines	CNSW to SNW	5000	5000	AEMO (TCD)
Bannaby to Dapto	Hydrogen scenario – To provide access to port near Dapto.	H-Dapto From IASR 2022 (This is not an alternative option to supply SNW)	• Three new 500 kV lines from Bannaby to Dapto • Four new 500/330 kV transformers at Dapto • Line shunt reactors at each of the new 500 kV lines	CNSW to SNW	5000	5000	AEMO (TCD)

3. Same increase applies to all transfer limit conditions (Peak demand, Summer typical and Winter reference).

SNSW – SNW

Table 21. Downstream network augmentations that impact the CNSW – SNW flow path

Development path	Development driver	Option name	Augmentation description	Forward direction power flow	Notional transfer level increase (MW)[3]		Cost estimate source
					Forward direction	Reverse direction	
HumeLink	To provide access to generation in southern NSW to load centres in SNW	SNSW-CNSW Option 1 (HumeLink) From IASR 2022	• New Wagga Wagga 500/330 kV substation and 330 kV double circuit • Connection to the existing Wagga Wagga 330 kV substation • Three new 500 kV transmission lines: – Between Maragle and Bannaby 500 kV substations; – Between Maragle and new Wagga Wagga 500 kV substations; and – Between new Wagga Wagga and Bannaby 500 kV substations • Three 500/330 kV 1,500 MVA transformers at Maragle • Two 500/330 kV 1,500 MVA transformers at new Wagga Wagga • 500 kV Line shunt reactors at the ends of Maragle – Bannaby, Maragle – new Wagga Wagga and new Wagga Wagga – Bannaby 500 kV lines	SNSW to CNSW	2,200	2,200	Transgrid

3. Same increase applies to all transfer limit conditions (Peak demand, Summer typical and Winter reference).

Development path	Development driver	Option name	Augmentation description	Forward direction power flow	Notional transfer level increase (MW)[3]		Cost estimate source
					Forward direction	Reverse direction	
Wagga Wagga to Bannaby	Increased import from Victoria and South Australia with high generation in southern NSW	SNSW-CNSW Option 2 From IASR 2022	(Pre-requisite: HumeLink) • An additional new 500 kV line from Wagga Wagga to Bannaby	SNSW to CNSW	2,000	2,000	AEMO (TCD)
		SNSW-CNSW Option 4A	(Pre-requisite: HumeLink) • An additional new 500 kV DCST line from Dinawan to Wagga Wagga • An additional new 500 kV DCST line from Wagga Wagga to Bannaby • 4 additional new 500/330/33 kV 1500 MVA transformers at Dinawan	SNSW to CNSW	6,000	6,000	AEMO (TCD)
		SNSW-CNSW Option 4B	(Pre-requisite: HumeLink) • An additional new 500 kV SCST line from Dinawan to Wagga • An additional new 500 kV SCST line from Wagga Wagga to Bannaby • 2 additional new 500/330/33 kV 1500 MVA transformers at Dinawan	SNSW to CNSW	3,000	3,000	AEMO (TCD)
		SNSW-CNSW Option 3 From IASR 2022	HVDC between Wagga Wagga and Bannaby: • A 2,000 MW bi-pole overhead transmission line from locality of Bannaby to locality of Wagga Wagga • A new 2,000 MW bipole converter station in locality of Bannaby • A new 2,000 MW bipole converter station in locality of Wagga Wagga • AC network connection between new HVDC converter station in the locality of Bannaby and the existing Bannaby 500 kV substation • AC network connection between HVDC converter station in the locality of Wagga Wagga and a future Wagga Wagga 500 kV substation (Assumption: This option comes after HumeLink)	SNSW to CNSW	2,000	2,000	AEMO (TCD)

3. Same increase applies to all transfer limit conditions (Peak demand, Summer typical and Winter reference).

Appendix E: Roles and Responsibilities

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Image courtesy of iStock. Family spending time together at farm.

NSW Framework entities

Minister

The Minister has functions under the EII Act. For example, the Minister must appoint certain Roadmap entities declares particular REZs and may declare an access schemes for projects to connect to REZs. In addition, the Minister may take steps to ensure reliability of supply for consumers if advised that a breach in the NSW Energy Security Target is likely within the next 10 years. The Minister may direct a Network Operator to construct a REZ network infrastructure project (RNIP) if a recommendation has been made by the Consumer Trustee.

EnergyCo

Energy Corporation of NSW (EnergyCo) undertakes strategic, holistic planning for REZs throughout NSW in a way that seeks to minimise impacts on and maximise opportunities for local communities, industries, and workers. This is supported by its lead role in community and local stakeholder engagement activities for delivering REZs, including on-the-ground coordination of infrastructure projects.

As the appointed Infrastructure Planner, EnergyCo performs technical network design for REZs in consultation with the Australian Energy Market Operator (AEMO), Transgrid as the NSW. Jurisdictional Planning Body, NSW DNSPs and market participants. EnergyCo, in its role as Infrastructure Planner for a REZ, must recommend options for RNIPs to the Consumer Trustee to authorise a network operator.

The network design for an individual REZ concludes by EnergyCo, in its role as Infrastructure Planner for a REZ, recommending individual RNIPs to the Consumer Trustee for authorisation.

Infrastructure Planner

The Infrastructure Planner is responsible for assessing and making recommendations to the Consumer Trustee on the scope and recommended delivery path for network infrastructure projects required to deliver the Roadmap objectives. This includes both RNIPs and Priority Transmission Infrastructure Projects (PTIPs).

Under the EII Act, EnergyCo has been appointed as the Infrastructure Planner for the five REZs listed in the legislation. In the future, EnergyCo, or another entity, may be appointed as Infrastructure Planner for a new REZ, part of a REZ, or a PTIP.

Consumer Trustee (AEMO Services Limited)

AEMO Services Limited, a subsidiary of AEMO, has been appointed as the Consumer Trustee. The Consumer Trustee acts independently to protect the long-term financial interests of NSW energy consumers.

The Consumer Trustee is required to prepare the IIO Report every two years to set out the 20-year Development Pathway for generation and long duration storage infrastructure in NSW to achieve the infrastructure investment objectives.

To give effect to the Development Pathway, the Consumer Trustee prepares a 10-Year Plan for conducting competitive tenders for Long-term Energy Service (LTES) Agreements and runs the associated tenders for generation, long-duration storage and, if directed, firming infrastructure.

In addition, the Consumer Trustee is responsible for authorising network operators to carry out RNIPs and setting a maximum amount for the prudent, efficient, and reasonable capital costs that can be recovered from consumers for the project.

Network Operator(s)

A Network Operator will develop, build, own (or lease), and finance new RNIPs authorised by the Consumer Trustee, or RNIPs and PTIPs authorised or directed (as relevant) by the Minister. A Network Operator will be nominated on a project-by-project basis. The incumbent transmission or DNSP will not automatically have the exclusive right to develop, own and operate RNIPs or PTIPs.

Regulator

Once a Network Operator is authorised by the Consumer Trustee, or appointed by the Minister, the Regulator makes a revenue determination regarding the amount payable to them by NSW consumers. Before making the determination, the Regulator is required to undertake a Transmission Efficiency Test (also known as the TET) to assess the prudent, efficient, and reasonable capital costs for the development and construction of a network infrastructure project. The Australian Energy Regulator (AER) has been appointed as the Regulator in NSW.

Energy Security Target Monitor

AEMO has been appointed the NSW Energy Security Target Monitor. It is responsible for preparing an annual report to advise the Minister on whether there is sufficient firm capacity to meet the NSW Energy Security Target over the next 10 years.

A forecast breach in the target is the trigger for the Minister to consider directing the Consumer Trustee to conduct a tender round for firming infrastructure or authorise or direct a Network Operator to carry out a PTIP. The Consumer Trustee is not required to authorise a PTIP. The Regulator is required to undertake a TET for a PTIP.

Annual reports from the NSW Energy Security Target Monitor are an input into the Development Pathway and support system planning for reliable electricity supply in NSW.

Image courtesy of iStock. Sunrise over solar farm.

National Framework entities

Transgrid

Transgrid retains its obligations and responsibilities as the Jurisdictional Planning Body for NSW. This includes the operation, management, and planning of NSW's existing high-voltage transmission network under the National Framework. The integrated nature of the REZs within the existing transmission network, and their impact on system operability, means that careful interfacing and coordination is required between EnergyCo, Transgrid, AEMO and future Network Operators.

Joint planning with Transgrid will be an essential, ongoing process that will ensure that the stability of the power system is maintained throughout this transformational period. Transgrid retains its responsibilities under the National Framework for procuring system strength, inertia, and other ancillary system services as required by AEMO. In certain instances, there may be an overlap between Transgrid and EnergyCo in the delivery of particular network services (e.g., system strength). EnergyCo may include scope for certain network services within, and explicitly for, a given RNIP, however this will not be incongruous with any network services plans that Transgrid would develop.

Transgrid publishes their TAPR outlining the works planned and in progress across NSW's existing network under the national regulatory framework. EnergyCo will coordinate the works delivered under the Roadmap that go beyond the existing network and are outside of the National Framework.

Australian Energy Market Operator (AEMO)

AEMO retains its obligations and responsibilities as the National Transmission Planner and market operator for the NEM. This includes market operation, network, and system security planning in NSW, in accordance with the National Electricity Rules.

Similarly, close joint planning with AEMO will be required in planning the future of the NSW transmission network, as REZ development will have significant impact on the operability of the grid. AEMO publishes their ISP at least every two years, outlining the works planned and in progress across the NEM under the National Framework. EnergyCo will coordinate works delivered under the Roadmap with those identified in the ISP, ensuring the network infrastructure projects are delivered under the right framework. In particular, the NIS will consider issues such as community sentiment, land-use planning, workforce availability and supply chain constraints, which are likely to be useful inputs for aligned outcomes for future ISPs.

NSW GOVERNMENT