15 November 2024

2024 Transmission Network Forum

#PQForum

Powerlink acknowledges the Traditional Owners and their custodianship of the lands and waters of Queensland and in particular the lands on which we operate.

We pay our respect to their Ancestors, Elders and knowledge holders and recognise their deep history and ongoing connection to Country.

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Agenda

State of the Network with Paul Simshauser, Chief Executive

AEMO Update with Merryn York, Executive General Manager System Design

Q&A with Paul and Merryn

BREAK

Decarbonising Central Queensland with Daniel Andersen, General Manager Energy Markets

Panel moderated by Jacqui Bridge, Executive General Manager Energy Futures

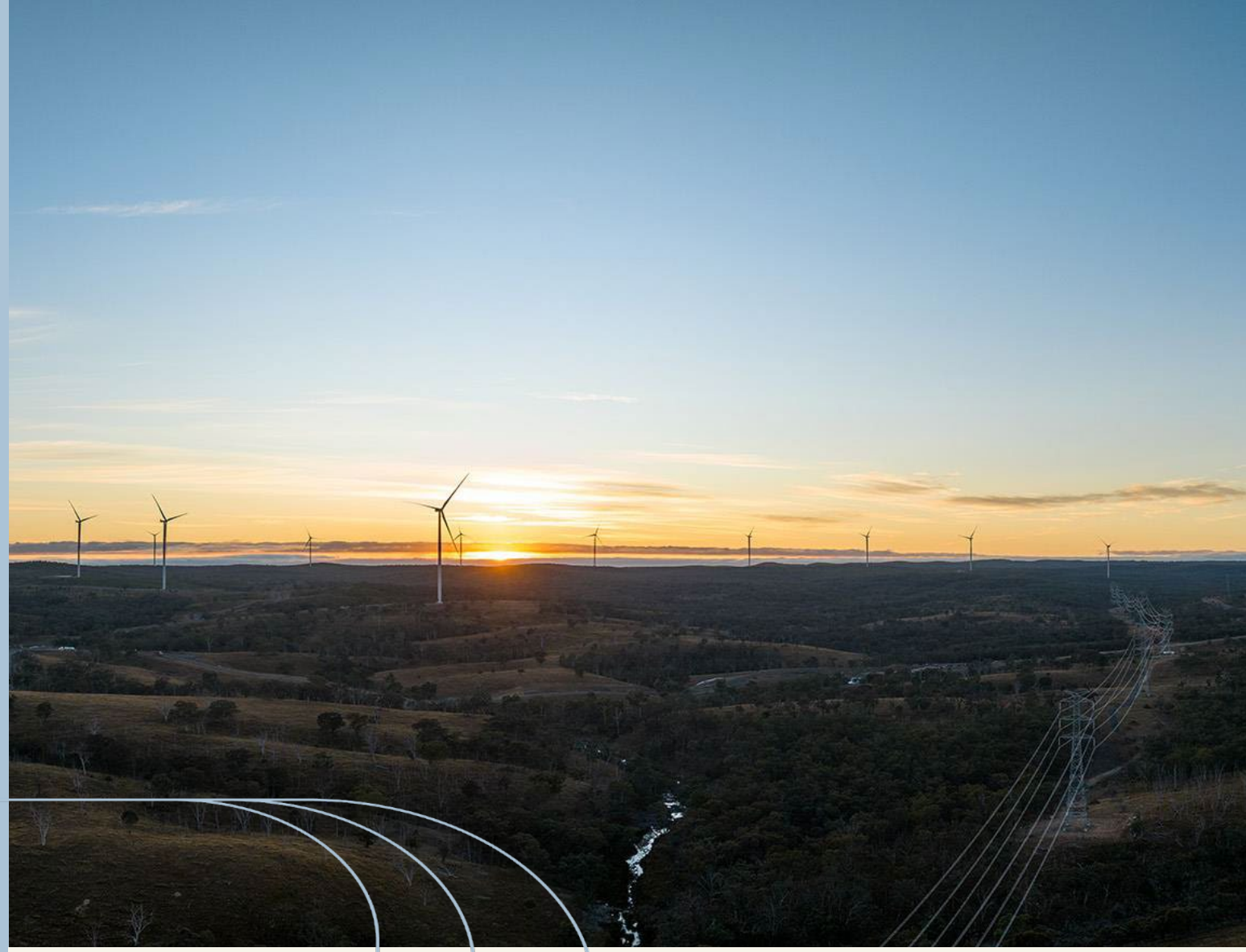
Interactive session

BREAK

Transmission Annual Planning Report update with Stewart Bell, Executive General Manager Network and Business Development, followed by Q&A

2024 Transmission Network Forum

State of the Network



Paul Simshauser
Chief Executive
Powerlink Queensland

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State of the Network

- **Stages of the energy transition**
- Investment outlook
- Stakeholder and community insights
- Responding to the market
- Renewable Energy Zones
- Minimum system load
- Innovation

First stage of the energy transition

2020 → **2024**

- Policy foundation (Net Zero)
- Led by capital markets and households
- Renewables dominate entry
- Proximity to existing infrastructure
- Resilient networks - operated well
- Battery economics improving

Entering the second stage of the energy transition

2025

2029

- Policy settings
- Investment clarity
- Approval processes
- Innovation to manage cost pressures
- Best practice community engagement
- Importance of storage
  *Negative prices

State of the Network

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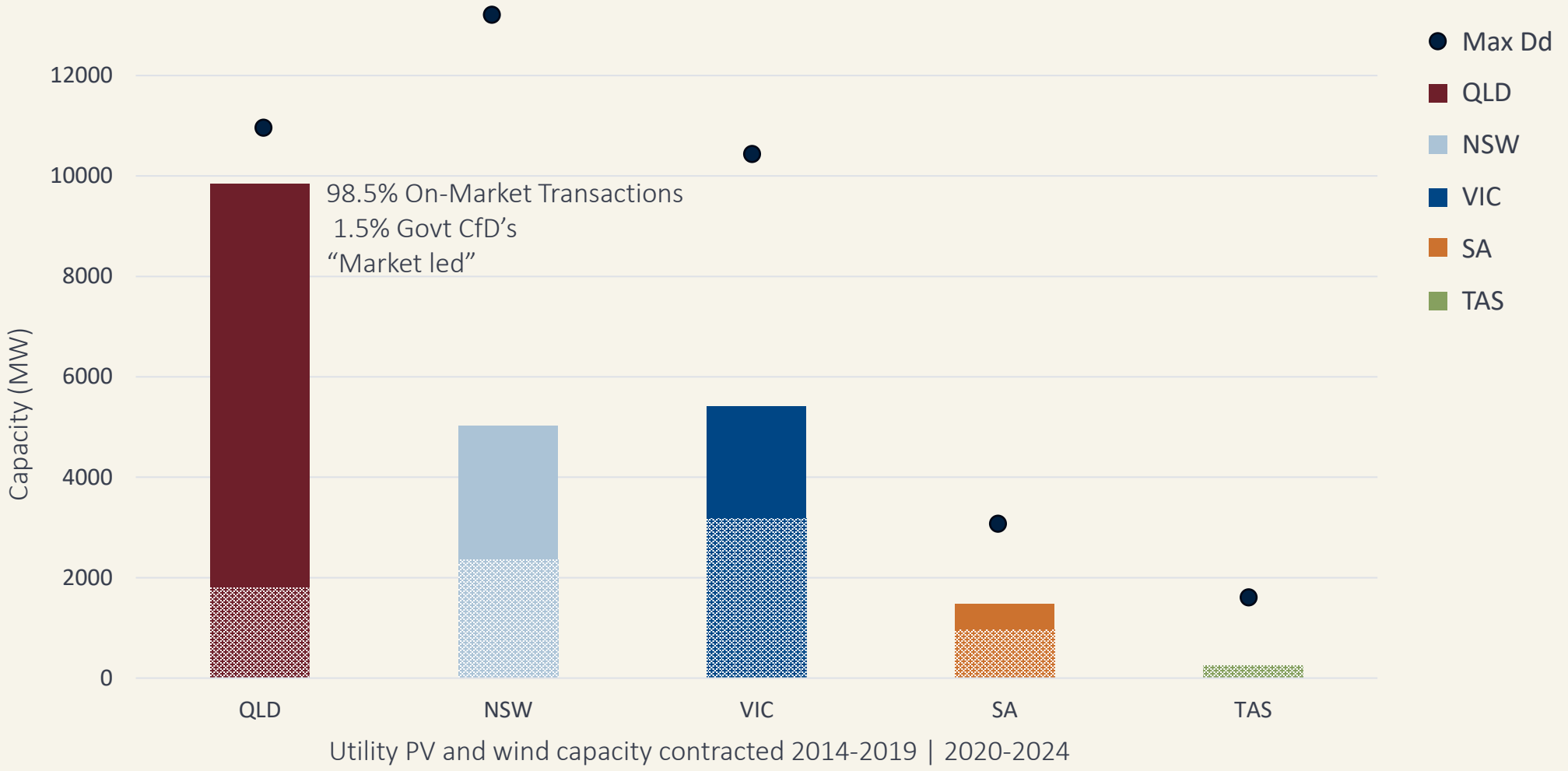
I + PS = MW*

Market led Investment + Policy Settings = MW*

*Subject to community, innovation, prices

Market led



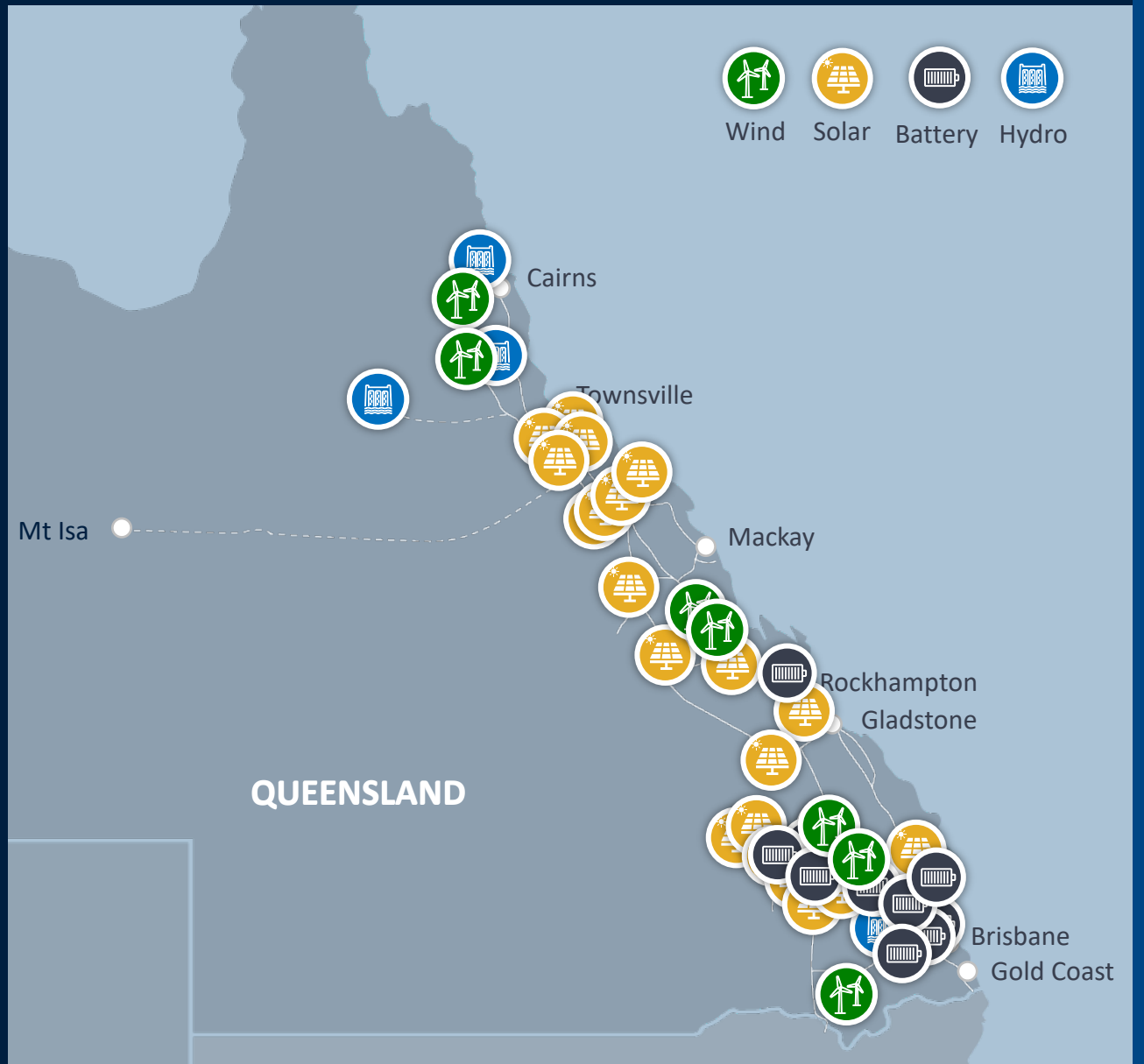
Source: Rystad Energy Research and Analysis

Queensland connections

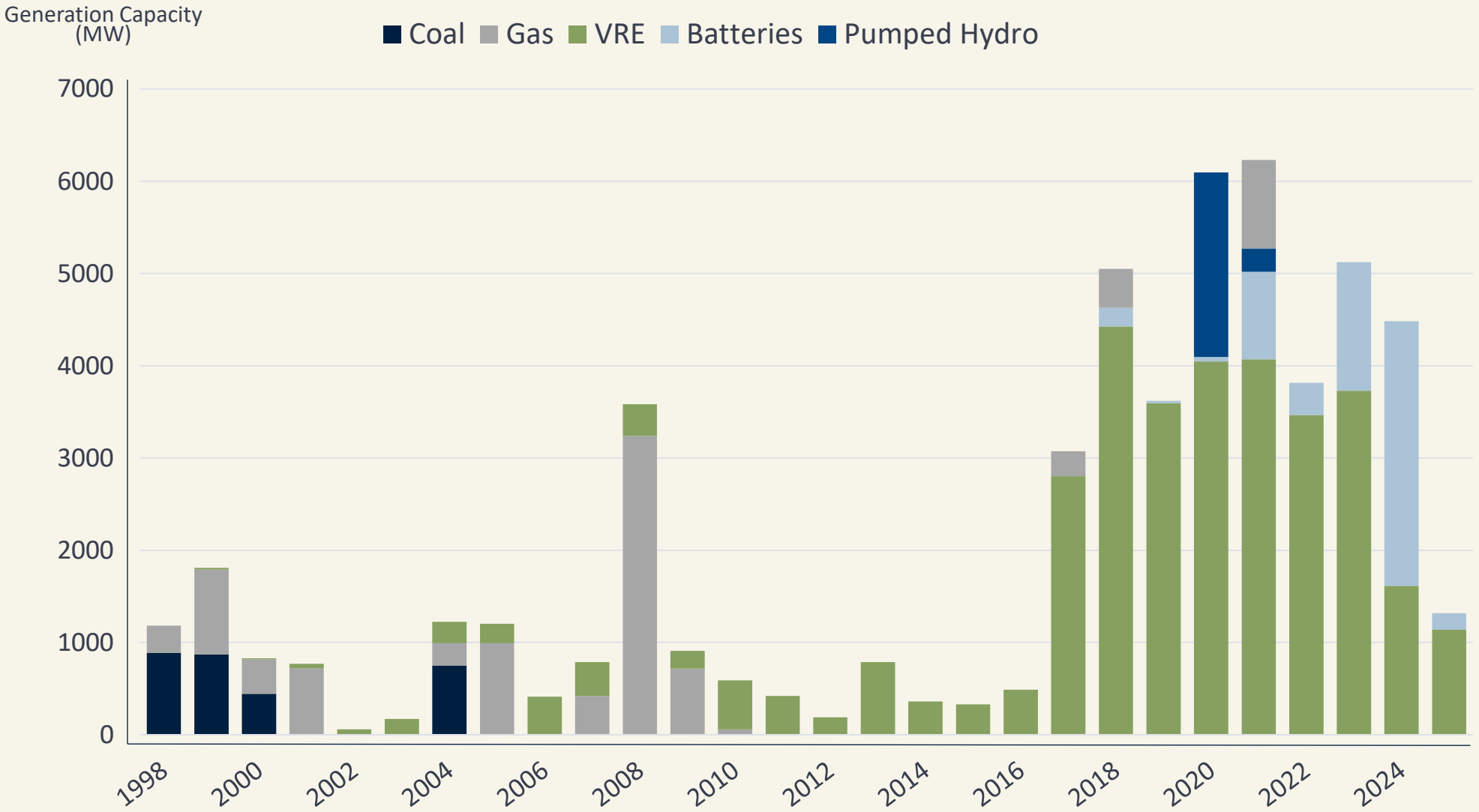
44 renewable and storage projects operational or under construction with combined maximum output of 8,950MW

As at October 2024, 71 renewable applications being processed representing ~29,381MW

Projects at the enquiry stage (including early engagements) with combined max output of ~103GW



NEM investment commitments 1998-2024



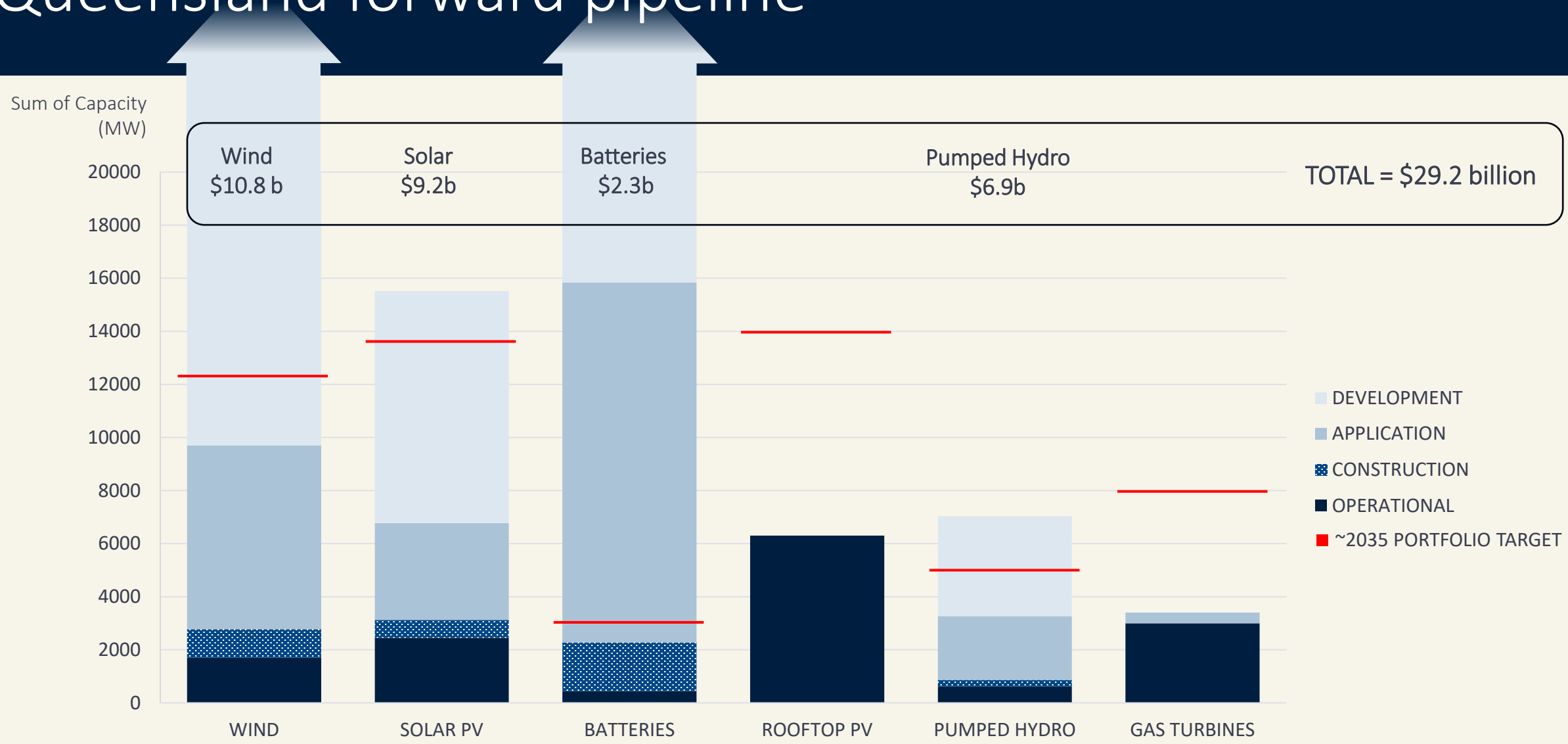
2016-2024
- 223 projects
- 35.4 GW
- $83.1 billion

Wind
- 56 projects
- 11.3GW
- $30 billion

Solar
- 111 projects
- 14.1 GW
- $24.8 bn

Batteries
- 41 projects
- 6 GW
- $9.9 bn

Queensland forward pipeline



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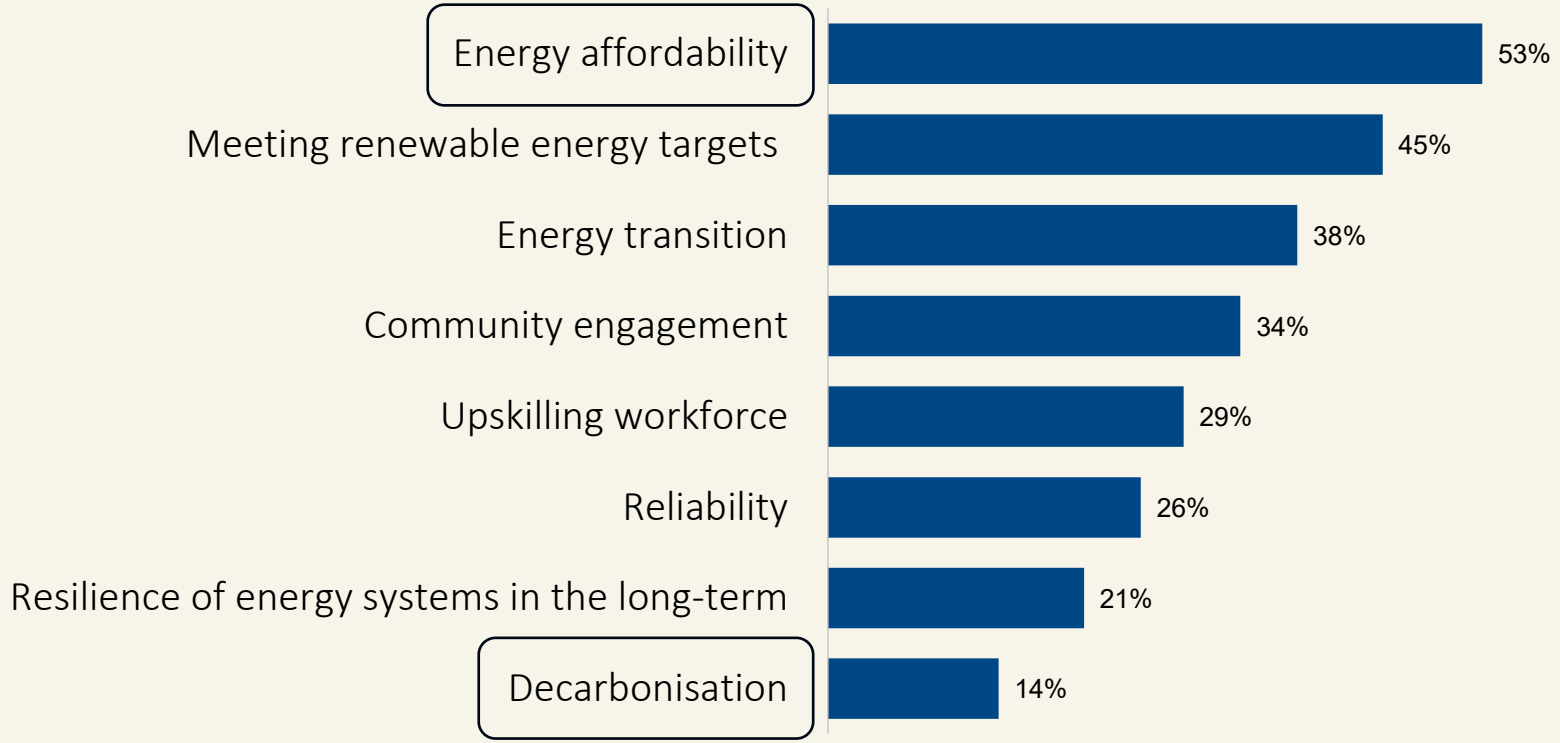
Stakeholder perception research - Key themes

Stakeholders identified many key themes in the industry that they expected Powerlink to play a role in addressing.

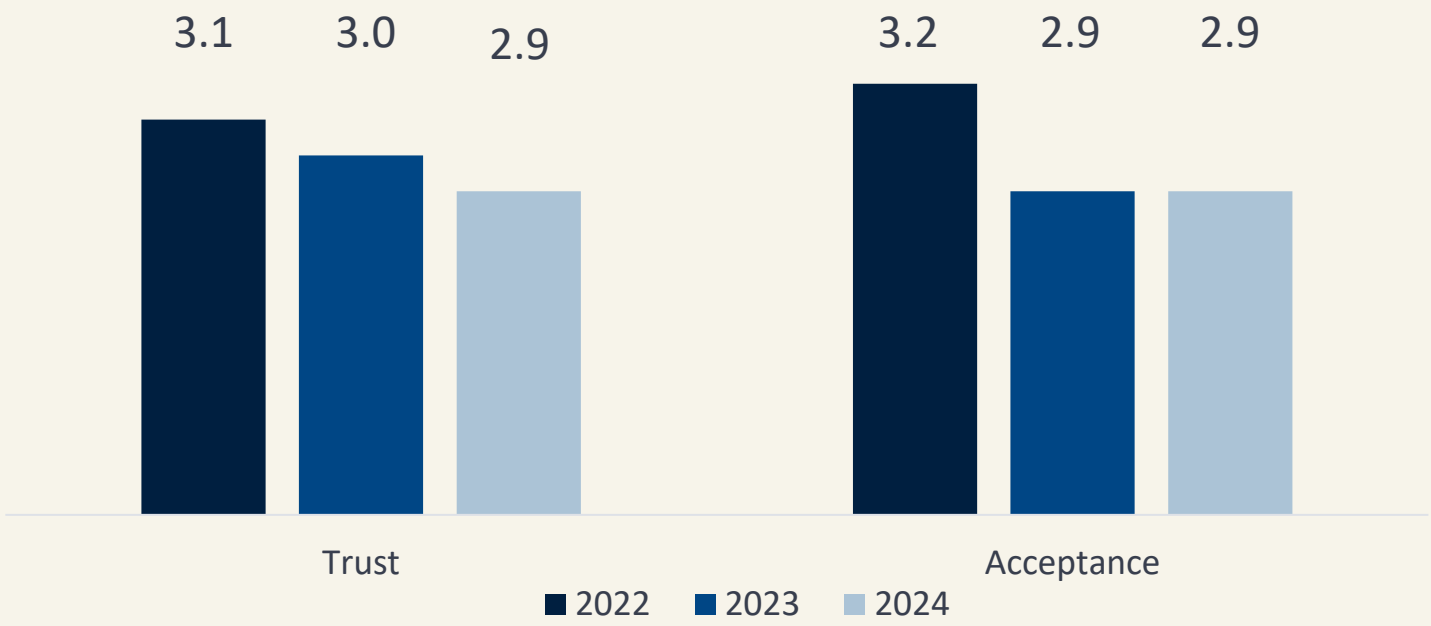
Stakeholder perception research - Key themes

Thinking about the next 5 years, which of the following issues do you think will present the biggest challenge to the energy industry?

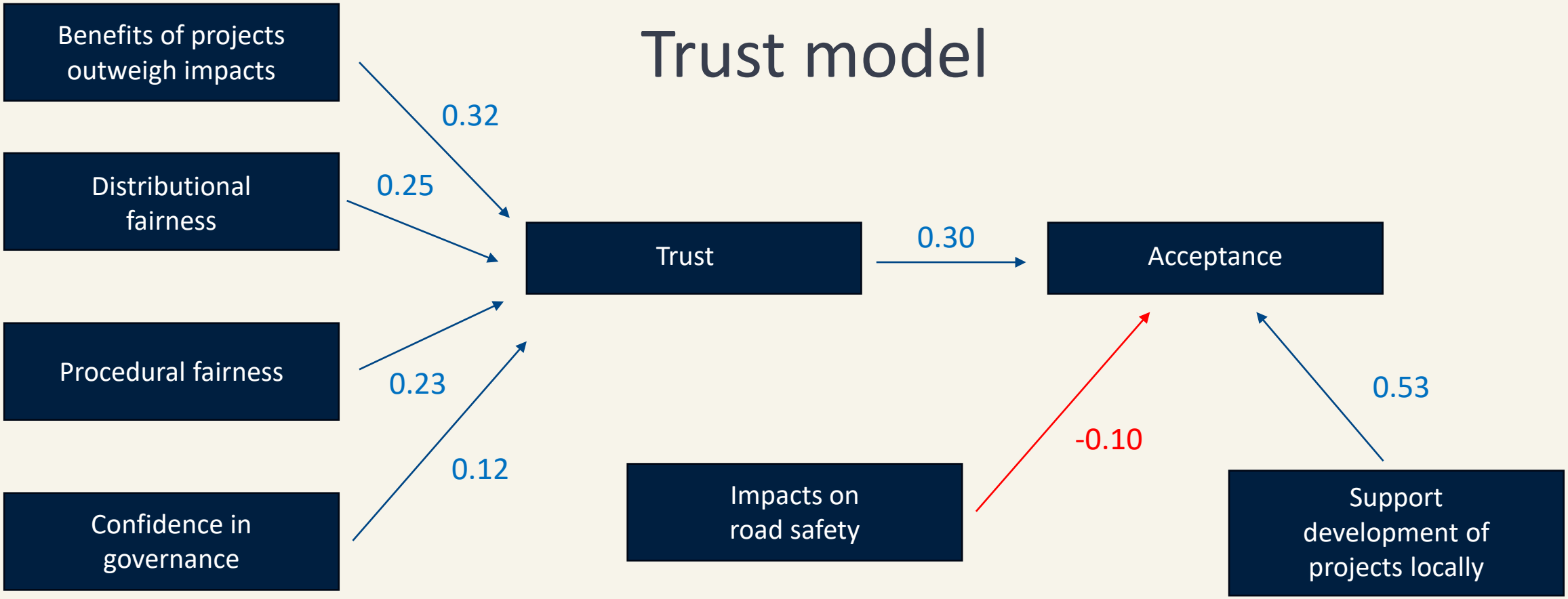


Voconiq community insights research

Community trust and acceptance has slightly reduced overall – but larger variations at individual LGA level



Trust, local community and clean energy



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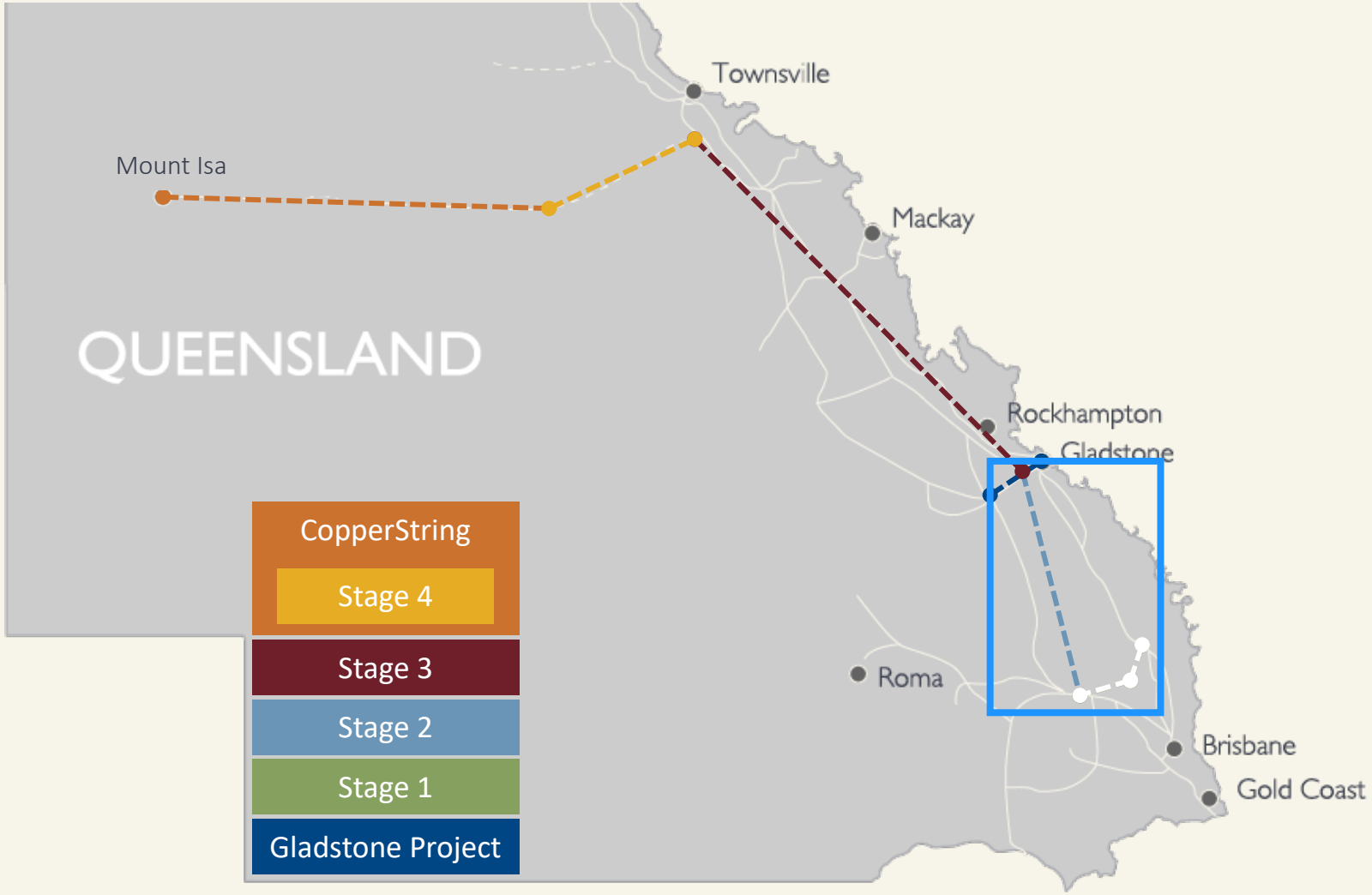
Queensland transmission backbone – September 2022

Queensland transmission backbone – November 2024



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Renewable Energy Zones

Renewable Energy Zones – In-flight

- Far North Queensland (energised)
- Southern Downs (energised)
- Western Downs (energised*)

Renewable Energy Zones - Planning

- Callide REZ
- Calliope REZ
- Darling Downs REZ

Renewable Energy Zones

	FAR NORTH QUEENSLAND	SOUTHERN DOWNS	WESTERN DOWNS
Network capacity	~500MW	~ 2,000MW	~1,800MW
Contracted capacity	152MW	890MW	500MW
Application date	September 2019	December 2020	January 2021
Energisation date	October 2022	December 2023	November 2024
Cycle time	3.2 years	3.0 years	3.7 years

Renewable Energy Zone (REZ) developer insights

Overall positive sentiment towards Queensland REZ approach

Support for market led REZ model

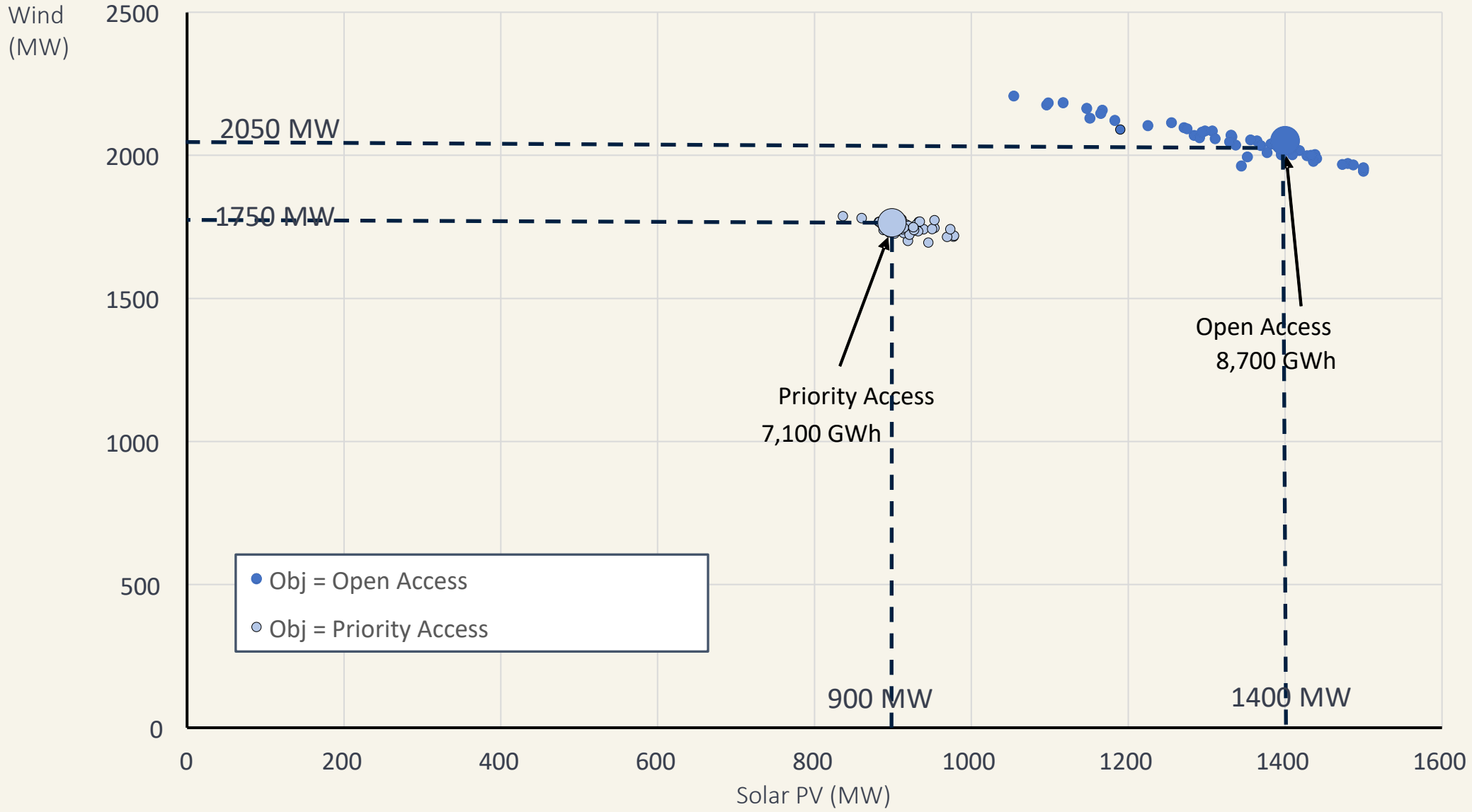
Conditional support for planned curtailment

Unanimous support for early community engagement

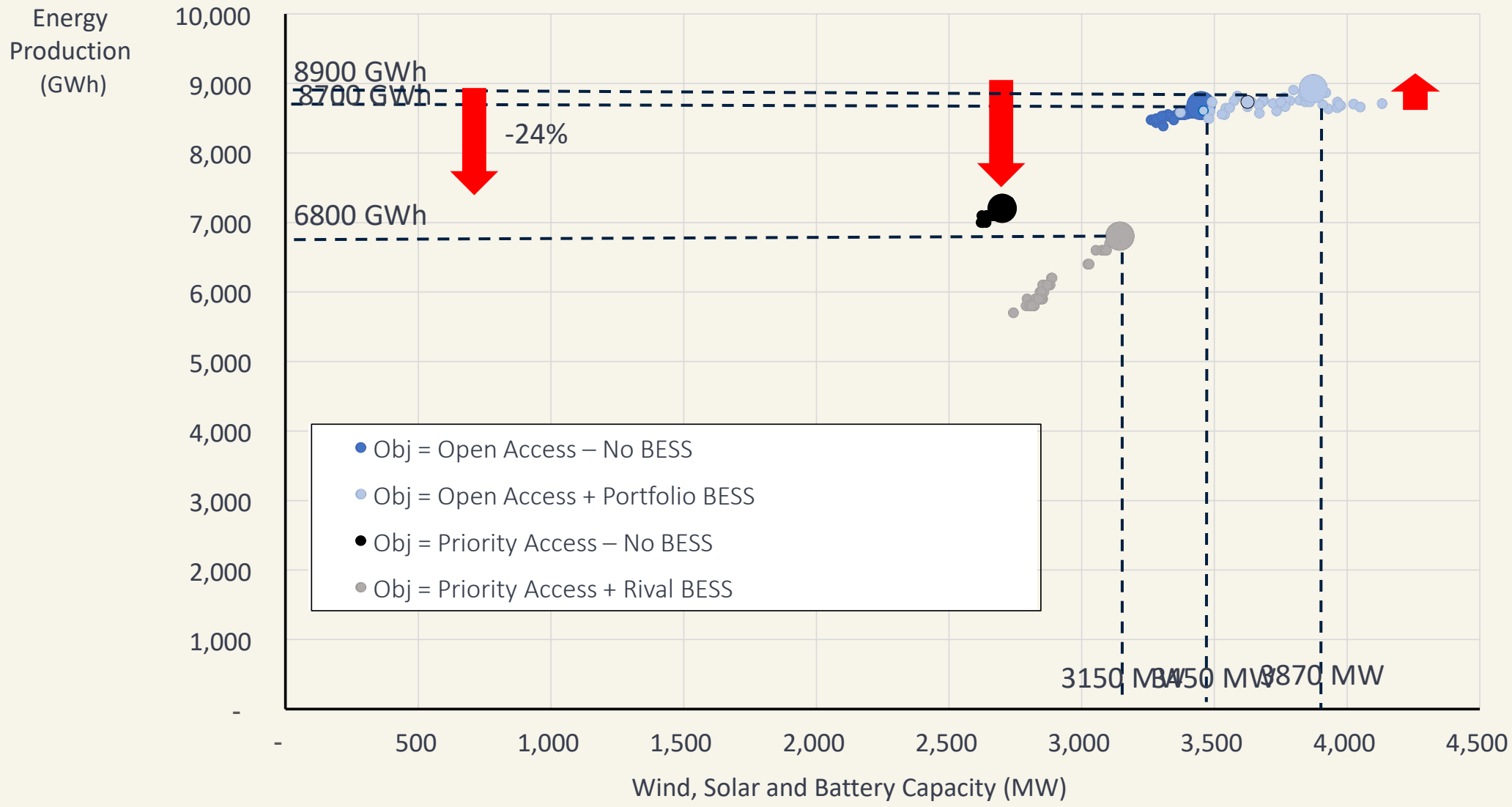
Conditional support for near-term wind bias

More information and clarity needed on key REZ aspects

REZ Open Access v Priority Access (275kV REZ)



REZ Access: Impact of Batteries (275kV REZ)



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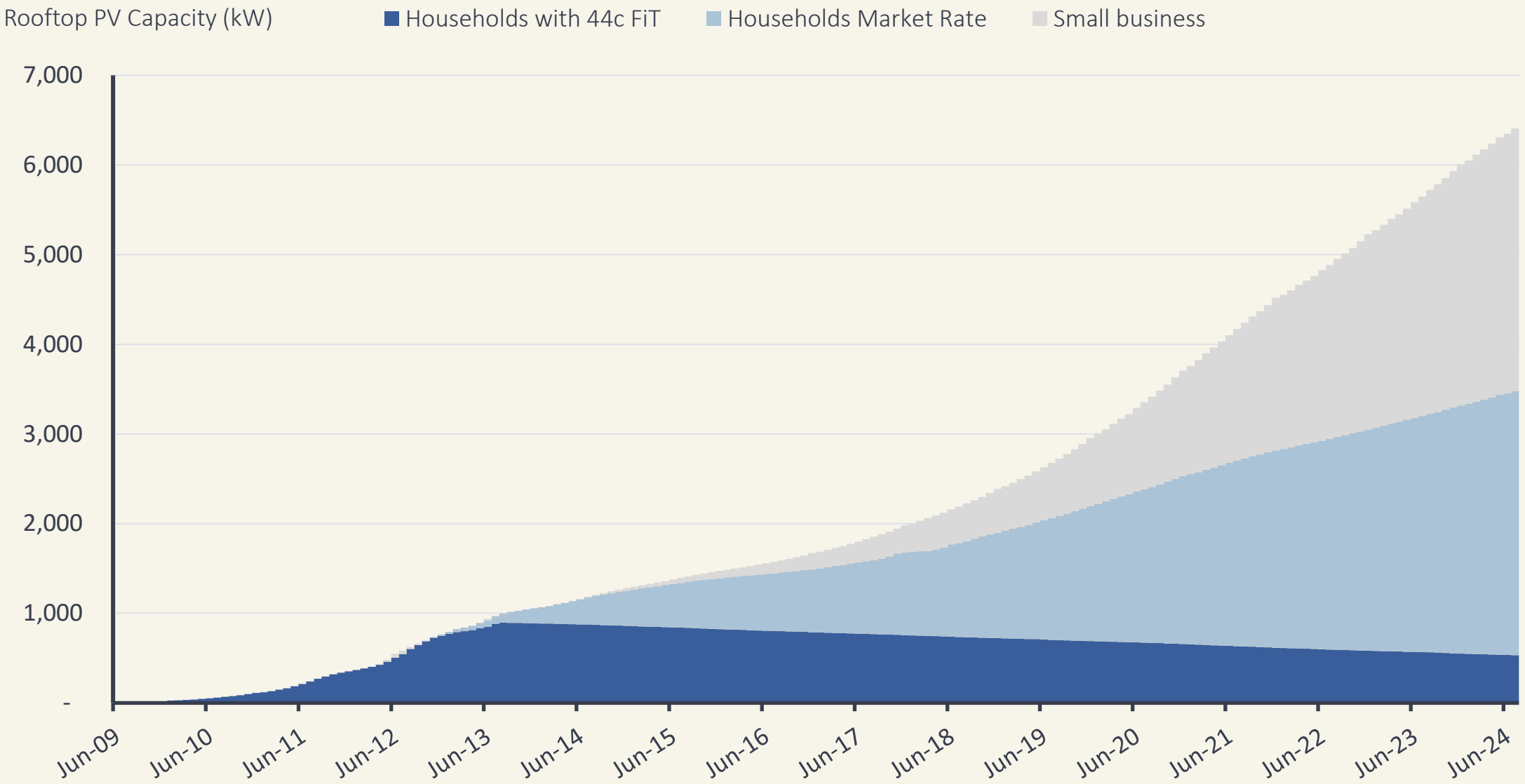
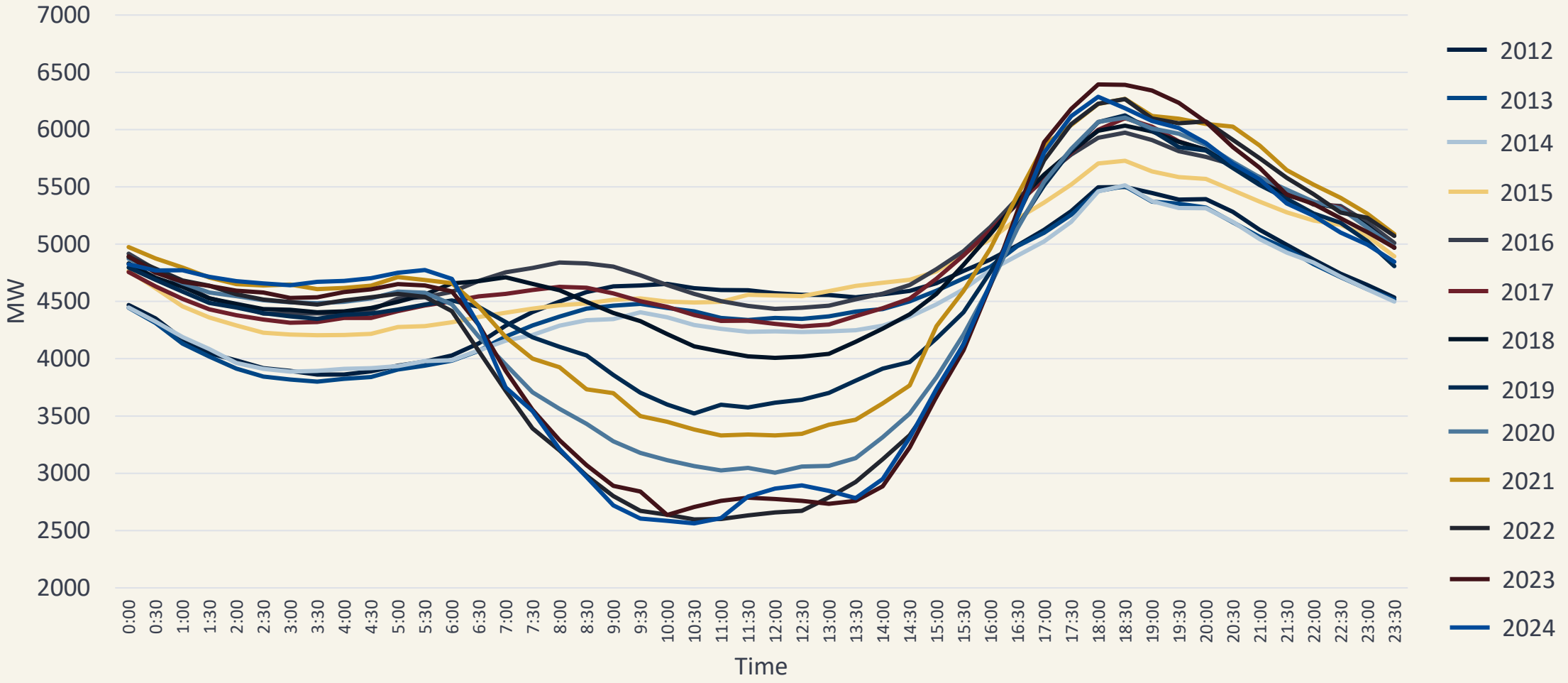
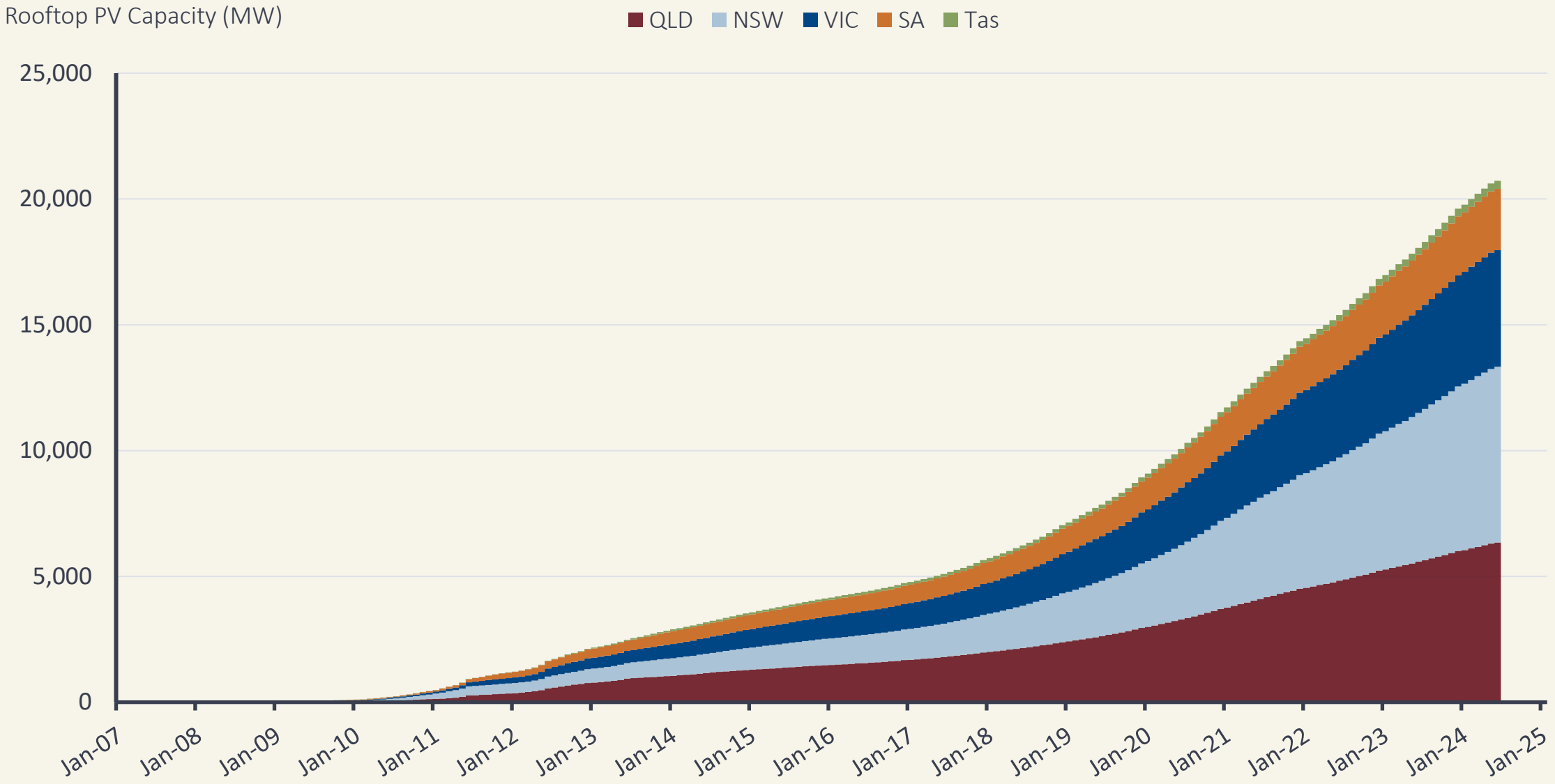
Queensland rooftop solar PV – 51.3% take-up rate



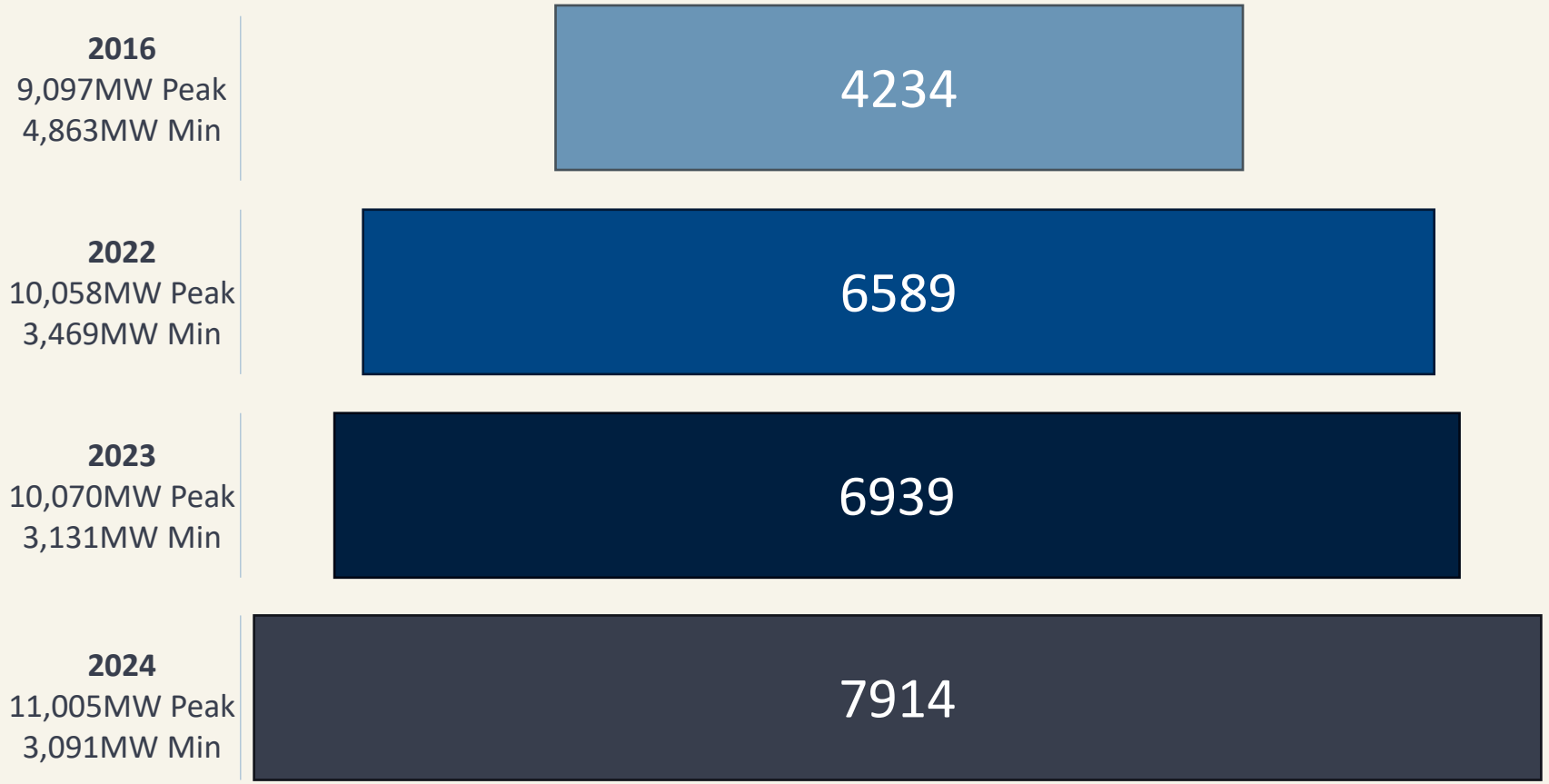
September minimum demand profile



Qld can’t export its way out of this… NEM Rooftop PV



Increasing operational envelope of network



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Powerlink's innovation journey

Over the years there has been some extraordinary pieces of work that have now become business as usual for the benefit of our network, our connected customers and Queenslanders.

Innovation

Live lines and live substations

Wide Area Monitoring Protection and Control

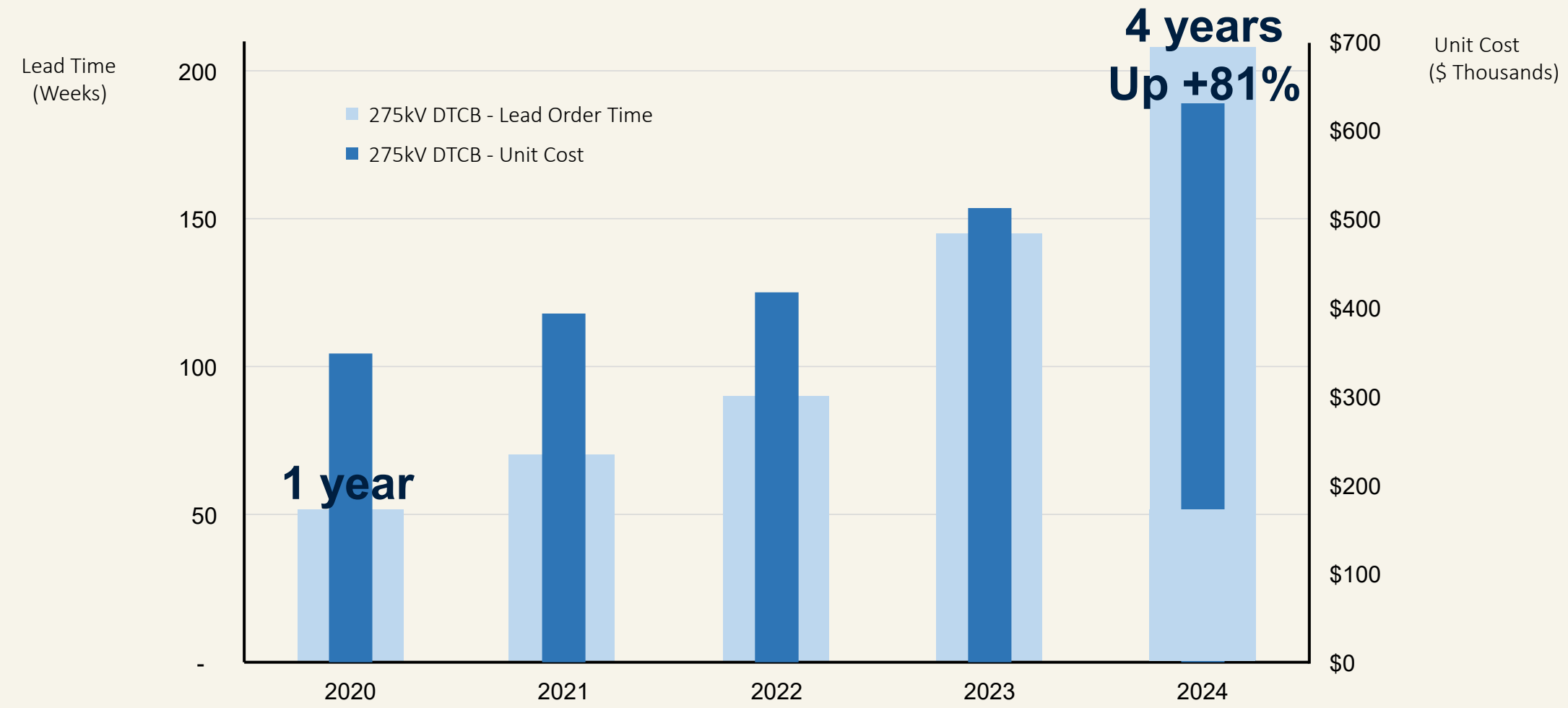
Line phase lifter

Line stringing

Robotic space installer

Concrete sensor strength maturity

275kV DT circuit breakers



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AEMO Update

Merryn York

Australian Energy Market Operator

November 2024

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

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

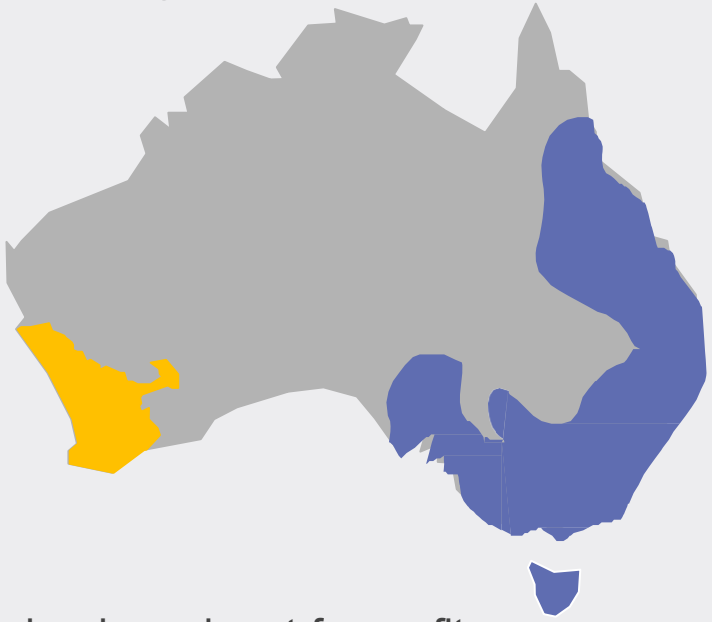
'Journey of unity: AEMO's Reconciliation Path' by Lani Balzan

AEMO Group is proud to have delivered its first Reconciliation Action Plan in May 2024. '*Journey of unity: AEMO's Reconciliation Path*' was created by Wiradjuri artist Lani Balzan to visually narrate our ongoing journey towards reconciliation – a collaborative endeavour that honours First Nations cultures, fosters mutual understanding, and paves the way for a brighter, more inclusive future.

Read our RAP

AEMO at a glance

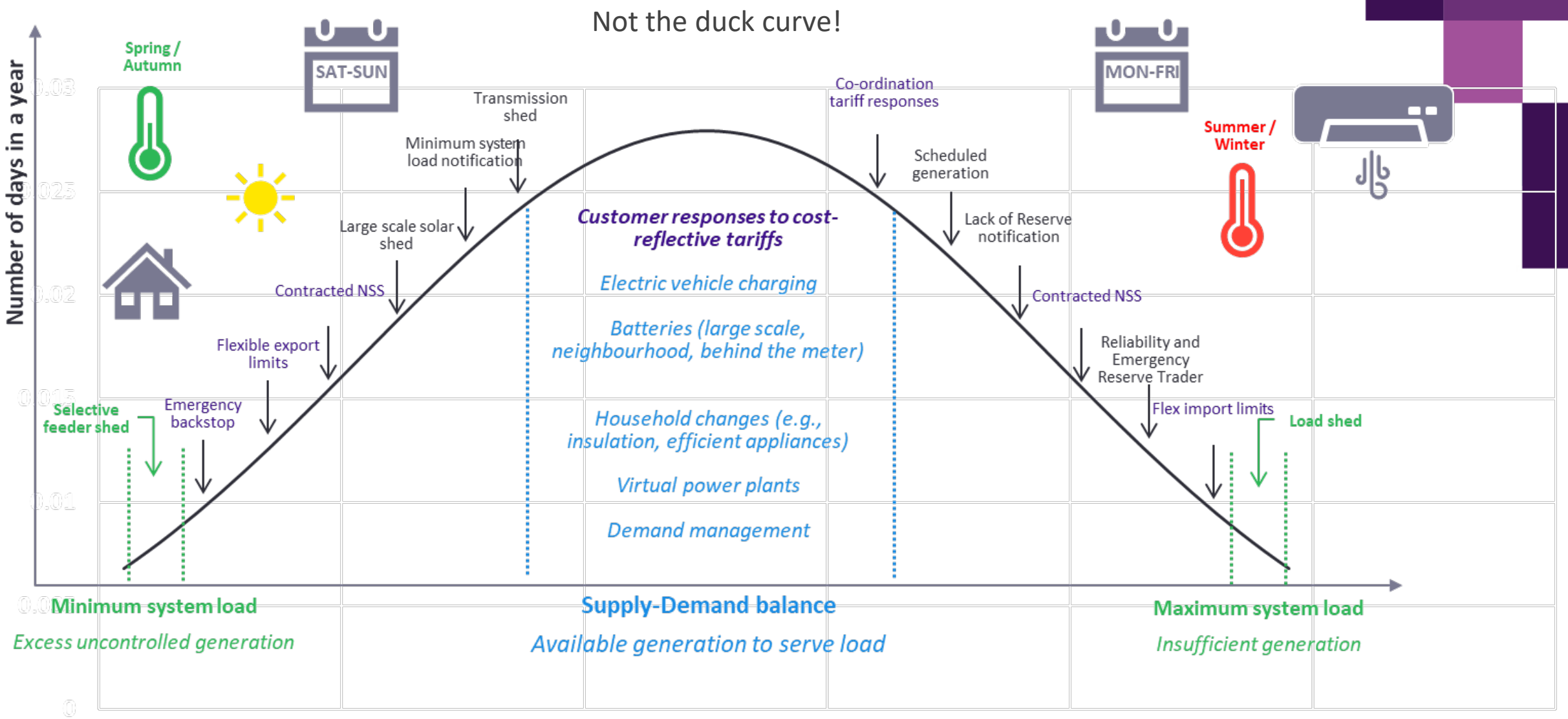
Our operating footprint



- Member-based, not-for-profit.
- 60% government, 40% industry members.
- Activities directed by National Electricity and Gas Law and Rules, jurisdictional laws and regulations.
- Funded primarily by participant fees, some funding from governments for specific activities.
- ~1500 people working around the country.

	WA	SA	VIC	NSW & ACT	QLD	TAS	NT
OPERATE ENERGY SYSTEMS AND MARKETS							
ELECTRICITY							
NATIONAL ELECTRICITY MARKET		●	●	●	●	●	
WHOLESALE ELECTRICITY MARKET	●						
GAS							
DAY AHEAD AUCTION		●		●	●		
DECLARED WHOLESALE GAS MARKET				●			
GAS SUPPLY HUB		●			●		
GAS BULLETIN BOARDS	●	●	●	●	●	●	●
GAS RETAIL MARKETS	●	●	●	●	●		
SHORT-TERM TRADING MARKET		●		●	●		
PLAN AND ENABLE FUTURE ENERGY SYSTEMS	●	●	●	●	●	●	
SUPPORT NEW INVESTMENT	●	●	●	●	●	●	

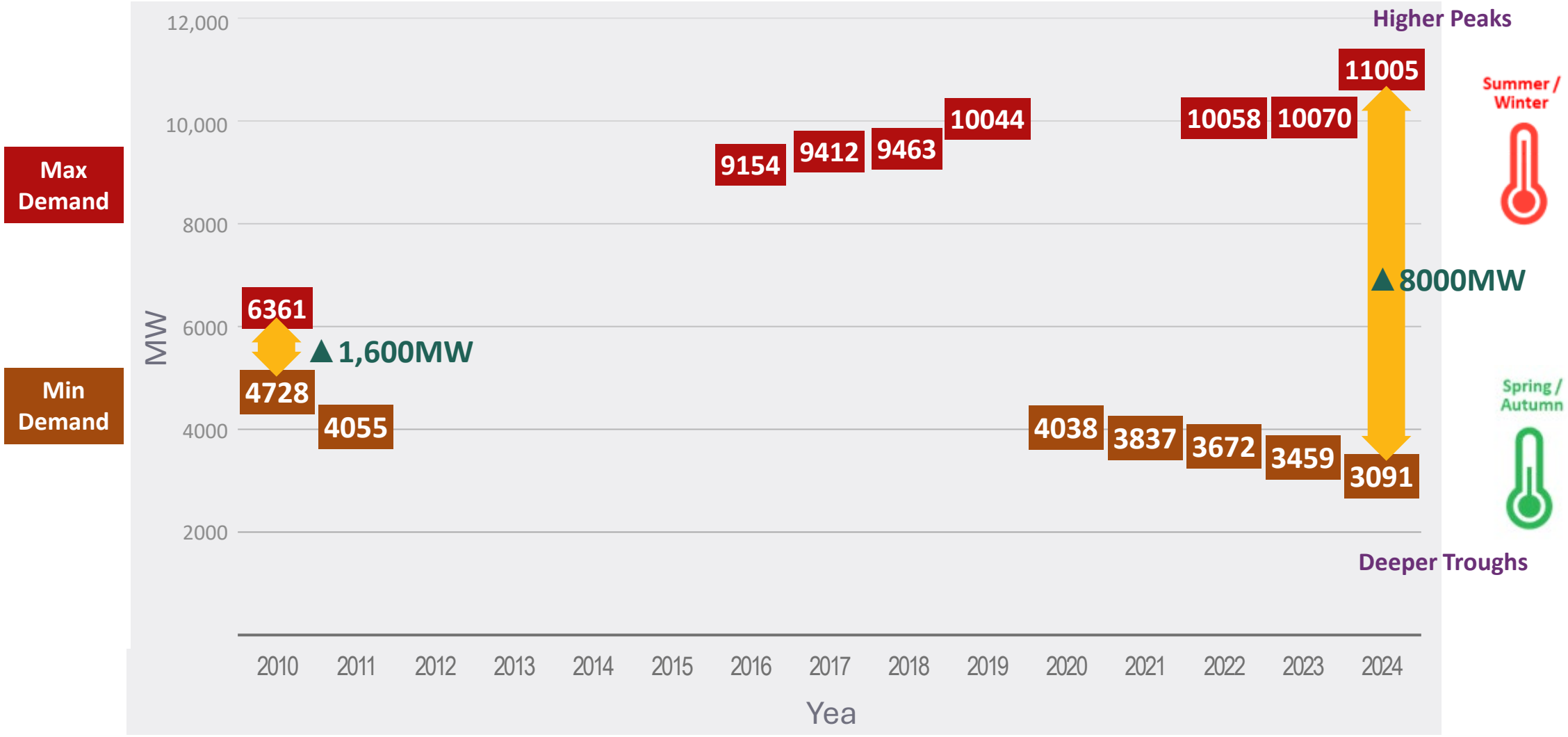
Managing varying system load conditions



Source: Adapted from a Victorian Government figure in the consultation paper for Victoria's emergency backstop mechanism for rooftop solar. Victorian Government. 2023, Victoria's Emergency Backstop Mechanism: Consultation paper, p 10. https://engage.vic.gov.au/victorias-emergency-backstopmechanism-for-rooftop-solar

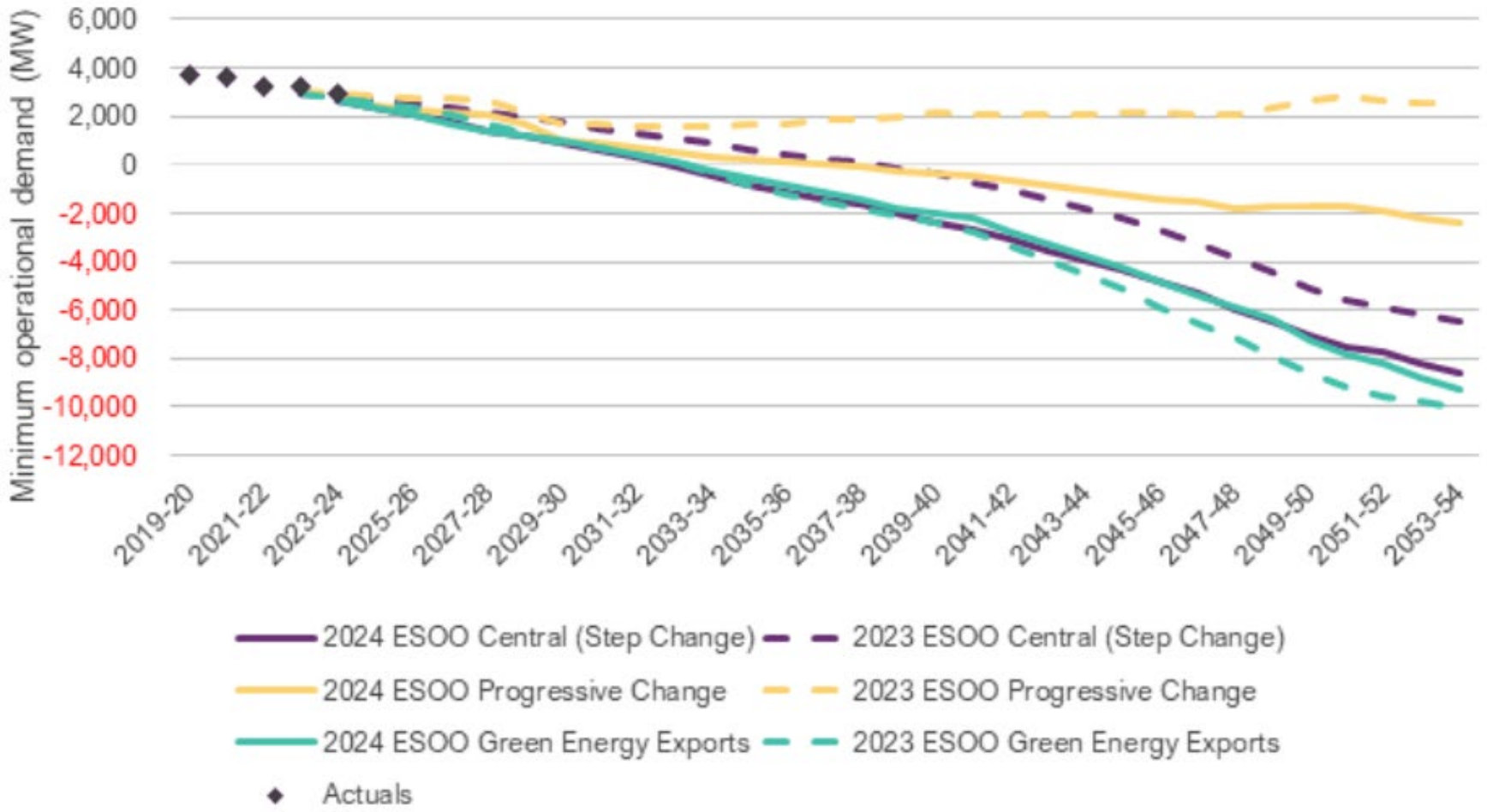
Consumer energy demands are changing

Queensland's Maximum and Minimum Electricity Operational Demand Records



Qld minimum demand forecast

Actual and forecast Queensland 50% POE minimum operational (sent-out) demand, 2024 ESOO all scenarios and 2023 ESOO all scenarios, 2019-20 to 2053-54 (MW)



AEMO is planning on many fronts across varying time horizons.

Data

Inputs, Assumptions and Scenarios Report

Generation information and closure dates

Connections scorecard

Transmission Augmentation Information Page

5 years | 10 years | 15 years | 20 years | 25 years

Forecasting & Planning

Security

- System Security Reports
- Transition plan for system security
- Engineering Roadmap to 100% Renewables

Reliability

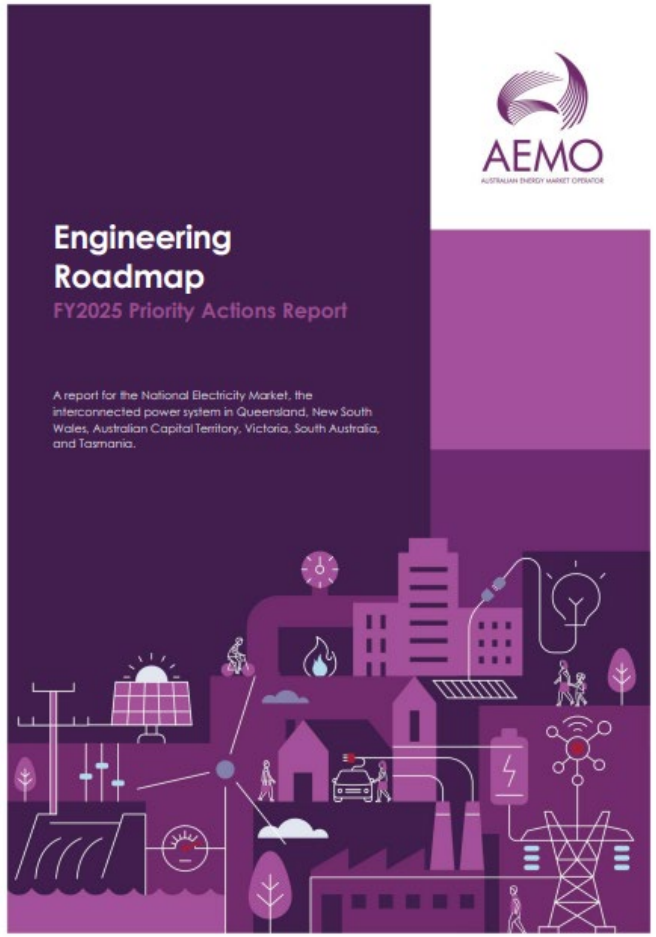
- Electricity Statement of Opportunities (ESOO)
- Gas Statement of Opportunities (GSOO)
- Energy Adequacy Assessment Projection

Infrastructure

- Integrated System Plan

Engineering Roadmap – FY25 priorities

FY25 Priority Actions fall broadly in three focus areas and build on previous actions from FY2024

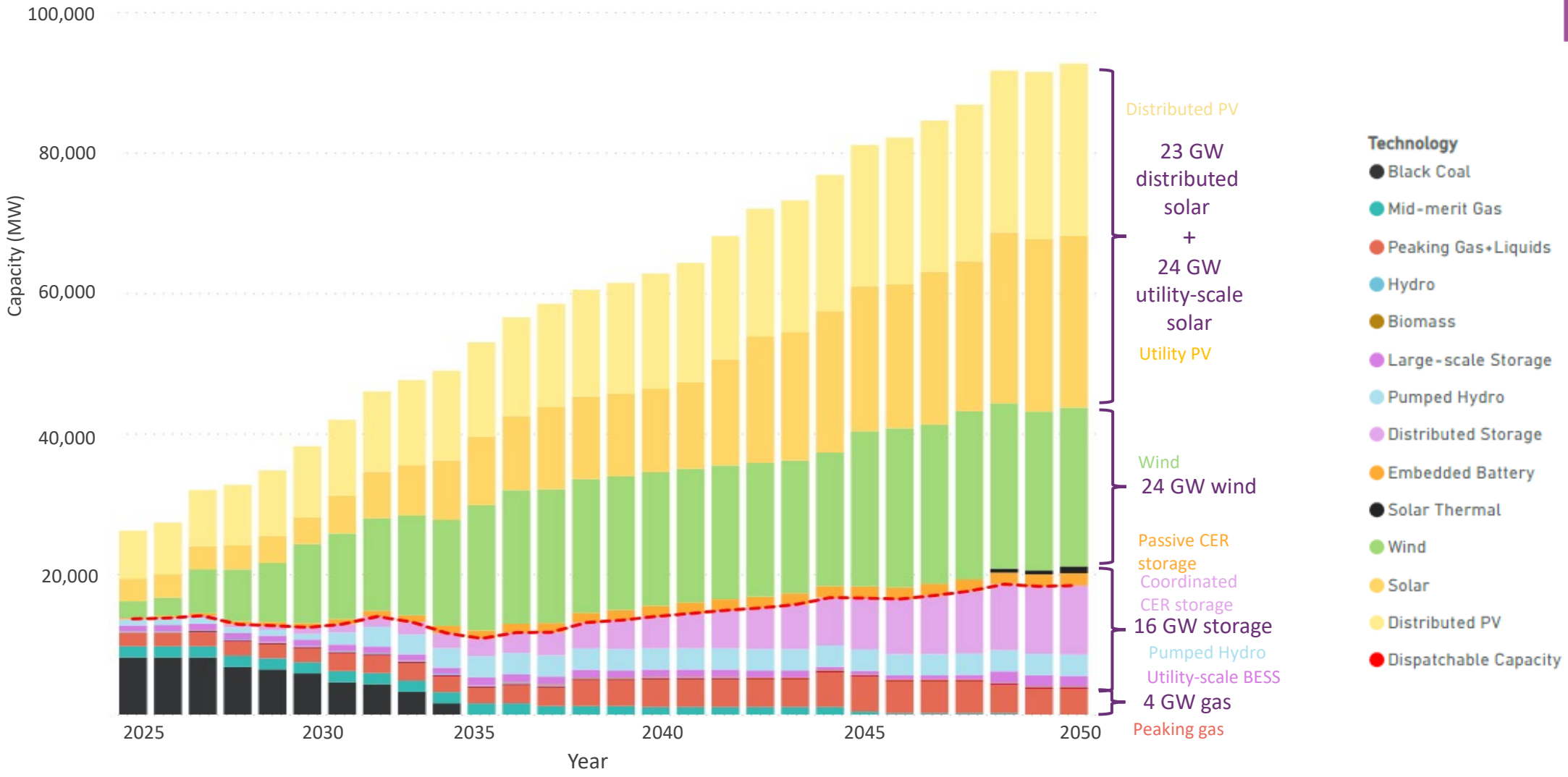


Priority focus area	Workstreams
Delivering foundational transition enablers *Collaborating closely with stakeholders to establish critical foundations for the future power system, defining roles and responsibilities for new technical matters, and establishing effective systems and processes for future system operation.*	**DER governance** *Ensuring appropriate enduring accountability across industry to meet ongoing technical requirements as DER capacity growth continues rapidly with increasing penetration of DPV, small-scale batteries, and EVs.*
	Operational DER integration *Actively managing and monitoring issues emerging in operational timeframes (now – 2 years ahead) as the NEM experiences world leading levels of DER.*
Providing long-range investment visibility *Identifying future power system needs that may require investment from one or more parties and providing clarity on the capability of different technologies to meet these needs.*	**Future power system phenomena** *Exploring new behaviours and system phenomena as the configuration of the power system changes, with inverter-based resources as an increasingly prevalent portion of the generation mix.*
	New technology capabilities *Enabling new technologies to be integrated into the power system, by completing required desktop investigations and real-world demonstrations.*
Progressing operational readiness *Maintaining power system security in real-time operation under unprecedented penetration of variable, inverter-based, and distributed resources.*	**Real Time Operations (RTO) and operations support** *Uplifting the capability of AEMO's real-time operations (RTO) and supporting functions to adapt to the needs of a high renewables power system.*
	Operational transition planning *Delivering proactive study, sequencing, and governance to critical system configurations known as 'operational transition points' to ensure secure system operation can be maintained in the long-term interest of consumers.*

Changing supply mix – QLD capacity

2024 ISP - Step Change

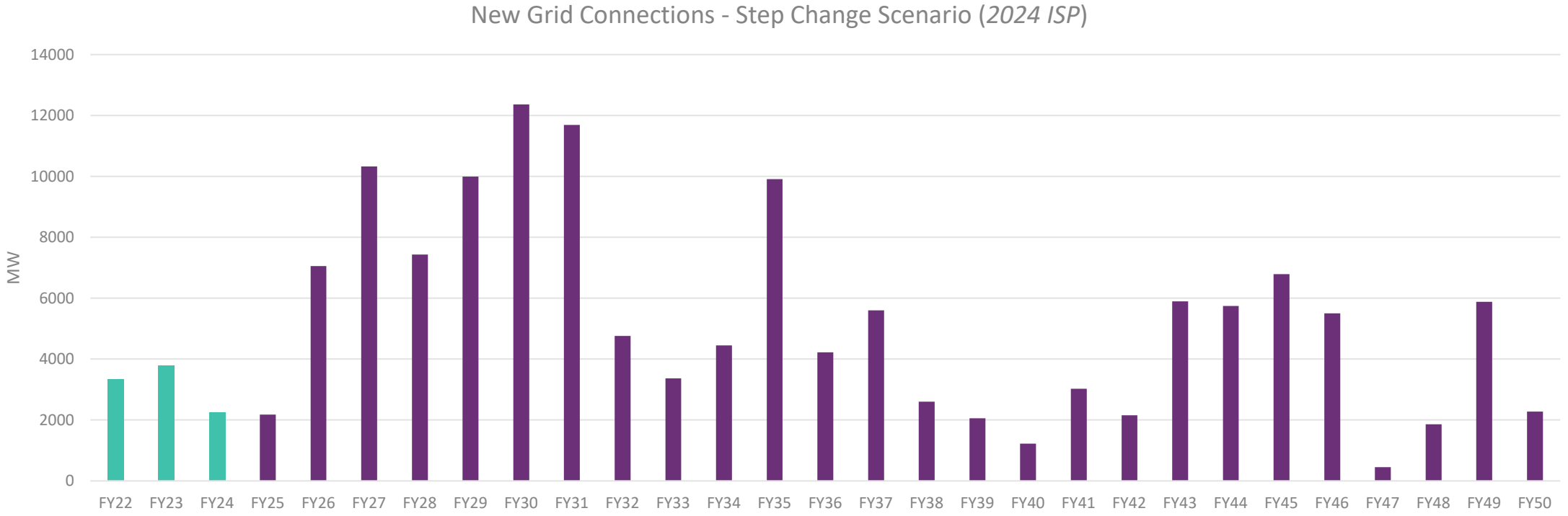
Eight times today's utility-scale wind and solar, and five times today's consumer energy resources, by 2050



Focus on large scale connections

New Connections Applications for Generator Performance Standards Approval	FY22	FY23	FY24	Δ FY22-FY24
National Energy Market	11.7 GW	14.1 GW	19.0 GW	**62%**
Queensland	1.3 GW	3.5 GW	6.2 GW	**377%**

- Significant levels of connection required across the NEM: 6-7 GW p.a. for next 15 years c.f. 3-4 GW per annum currently



Small scale - Operating with high-CER
Draft functional requirements

AEMO's responsibilities as the bulk power system operator

- Maintaining power system security
  - Managing technical envelope
  - Frequency management
  - Voltage management
  - System strength
  - System restart
- Centralised dispatch process
  - Operational forecasting
  - Scheduling and dispatch

Assess current and emerging challenges with increasing CER

How CER uptake impacts AEMO's operational responsibilities:

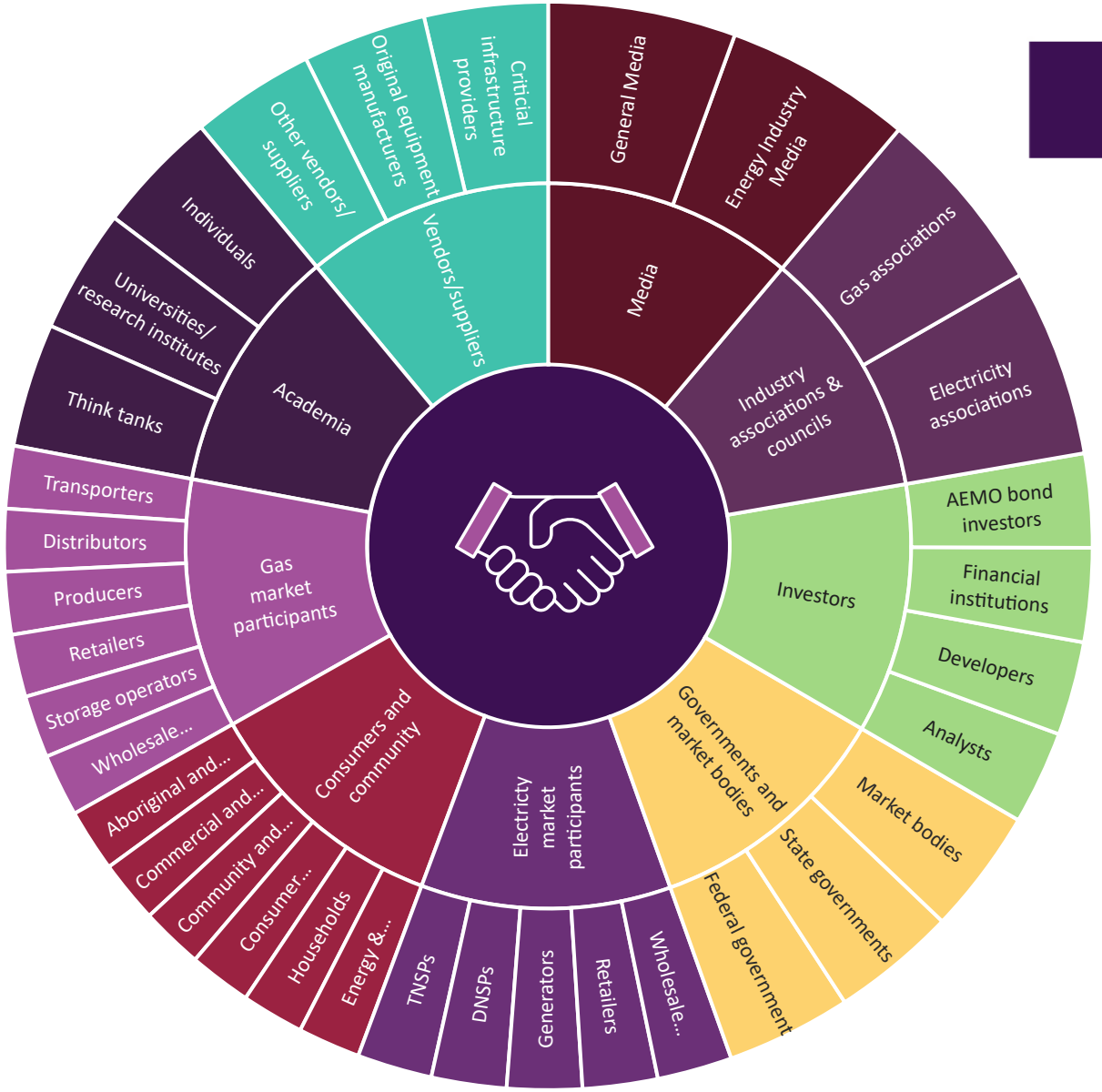
- Device-level
  - Visibility & predictability
  - Controllability
  - Performance
- System management
  - Activity within Dx network operating zone
  - AEMO-T-D coordination

Use Cases & Requirements that need to be reviewed due to these impacts

1. CER visibility and predictability
2. CER performance during disturbances
3. Emergency DPV curtailment
4. Voltage Management
5. CER scheduling and operational coordination
6. Manage CER cyber security compromise
7. System restart with increasing DER
8. Underfrequency management with increasing DER

The challenge that lies ahead is too big for any one organisation to tackle alone.

It requires robust collaboration encompassing the diverse organisations across the energy sector, our broader community, industry and governments.



Thank you

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Decarbonising Central Queensland

Daniel Andersen
General Manager Energy Markets
Powerlink Queensland

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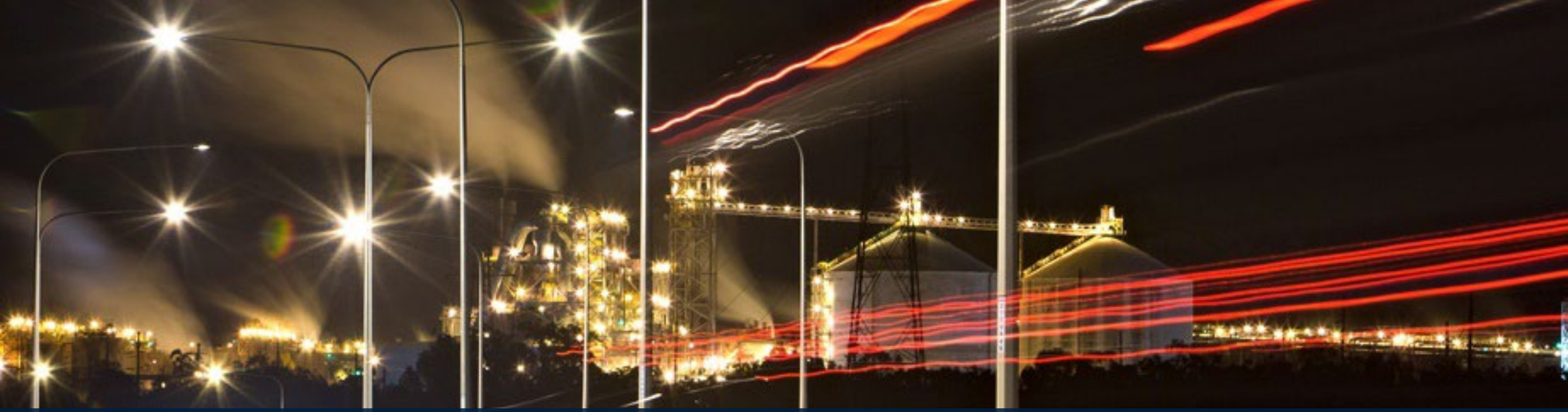
Importance of Gladstone



Gladstone region load

20-25%
state electricity supply

1.1GW
Largest load outside SEQ

3-8GW
Electrification impact

Gladstone region generation

1680MW

Gladstone Power Station

Scheduled close in 2035

700MW

Callide B Power Station

Scheduled close in 2028

1MW COAL FIRED POWER RETIRING

=

3-4 x RENEWABLE RESOURCES

+

STORAGE/FIRMING REQUIRED

At least 3.5 years' notice of expected closure required

Gladstone region generation

1680MW

Gladstone Power Station

Scheduled close in 2035

700MW

Callide B Power Station

Scheduled close in 2028

30,000MW

Battery/solar/wind already in development

At least 3.5 years' notice of expected closure required

Central Queensland
Coordinating generation


Central Queensland
Network reinforcement
Existing network
Existing coal generator
Potential REZ
SQ-CQ connection
Gladstone Project
Gladstone
Callide REZ
Calliope REZ
10GW
WIND DEVELOPER INTEREST
*Indicative geographical representation only

Enablers

Priority Transmission Investment

Renewable Energy Zone (REZ) Delivery Body

Social licence

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Panel | Decarbonising Central Queensland

Jacqui Bridge
Executive General Manager Energy Futures

Vik Selvaraja
General Manager Pacific Repowering Rio Tinto

Dana Boxall
General Manager Community and Delivery Services

Roger Smith
Director Revenue Reset

Daniel Andersen
General Manager Energy Markets

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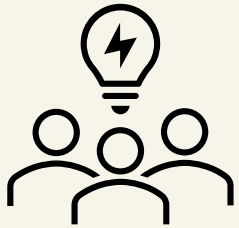
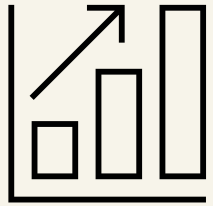
Interactive session questions

ONLINE PARTICIPANTS please go to **bit.ly/PQForum**

What can Powerlink do to provide **more investment certainty** in the Central Queensland region?



What else does Powerlink **need to consider** from a social licence and community perspective?



How does Powerlink **best time network investment** in Central Queensland to **meet future load growth**?

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Q&A with Paul and Merryn

BREAK

Decarbonising Central Queensland with Daniel Andersen, General Manager Energy Markets

Panel moderated by Jacqui Bridge, Executive General Manager Energy Futures

Interactive session

BREAK

Transmission Annual Planning Report update with Stewart Bell, Executive General Manager Network and Business Development, followed by Q&A

2024 Transmission Network Forum

Transmission Annual Planning Report (TAPR) Technical Session

Stewart Bell
Executive General Manager
Network and Business Development
Powerlink Queensland

Powerlink acknowledges the Traditional Owners and their custodianship of the lands and waters of Queensland and in particular the lands on which we operate.

We pay our respect to their Ancestors, Elders and knowledge holders and recognise their deep history and ongoing connection to Country.

Disclaimer

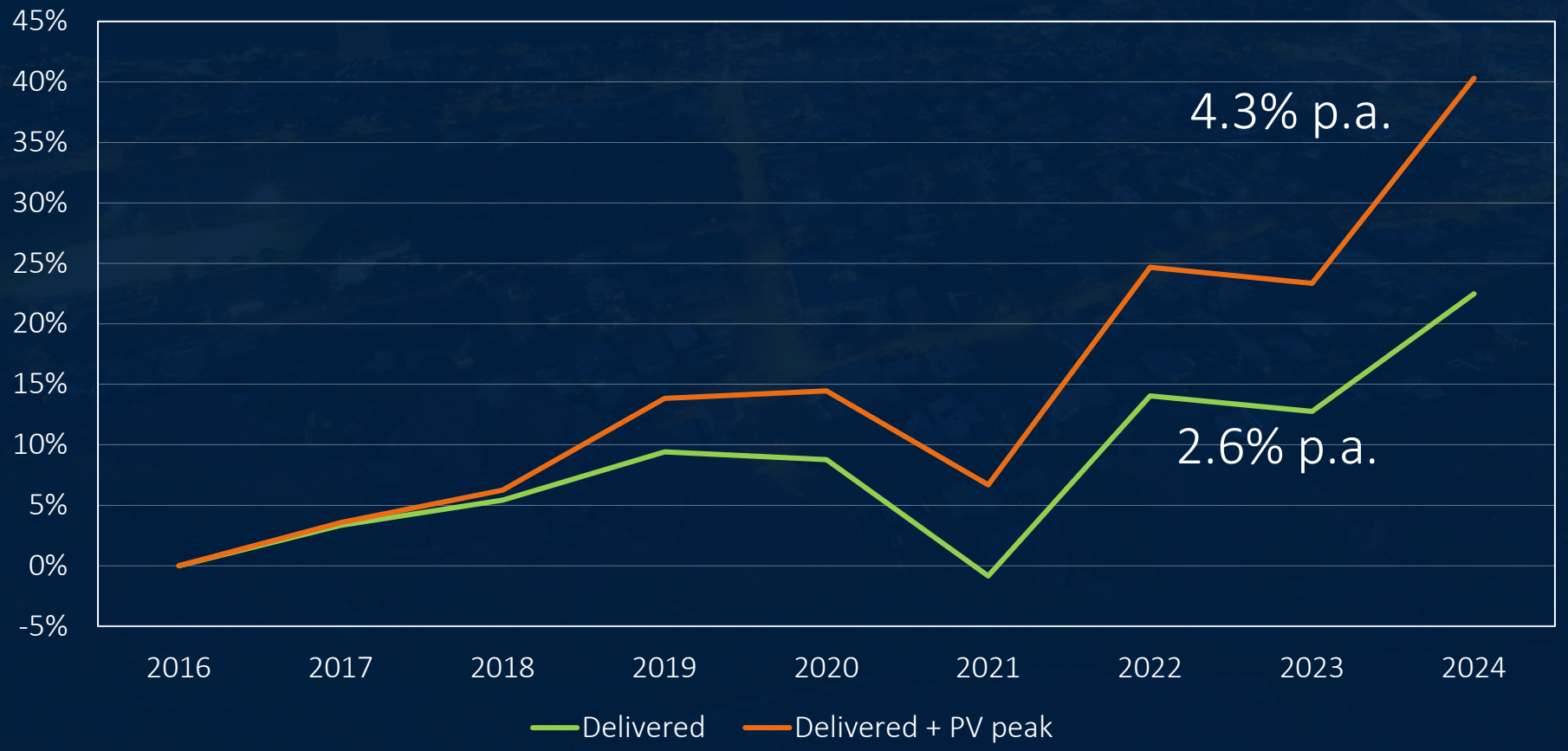
While care was taken in preparation of the information in this presentation, and it is provided in good faith, Powerlink accepts no responsibility or liability (including without limitation, liability to any person by reason of negligence or negligent misstatement) for any loss or damage that may be incurred by any person acting in reliance on this information or assumptions drawn from it, except to the extent that liability under any applicable Queensland or Commonwealth of Australia statute cannot be excluded. Powerlink makes no representation or warranty as to the accuracy, reliability, completeness or suitability for particular purposes, of the information in this presentation.

Thank you

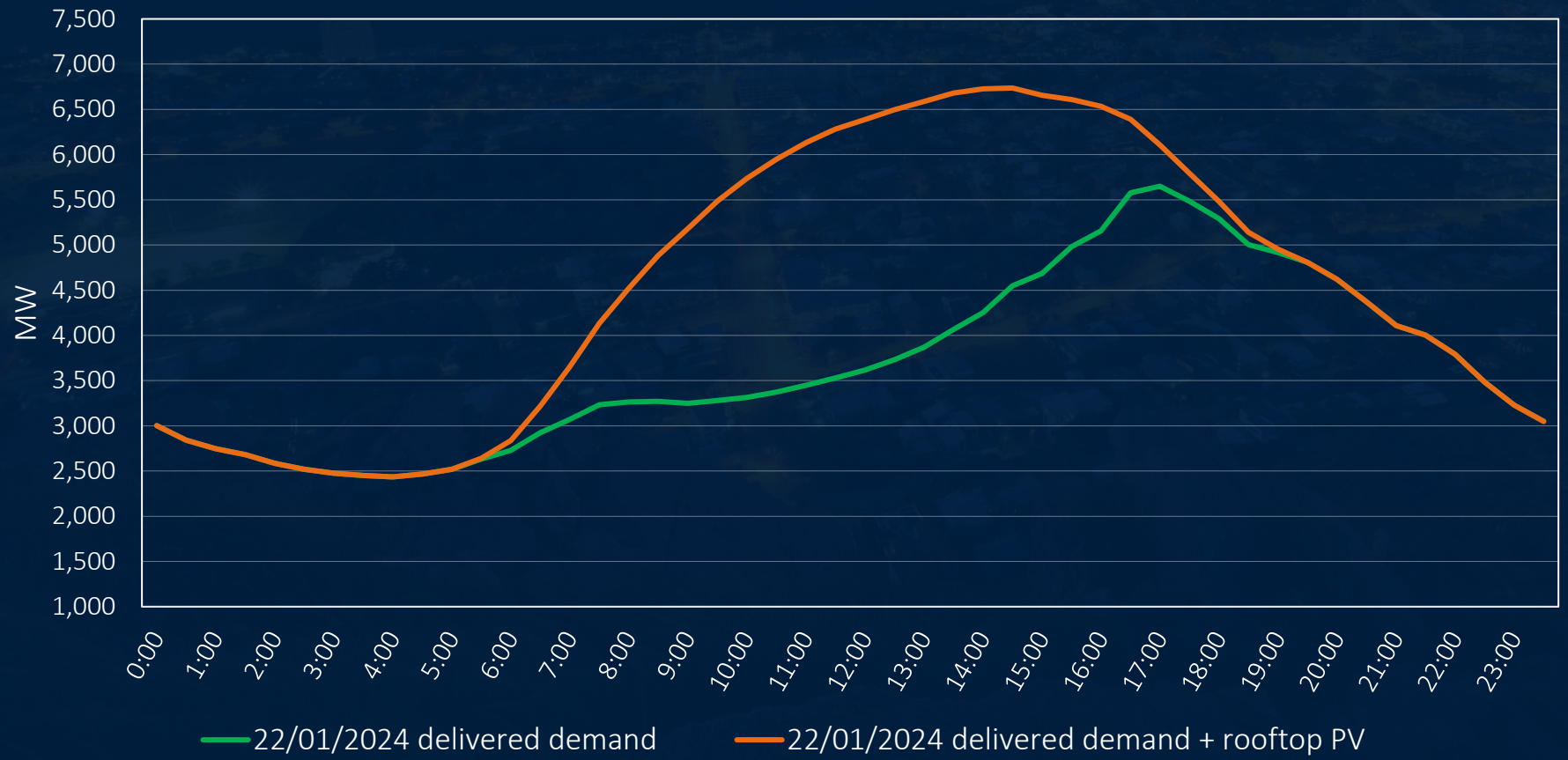
TAPR

- **Demand forecasts**
- Connection pipeline
- Network development
- Ancillary services
- Leverage shared network capacity
- Guide the market

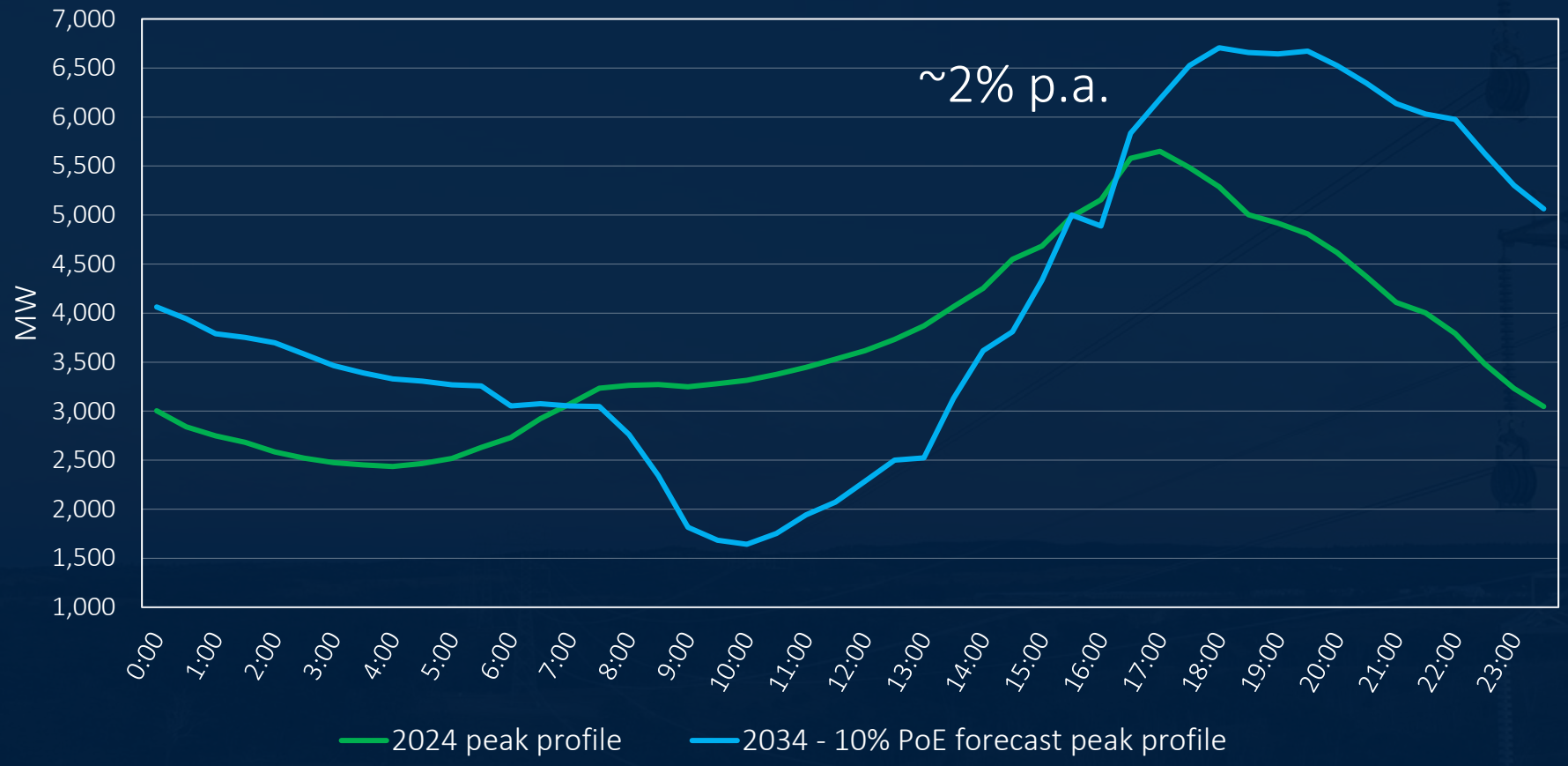
Historical SEQ maximum demand



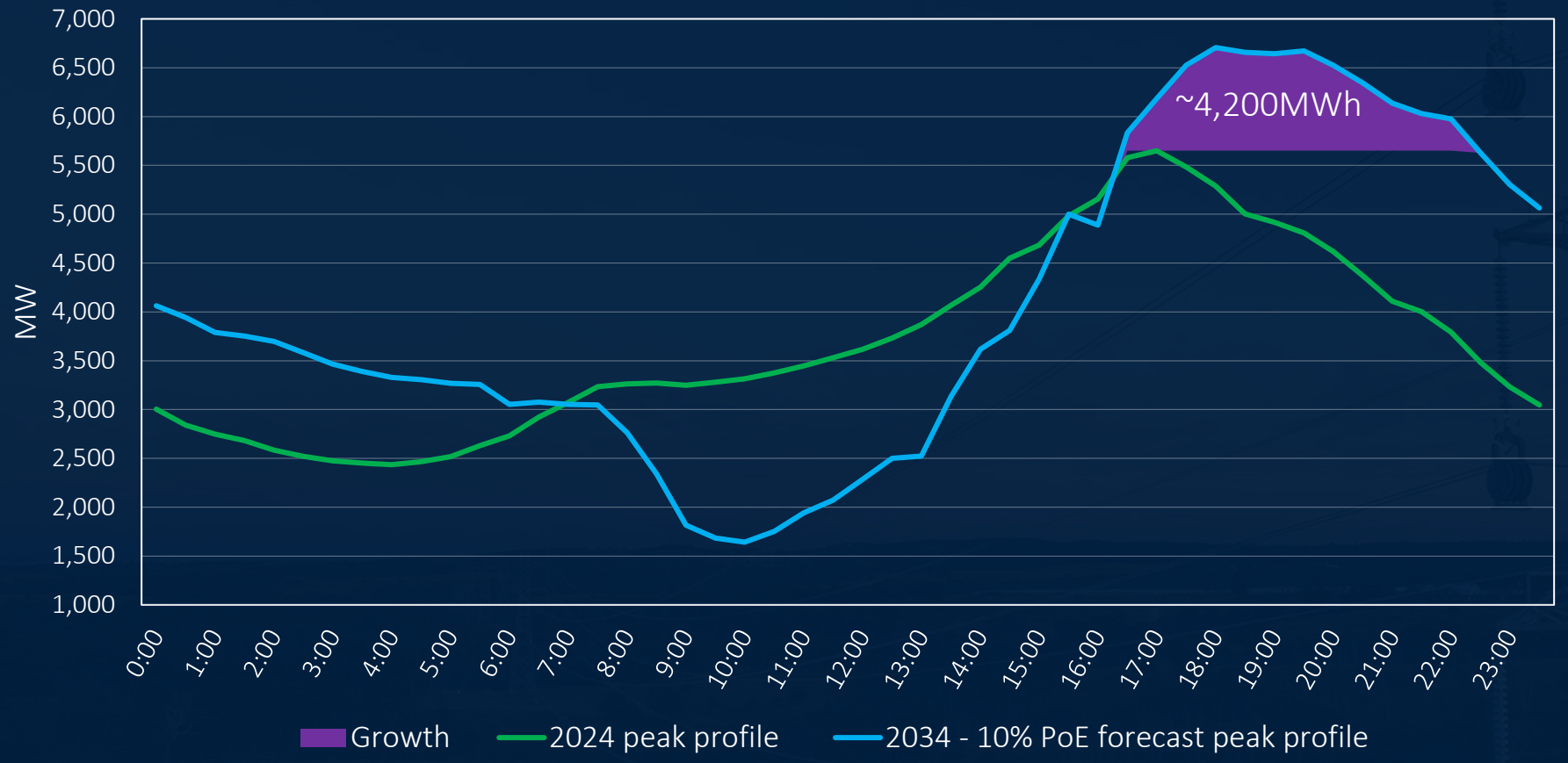
SEQ maximum demand day



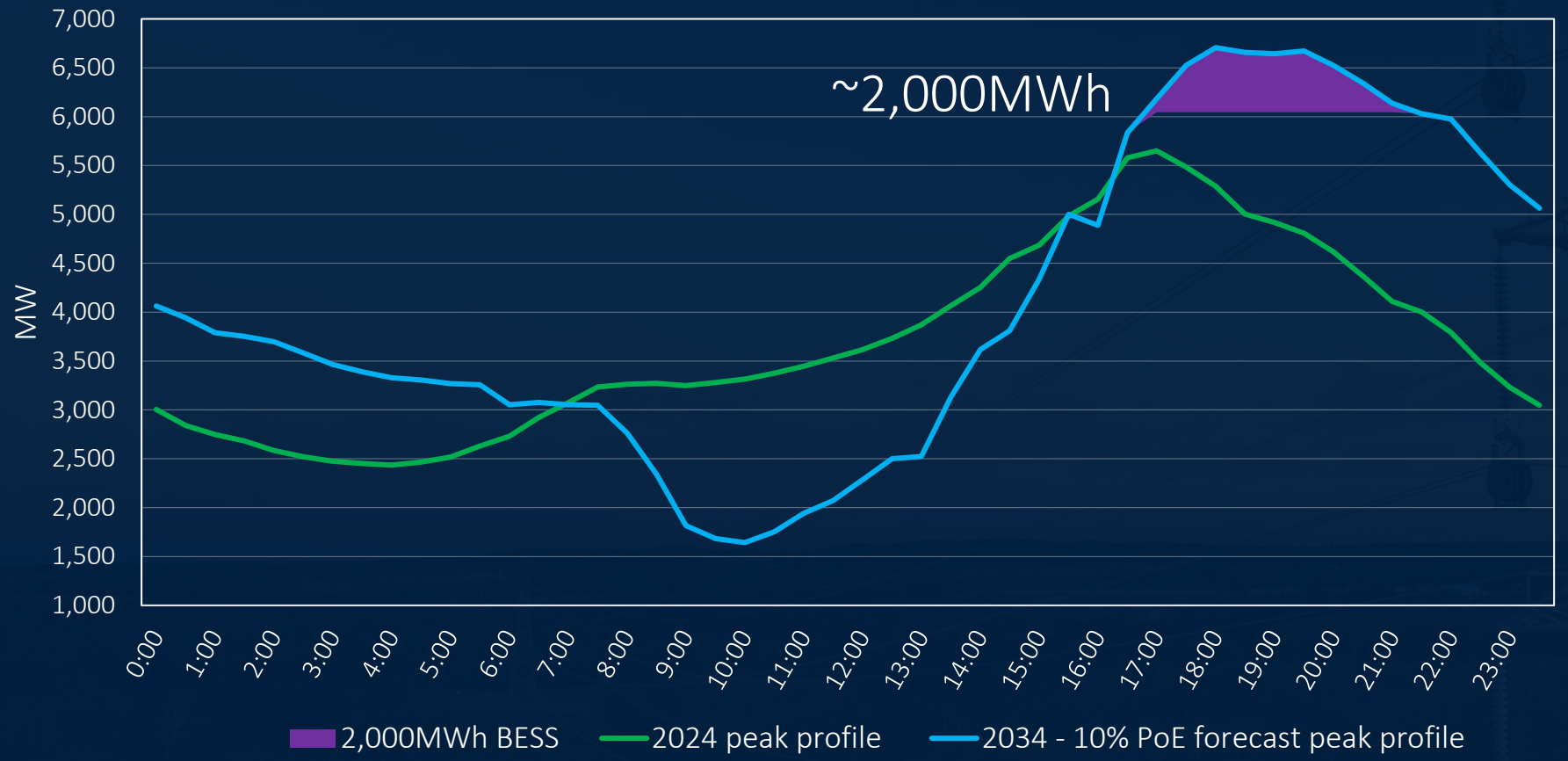
Forecast SEQ maximum demand



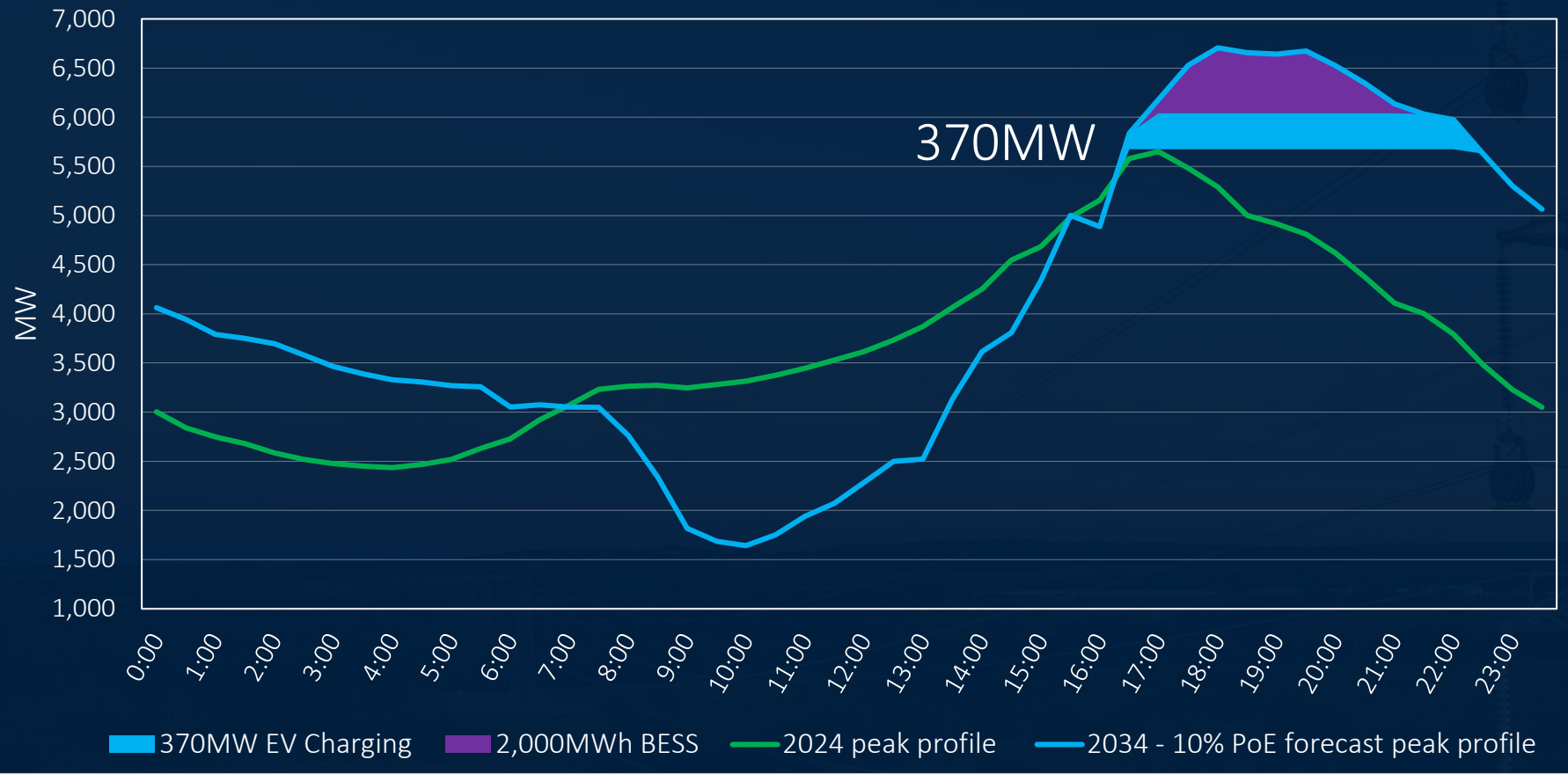
Moderating SEQ maximum demand

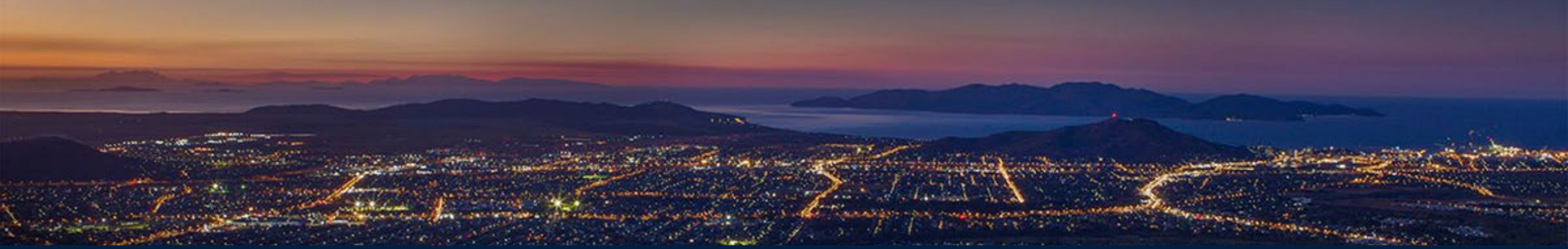


Moderating SEQ maximum demand



Moderating SEQ maximum demand

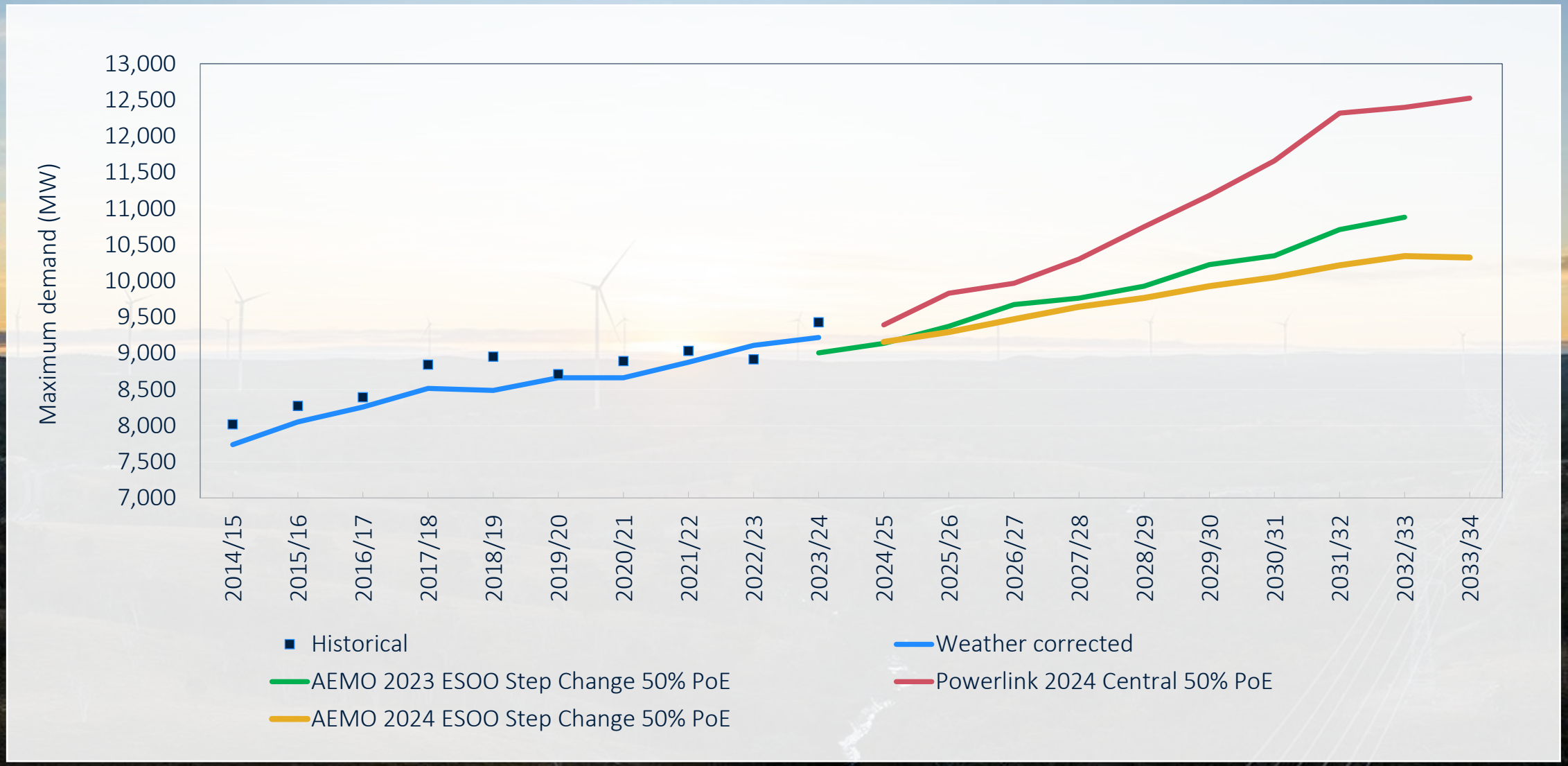




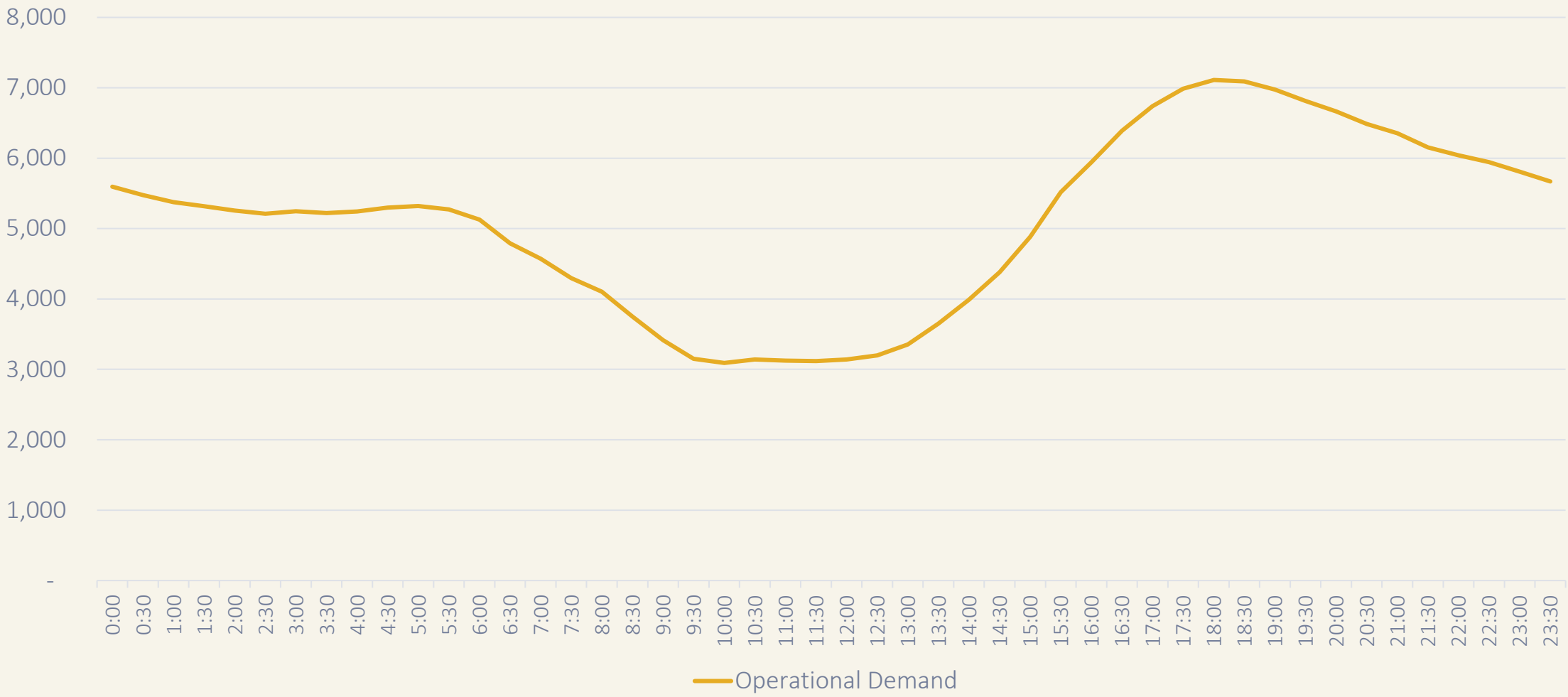
New large industrial loads

Zone	Description	Load in forecast	Possible load
North Queensland	Electrification	~1,500MW	1,600MW
	Manufacturing		
Gladstone	Hydrogen production and liquefaction		3,300 – 7,750MW
	Electrification		
Southern Queensland	Data Centre and industrial		275MW

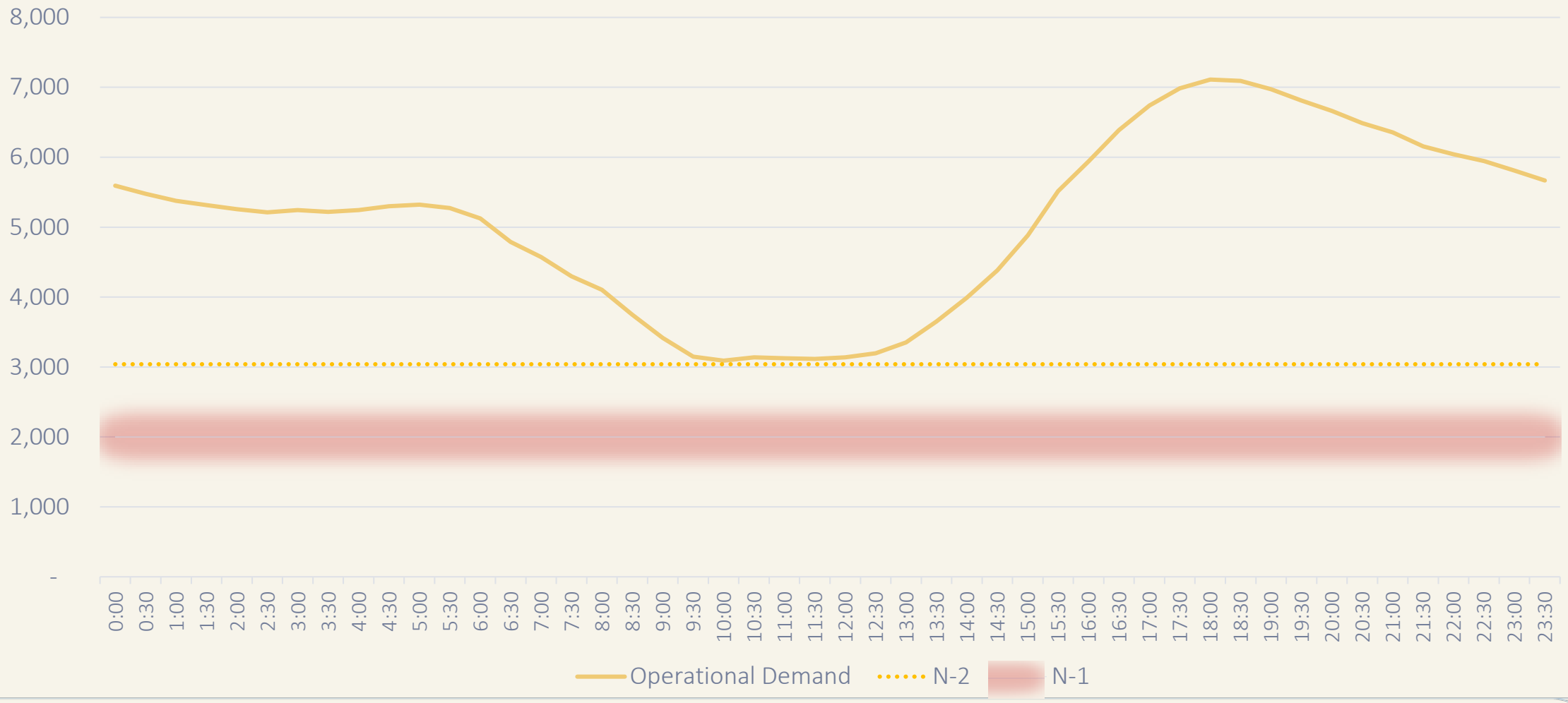
Queensland maximum demand forecast



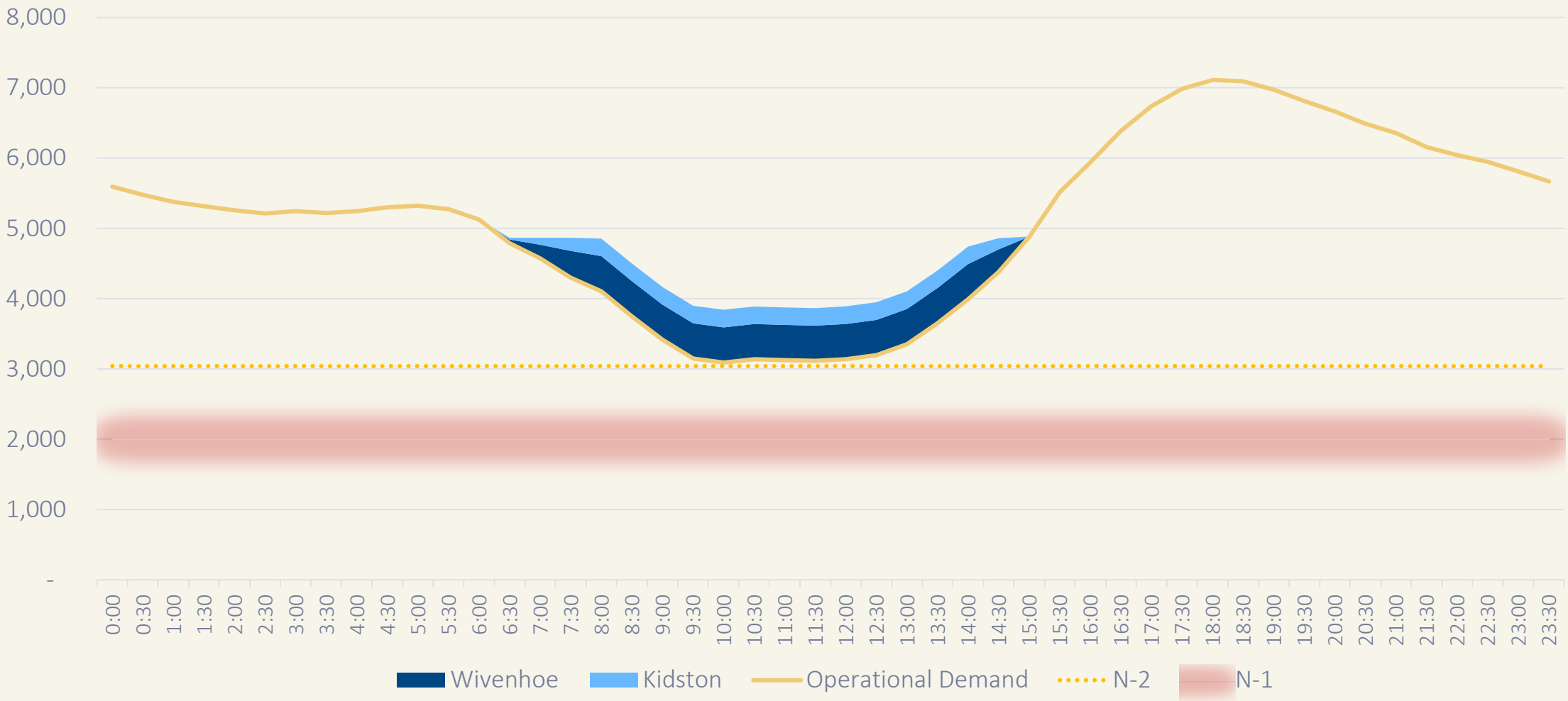
Minimum demand



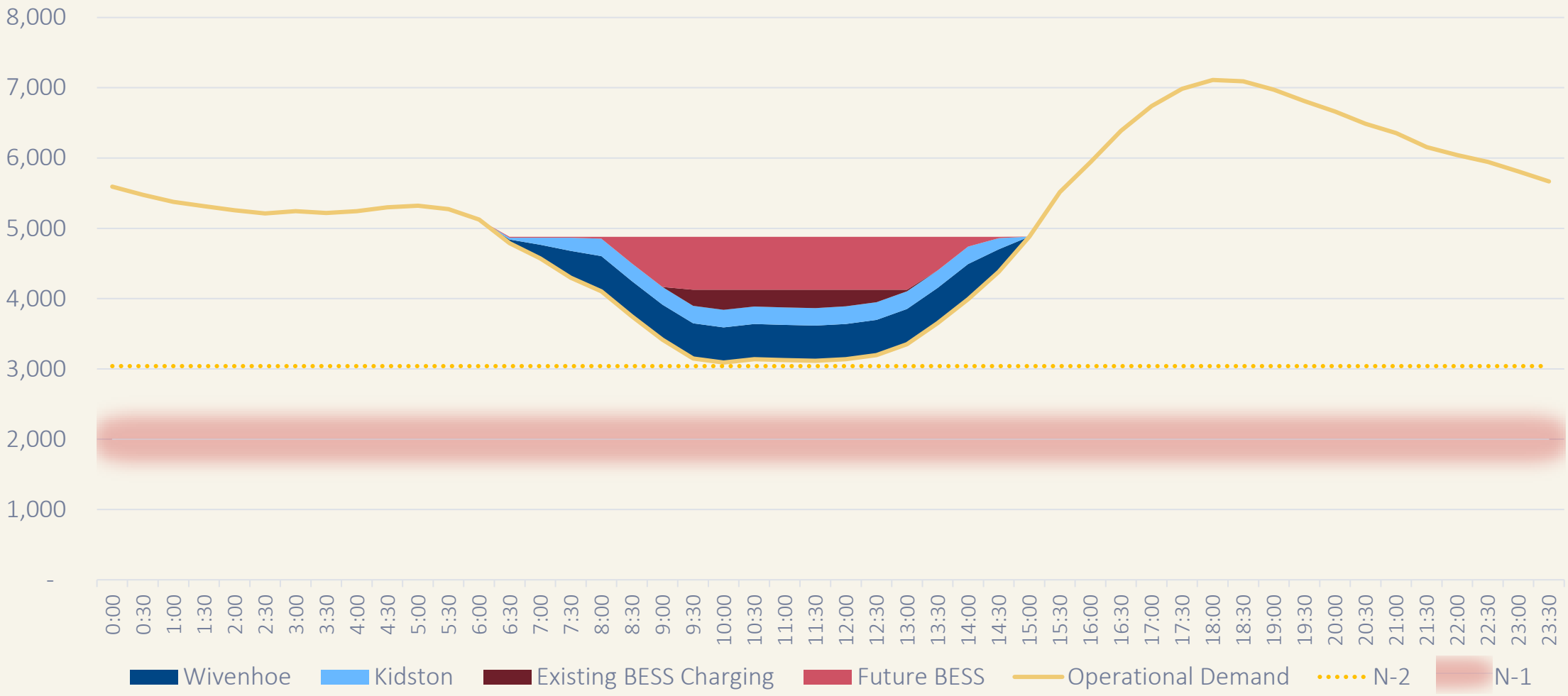
Minimum demand – stability limits



Minimum demand – pumped hydro



Minimum demand – batteries



TAPR

Demand forecasts

Connection pipeline

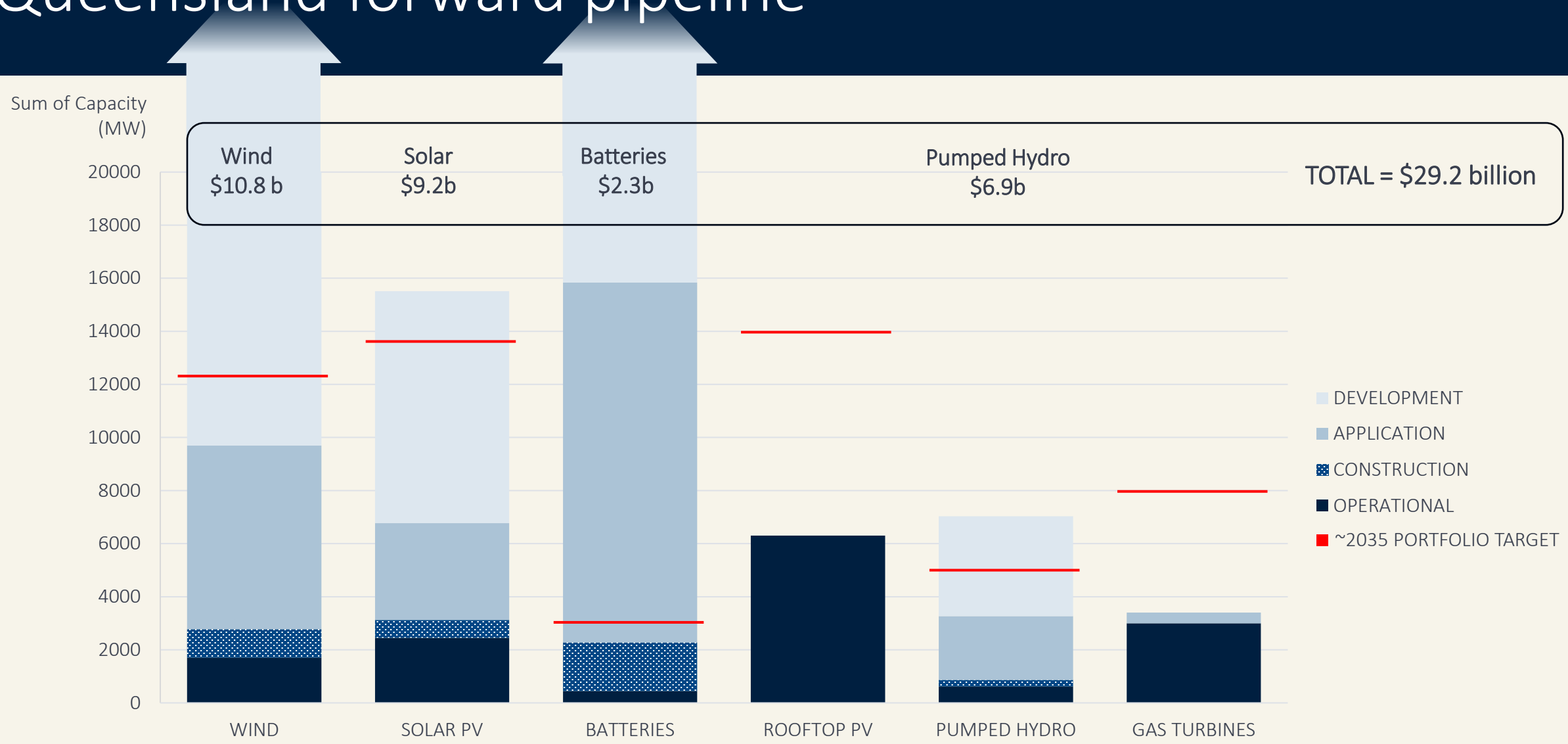
Network development

Ancillary services

Leverage shared network capacity

Guide the market

Queensland forward pipeline



TAPR

Demand forecasts

Connection pipeline

Network development - Renewable Energy Zones

Ancillary services

Leverage shared network capacity

Guide the market

Renewable Energy Zones

	FAR NORTH QUEENSLAND	SOUTHERN DOWNS	WESTERN DOWNS
Network capacity	~500MW	~ 2,000MW	~1,800MW
Contracted capacity	152MW	890MW	500MW
Application date	September 2019	December 2020	January 2021
Energisation date	October 2022	December 2023	November 2024
Cycle time	3.2 years	3.0 years	3.7 years

TAPR

Demand forecasts

Connection pipeline

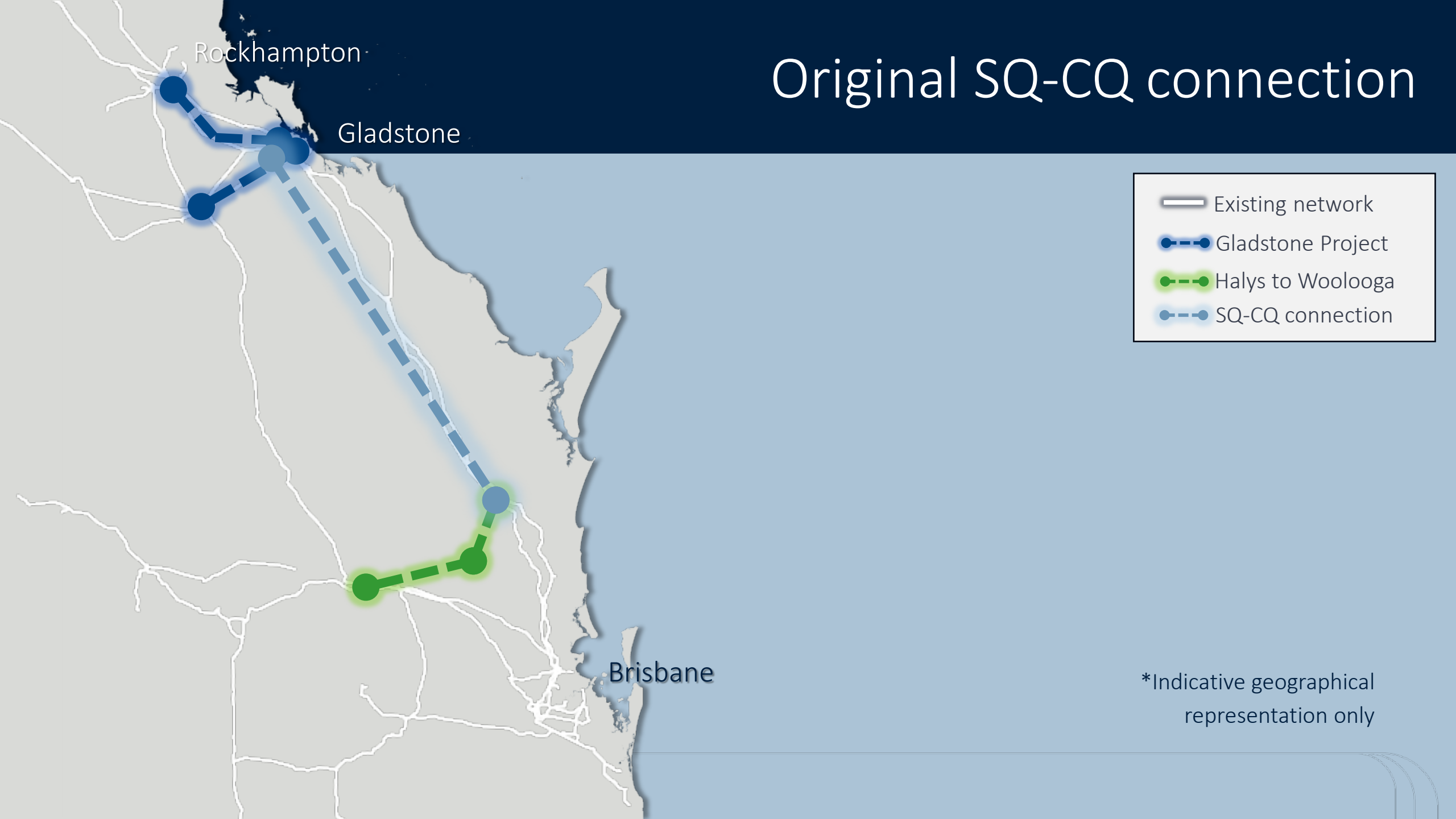
Network development – SQ-CQ connection

Ancillary services

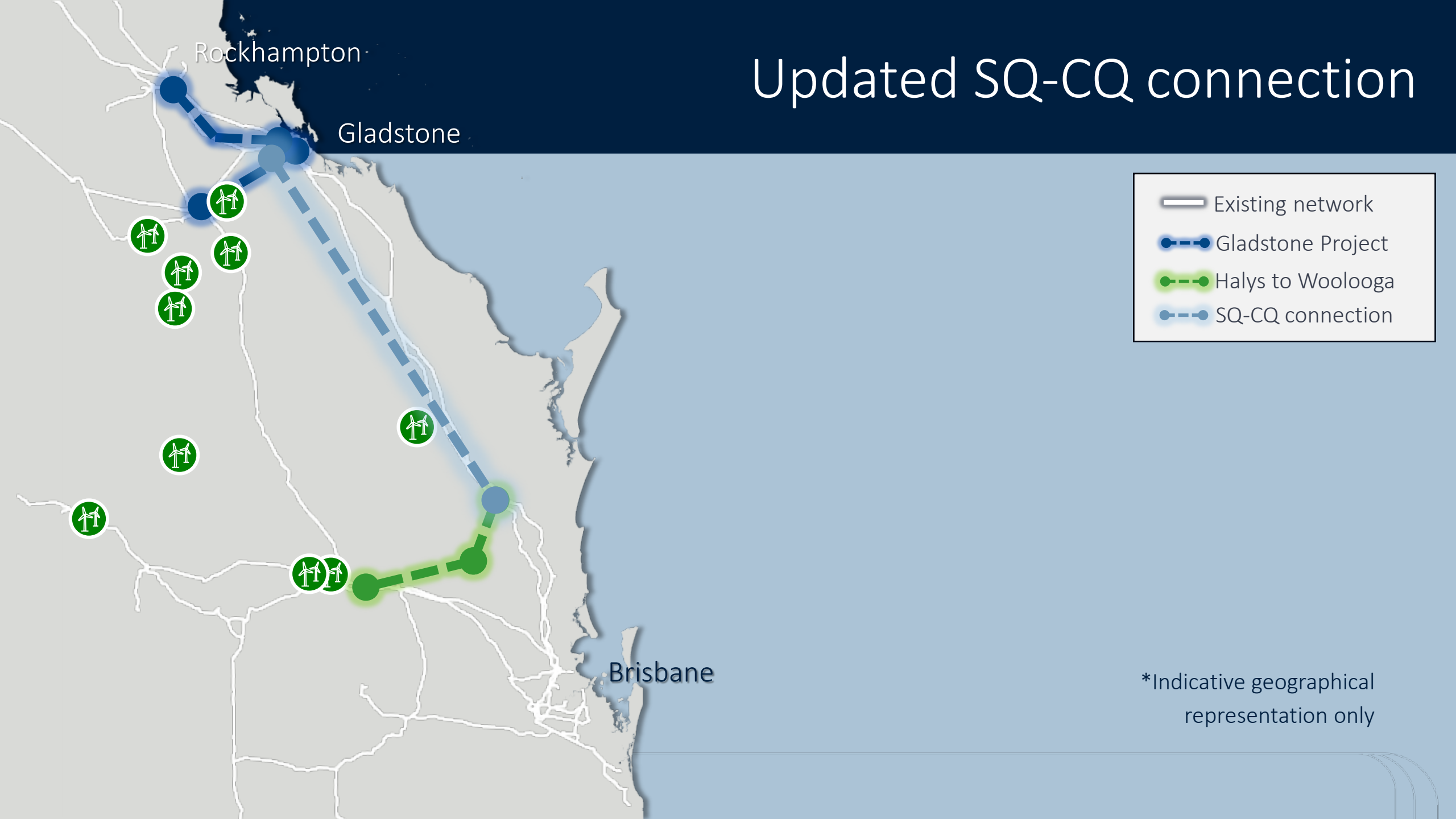
Leverage shared network capacity

Guide the market

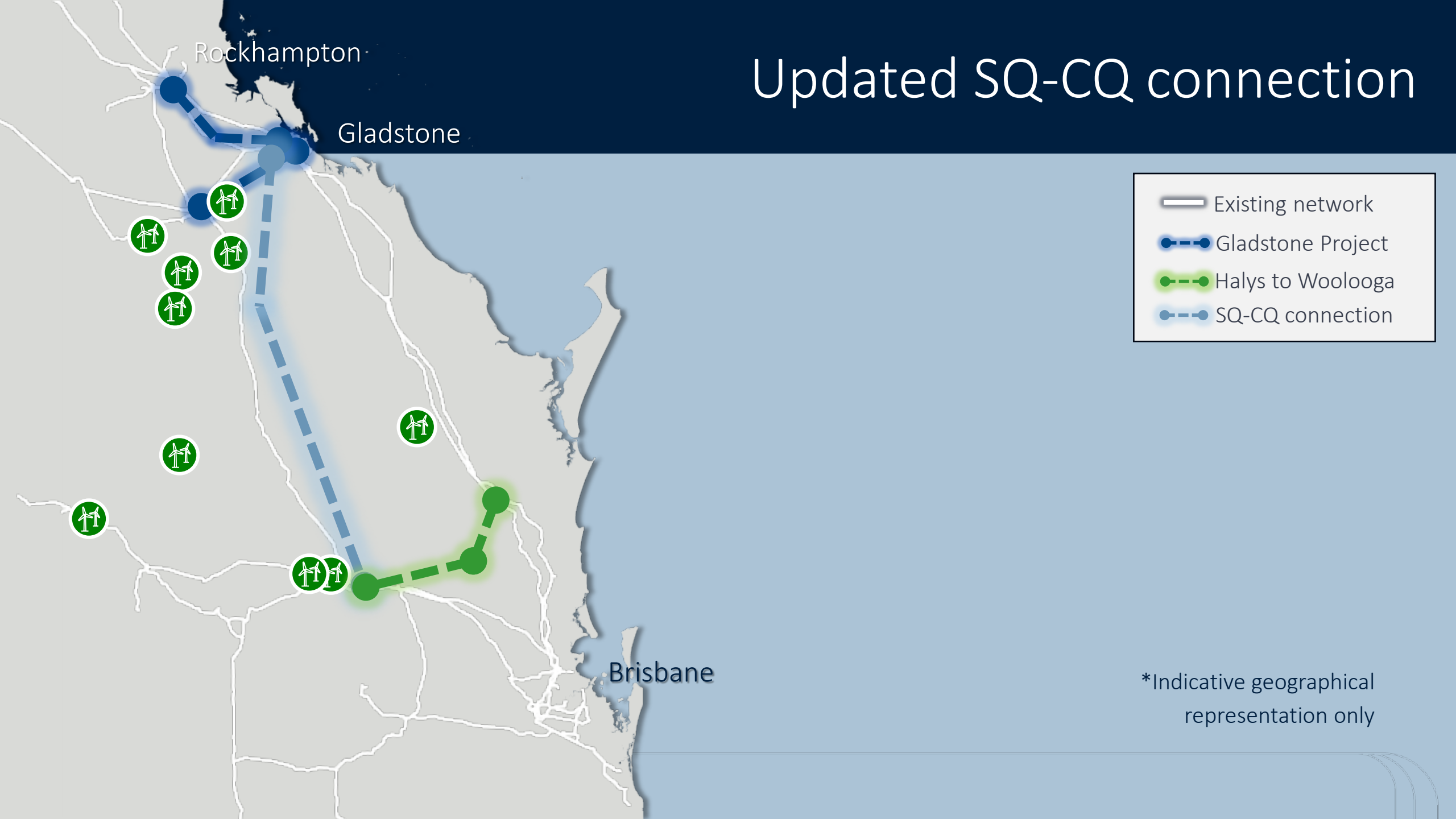
Original SQ-CQ connection



Updated SQ-CQ connection



Updated SQ-CQ connection



TAPR

Demand forecasts

Connection pipeline

Network development

Ancillary services

Leverage shared network capacity

Guide the market

Ancillary services

Technology type	System Strength - protection quality fault level	System Strength - stable voltage waveform	Inertia	Voltage control
Synchronous machines (gas, coal, PHES, syncon)	Yes – High	Yes	Yes – synchronous inertia *(note 2)*	Yes – slow voltage control
Grid forming BESS	Yes – Low *(note 1)*	Yes	Yes – synthetic inertia	Yes – fast voltage control
Grid forming STATCOM	Yes – Low *(note 1)*	Yes	No, without storage, Yes, with energy storage *(note 3)*	Yes – fast voltage control

(1) The magnitude is significantly lower than that of synchronous machines
(2) Synchronous condensers may require flywheels to provide sufficient inertia levels
(3) With an alternative configuration supercapacitors can provide inertia and primary frequency control

System Strength Regulatory Investment Test for Transmission (RIT-T)

- Powerlink is the designated System Strength Service Provider for Queensland, and is responsible for the provision of system strength services from 2 December 2025
- Commenced the RIT-T process to make system strength services available in March 2023
    - Around 80 unique potential solutions from over 20 proponents
- Project Assessment Draft Report published 4 November 2024
    - Technical and economic assessment of five portfolio options
    - Potential need for up to nine new synchronous condensers by 2034
    - Expect other cost-effective solutions to become available

System Strength proposed solution

- Contract with generating units in Southern and Northern Queensland
- Contract with existing gas turbines to install clutches
- Contract with grid forming batteries to enable connection of future renewable generation
- Powerlink to invest in two or three synchronous condensers in Central Queensland
- Maintain flexibility to reopen the regulatory investment test when other projects become committed

Submissions and proposals for non-network solutions due by
Friday, 20 December 2024

Email networkassessments@powerlink.com.au for information

TAPR

Demand forecasts

Connection pipeline

Network development

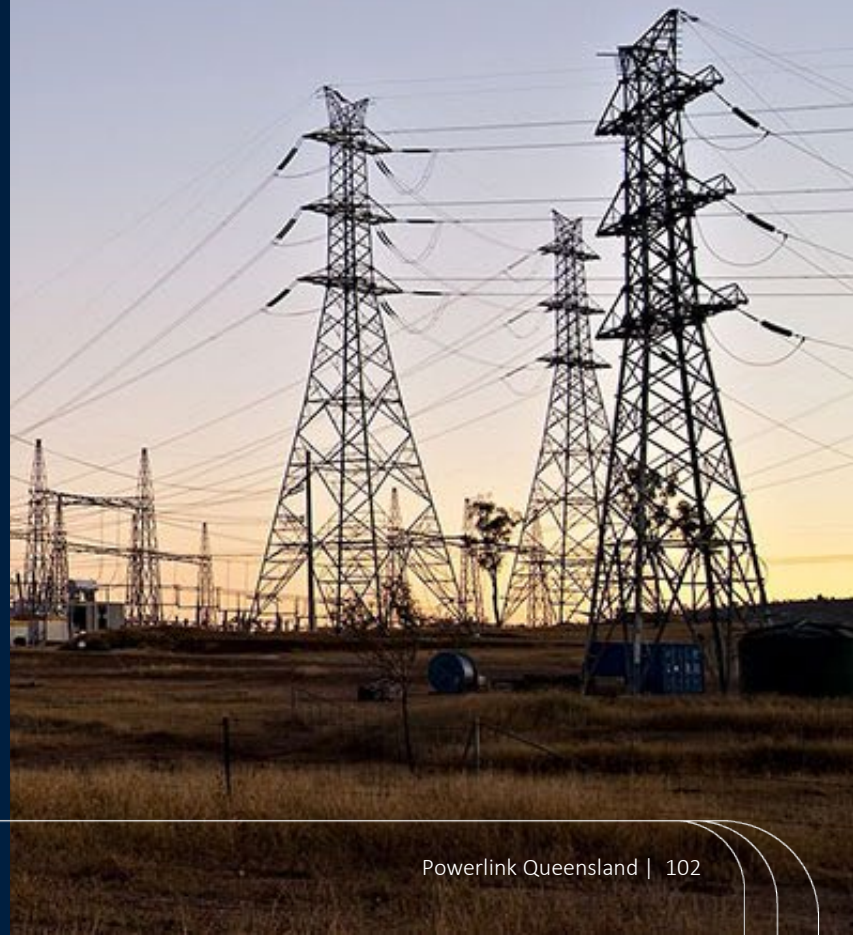
Ancillary services

Leverage shared network capacity

Guide the market

Getting more from what we have

- Wide Area Monitoring Protection and Control (WAMPAC)
  N-2 non-credible event
- Wide Area Monitoring Protection and Control for system strength
- High temperature conductor to provide a higher thermal capacity
- Real-time line ratings
- Virtual transmission line - we can use WAMPAC capability with batteries to get more out of the transmission network
- Leveraging flexible loads to defer augmentations



TAPR

Demand forecasts

Connection pipeline

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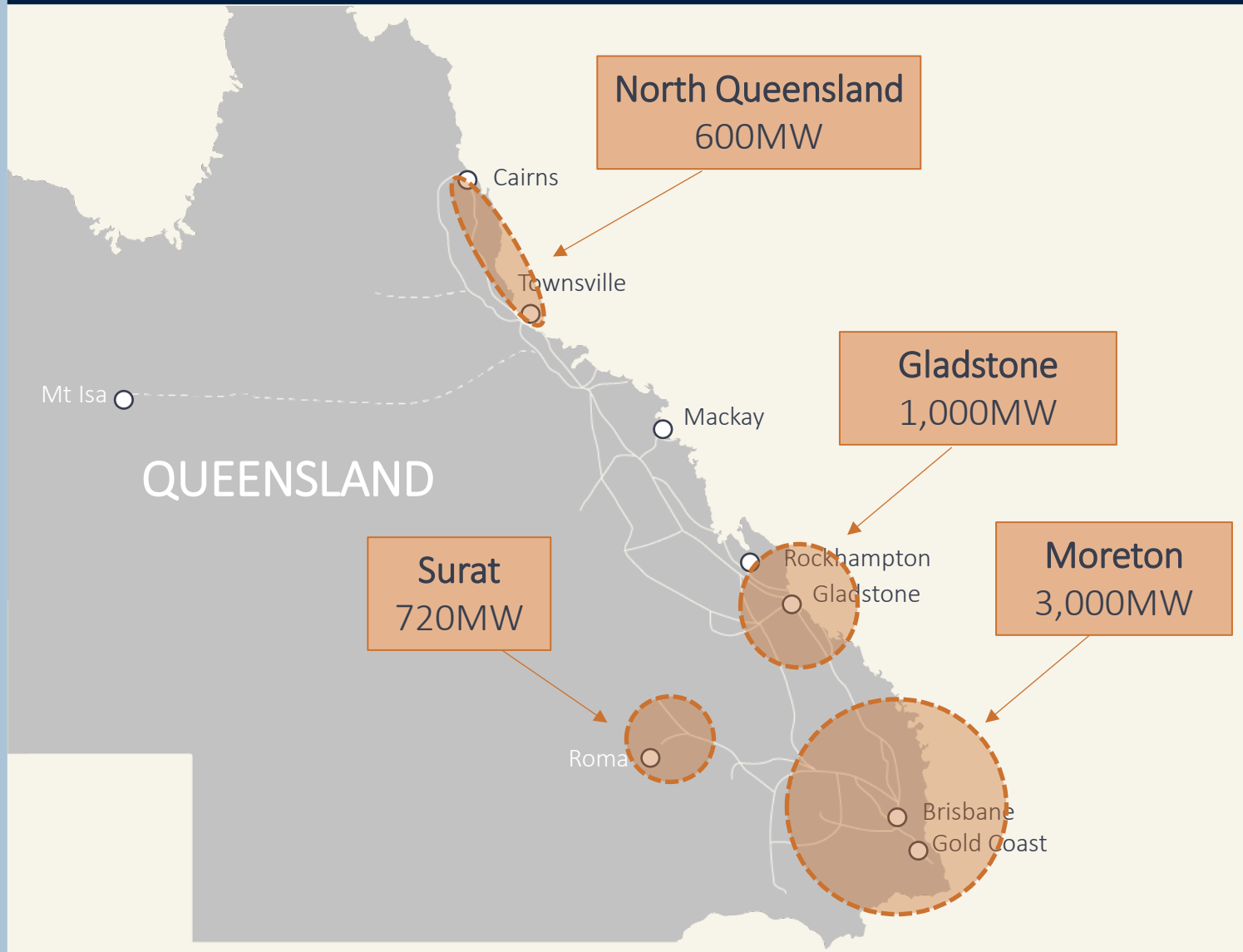
Leverage shared network capacity

Guide the market

Load centres



Pumped Hydro Energy Storage

EXISTING AND UNDER CONSTRUCTION

- **Kidston** 250MW 2.0GWh
- **Wivenhoe** 570MW 5.7GWh

PROPOSED

- **Borumba** 2000MW 48GWh
- **Capricornia Energy Hub** 750MW 12GWh
- **Cressbrook** (Big T) 400MW 4GWh
- **Flavian** 600MW 10GWh
- **Mt Rawdon** 1000-2000MW 20GWh

Total : ~6GW ~100GWh

Wind

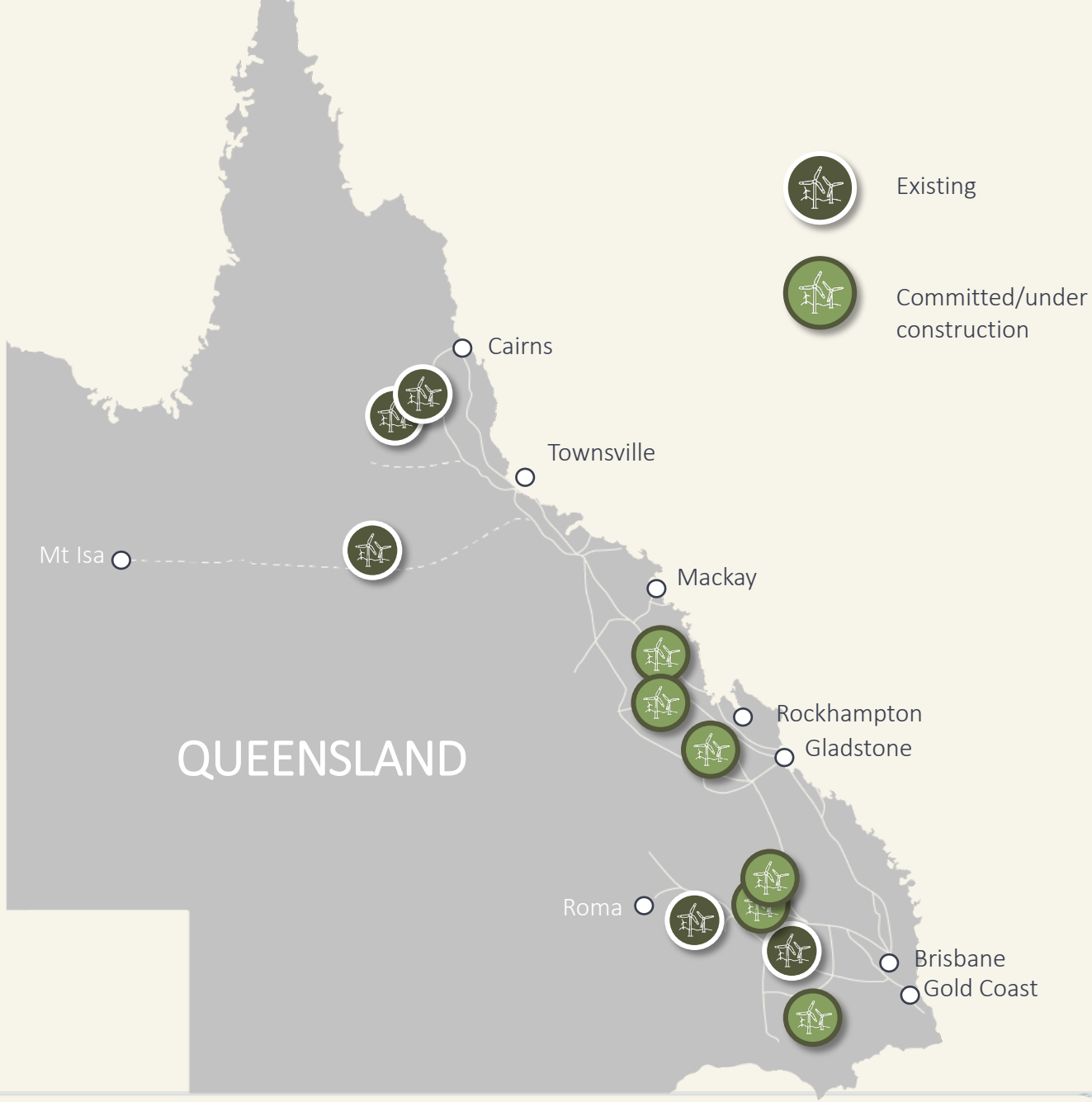
EXISTING

- **Coopers Gap Wind Farm** 440MW
- **Dulacca Renewable Energy Project** 173MW
- **Kaban Green Power Hub** 152MW
- **Kennedy Energy Park** 43MW
- **Mt Emerald Wind Farm** 180MW

UNDER CONSTRUCTION

- **Boulder Creek Wind Farm** 221MW
- **Clarke Creek Wind Farm** 440MW
- **Lotus Creek Wind Farm** 276MW
- **MacIntyre Wind Farm** 890MW
- **Wambo 1 and 2 Wind Farms** 497MW

Total : 3,312MW



Gas Generation

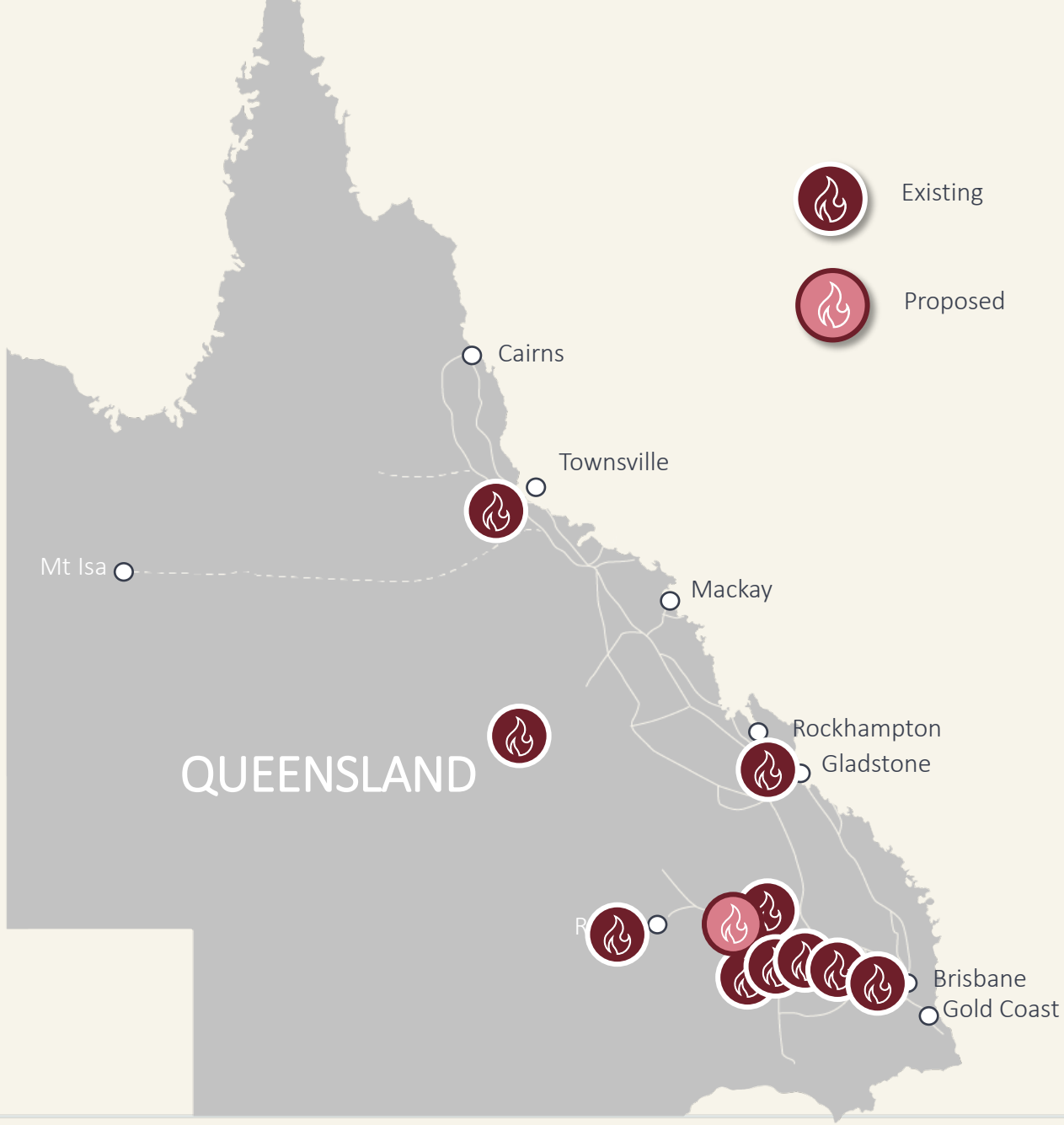
EXISTING

- **Barcaldine** 37MW
- **Braemar 1** 540MW
- **Braemar 2** 520MW
- **Condamine** 144MW
- **Darling Downs** 630MW
- **Oakey** 346MW
- **Roma** 68MW
- **Swanbank E** 365MW
- **Townsville** 240MW
- **Yarwun** 160MW

PROPOSED

- **Brigalow GT** 400MW

Total : 3,450MW



Batteries

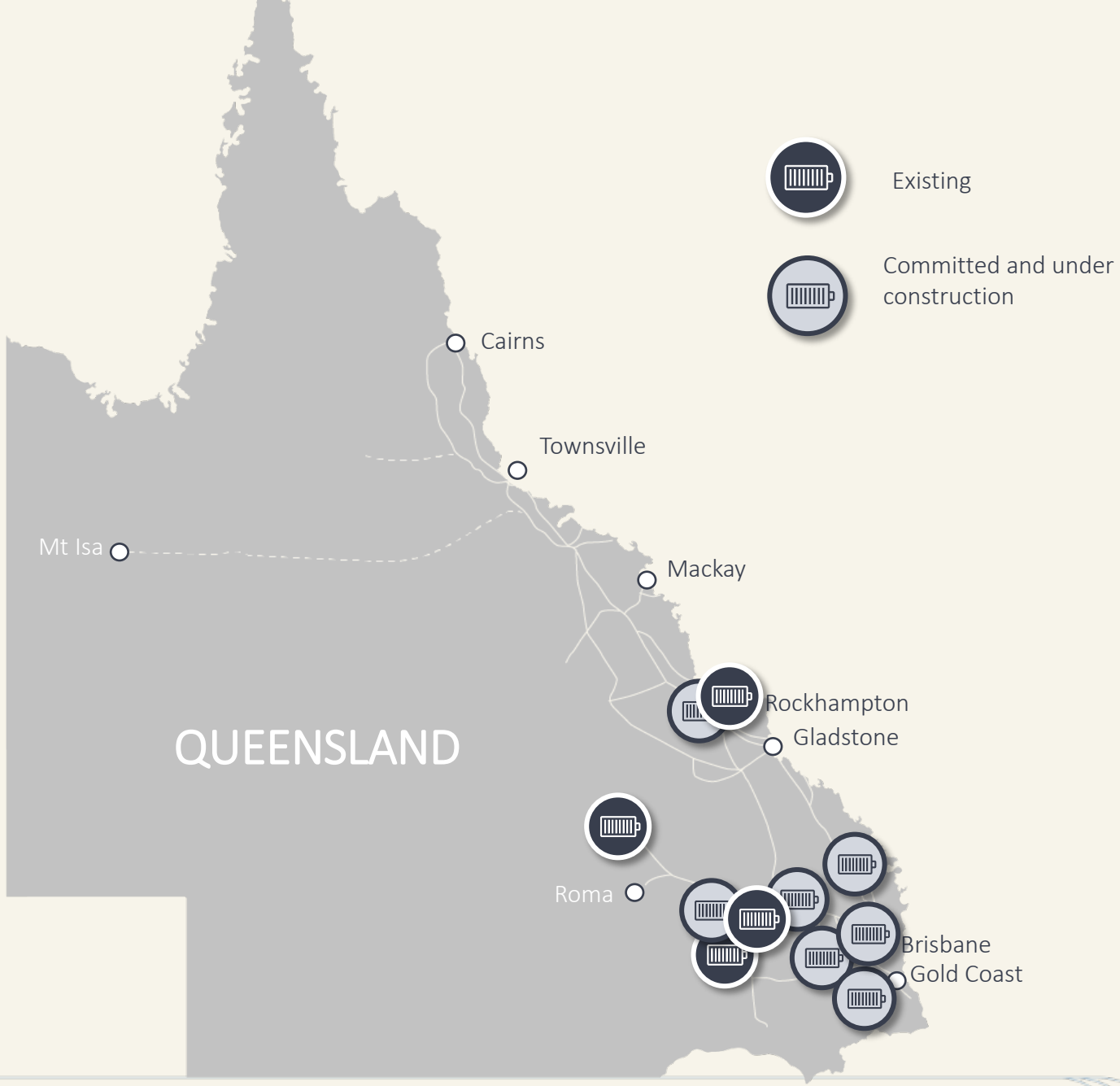
EXISTING

- **Bouldercombe** 50MW 100MWh
- **Chinchilla BESS** 100MW 200MWh
- **Wandoan BESS** 100MW 150MWh
- **Western Downs BESS** 200MW 400MWh

UNDER CONSTRUCTION

- **Central REZ BESS** 300MW 1200MWh
- **Greenbank BESS** 200MW 400MWh
- **Supernode BESS** 500MW 1500MWh
- **Brendale BESS** 205MW 410MWh
- **Swanbank BESS** 250MW 500MWh
- **Tarong REZ BESS** 300MW 600MWh
- **Ulinda BESS** 155MW 298MWh
- **Woolooga BESS** 200MW 400MWh

Total : 2,560MW 6,158MWh

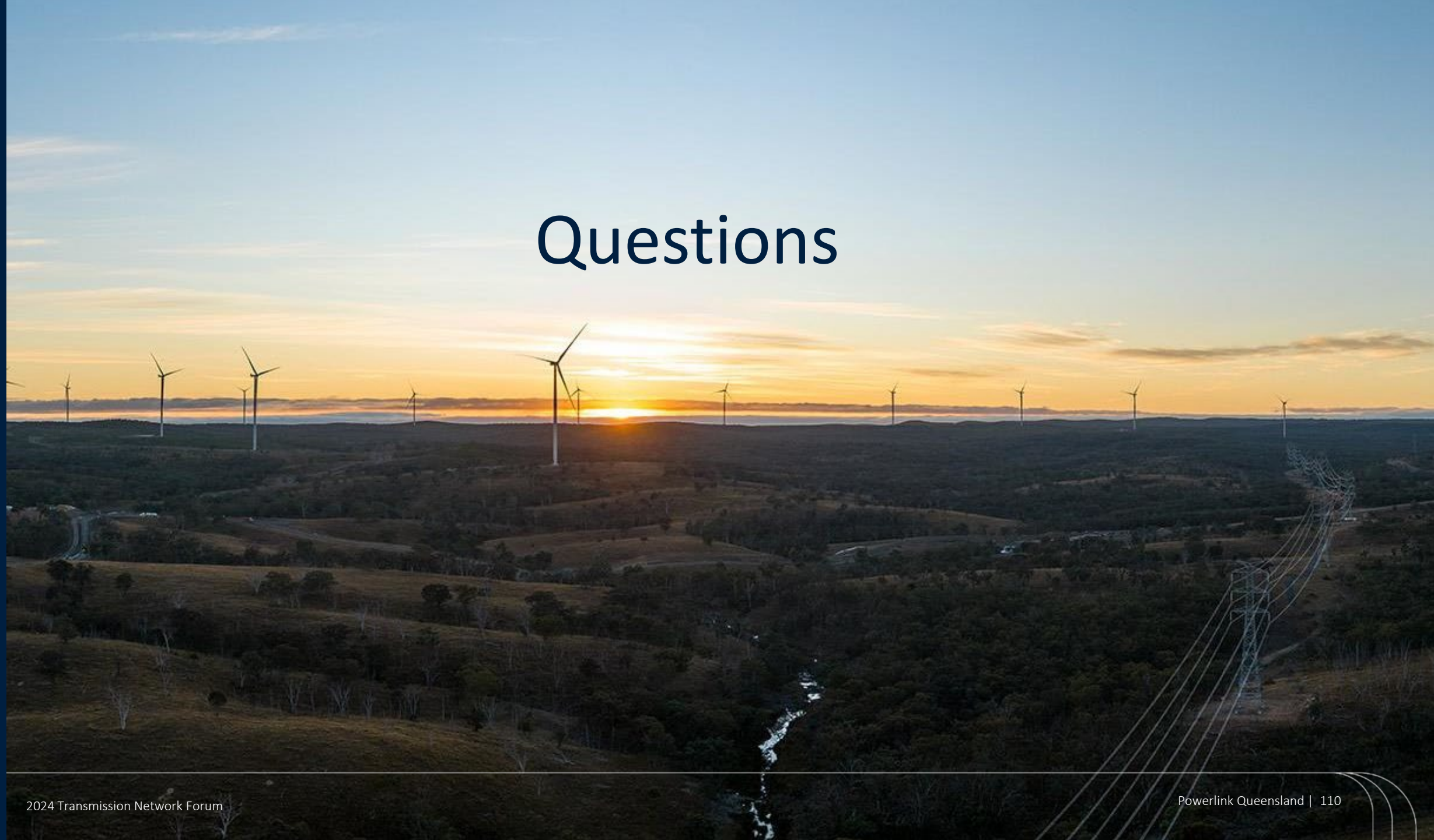


Dynamic Voltage Support

EXISTING

- **Woree** 132kV -80 – 150MVAr
- **Ross** 275kV -80 – 150MVAr
- **Strathmore** 275kV -94 – 260MVAr
- **Nebo** 275kV -80 – 260MVAr
- **Woolooga** 275kV -100 – 350MVAr
- **South Pine** 275kV -100 – 350MVAr
- **Blackwall** 275kV -50 – 250MVAr
- **Greenbank** 275kV -100 – 350MVAr

Questions



2024 Transmission Network Forum

A word from our **Chair**

Kathy Hirschfeld AM
Chair

HAVE YOUR SAY

Scan the QR Code to share your feedback and help us shape future forums

bit.ly/PQForumFeedback

Thank you for being part of our 2024 Transmission Network Forum