



Powerlink Queensland

Preparatory Activities – Darling Downs REZ Expansion (Stage 1)

2024 Integrated System Plan

June 2023



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Executive summary

The 2022 Integrated System Plan (ISP) [1] defined the projects and timing of 22 network investments in the optimal development path (ODP). Future ISP projects are a subset of these projects that are not yet 'actionable' under the new ISP Rules, but are expected to become actionable in the future. Those projects categorised as 'future ISP projects' require the responsible TNSP to carry out preparatory activities including providing a report of these activities to AEMO by 30 June 2023.

The Darling Downs REZ Expansion (Stage 1) is one of the Future ISP projects which is needed for the effective design of Renewable Energy Zone (REZ) expansions and flow path upgrades.

Appendix A5.5.2 of the 2022 ISP [2] describes the future ISP project associated with the Darling Downs REZ Expansion (Stage 1) as:

- Replace existing 1,125MVA 330/275 kV transformer at Middle Ridge with 1,500 MVA 330/275 kV transformer
- Implement a post-contingent bus-splitting scheme and a Special Protection scheme involving 300 MW SEQ Battery Energy Storage System (BESS) and generation run-back within Q8 REZ.

This report summarises the preparatory activities undertaken by Powerlink for this project for the purposes of input to future ISPs.

Preliminary Engineering Design

Single Line Diagram

The single line diagram (SLD) of the Middle Ridge 275kV Substation (refer to Figure 1) shows the existing connection arrangement of the 4T 1,125MVA transformer and proposed replacement works.

H014 MIDDLE RIDGE 275kV

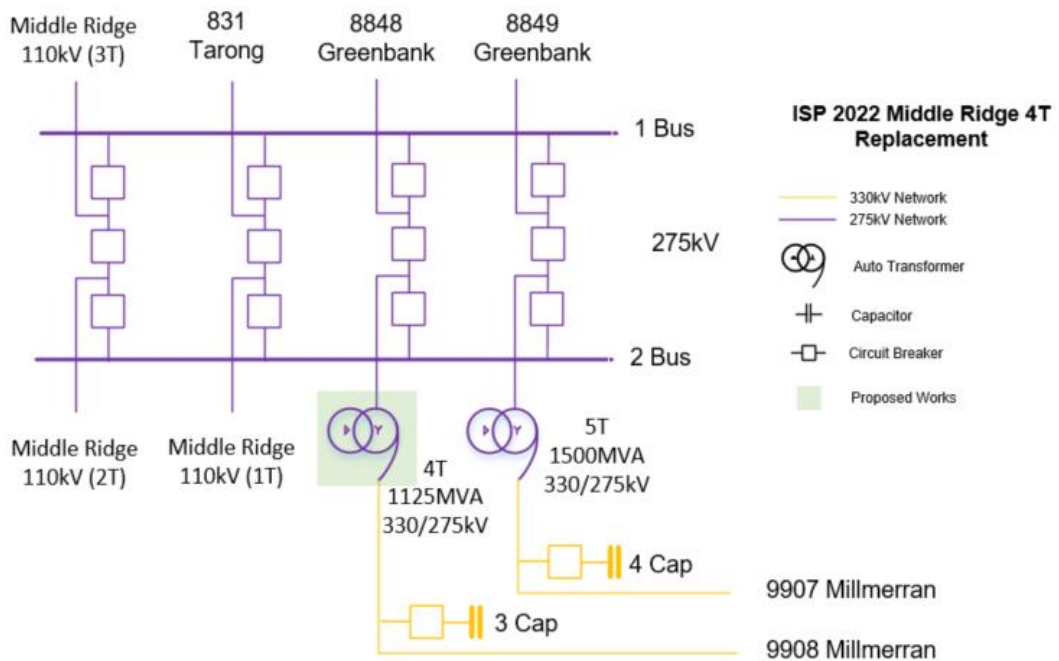


Figure 1 – Single line diagram of proposed works

Site Layout

Project staging requires the existing 4T to remain in service until the new 4T is commissioned into service. To facilitate the replacement, the new transformer will be located under the existing strung bus as shown in Figure 2.



Figure 2 – Overview of proposed works

Proposed substation works at Middle Ridge

The scope of work includes:

- Procure a new 330/275kV transformer rated at 1,500 MVA, including associated surge arrestors for all voltage levels.
- Civil works to establish new transformer pad.
- Review and update primary and secondary equipment associated with the transformer bays as required
- Decommission and recover the existing 4T.

Proposed estimate deliverable

Indicative site layout (general arrangement) diagrams and SLDs are being prepared for the Middle Ridge Substation to inform estimating. These will capture high level staging, outage requirements and site constraints. These detailed 'work products' will not be presented due to the complexity in

the diagrams and the indicative nature of the layout, but are required for the cost estimate. The estimate will also consider resource requirements and availability.

Asset List

The total procurement costs for each broad asset grouping is provided in the cost estimate in Table 5. Powerlink does not present itemised costs for specific plant items to external parties, as this is commercially sensitive information subject to confidentiality.

Network Parameters and Transfer Limits

Network Parameters

For the following studies, Powerlink modelled the replacement 330/275kV transformer with identical parameters to the existing 5T 1,500MVA transformer at Middle Ridge.

Existing Transfer Limits

The maximum power transfer capability during system normal conditions may be set by the emergency cyclic rating of 4T transformer at Middle Ridge Substation (1,293MVA). The critical contingency is an outage of the parallel 330kV transformer-ended circuit between Millmerran and Middle Ridge substations which also removes the 5T 1,500MVA transformer.

System conditions in Southern Queensland have the biggest impact on the emergence of this thermal limitation. Key dependencies include:

- Net-load in South East Queensland (SEQ)
- Generation dispatch in South West Queensland. Generators with the greatest impact include (descending in impact) :
 - Generation in the south of the Darling Downs REZ (e.g. Bulli Creek or further east of Millmerran)
 - Millmerran Power Station
 - QNI north transfers
 - Generation at Braemar
 - Generation at Western Downs
 - Generation at Tarong or Halys.

Transfer Limits following replacement of 4T transformer

The replacement network project increases the N-1 capability through Middle Ridge 330/275kV 4T from 1,293MVA to 1,650MVA. 1,650MVA is greater than the emergency cyclic rating of the 330kV line in series with the remaining transformer. It is assumed that real-time-ratings, together with the post-contingent action of any Special Protection Scheme (SPS), and National Electricity Market Dispatch Engine (NEMDE) beginning to re-dispatch to resecure the system, will mean that the 330kV line will not, at times, be a limitation.

Assumptions and Methodology

For the purposes of this preparatory activity, the 4T transformer replacement benefit is quantified by the increase in the Darling Downs REZ generation pre and post the upgrade.

AEMO has provided Powerlink with three PSS[®]E cases representing different future system conditions which have been labelled as Summer Peak, Summer Typical and Winter Typical. These cases are the starting point for the analysis.

The following network changes have been applied to each case prior to any analysis:

- The QEJP stage 1 projects have been included. This involves the establishment of 2GW Borumba PHES connected at 500kV to Halys and Woolooga West substations (with 275kV connection from Woolooga West to Woolooga Substation).
- Feeder ratings have been updated to reflect the seasonal ratings that would apply.

AEMO requested the limits be specified in a simplified manner (single numbers) that can be used in the Detailed Long-Term (DLT) model. To meet this requirement Powerlink has applied the following methodology to derive the Darling Downs REZ limit for each system condition:

1. Calculate thermal limit of the existing network by increasing the output of the Darling Downs REZ generation.
2. Upgrade Middle Ridge 330/275kV 4T transformer.
3. Recalculate the thermal limit for each system condition.

The results of this analysis are summarised in Table 1.

Table 1 – Darling Downs REZ limits for Existing Network

System Condition	Darling Downs REZ Capacity (MW)		
	Pre Upgrade	Post Upgrade	Increase
Summer Peak	4100	4700	600
Summer Typical	5700	6200	500
Winter Typical	7600	8100	500

The variation in the Darling Downs REZ generation is a result of the different generation dispatches set in each of the base cases. However, the increase in capacity provided by the Middle Ridge 4T transformer replacement is consistent across the cases.

Paired generation run-back

This involves implementing a SPS that triggers an increase in generation at BESS in South East Queensland (SEQ) and a balanced reduction in generation from the renewable generators in the southern Darling Downs REZ. This post-contingent interchange of generation reduces the power transfer through the 4T Middle Ridge transformer. Renewable generation closer to Middle Ridge will have a greater impact in relieving the constraint.

This SPS can be implemented for the existing network or following the 4T 330/275kV transformer upgrade to 1,500MVA.

To quantify the benefit of this run-back scheme, an assumed 200MW BESS located at Greenback Substation was paired with generation connected between Millmerran and Middle Ridge Substations. Power system simulations showed that this configuration increased the hosting capacity of the Darling Downs REZ by more than 200MW. The results are summarised in Table 2.

Table 2 – Paired generation run-back limit increases

System Condition	BESS Capacity (MW)	Darling Downs REZ Capacity Increase (MW)	
		Existing Network	Post-4T Upgrade
Summer Peak	300	330	360
Summer Typical	300	330	360
Winter Typical	300	330	360

Special protection bus splitting scheme

This involves radialising some or all of the variable renewable energy (VRE) generation that connects in the southern part of the Darling Downs REZ. VRE generation that connects between Millmerran and Middle Ridge substations can have a significant impact on the power flows through the Middle Ridge 330/275kV transformers, both under system intact and following critical contingencies.

The proposed SPS:

- detects an outage of 4T or 5T transformers at Middle Ridge Substation (and will be extended to include the monitoring of the 275kV circuits between Middle Ridge and Greenbank substations), and
- if the contingency would overload the remaining parallel element, then
- split the 330kV system between Millmerran and the VRE point-of-connection (PoC) to the east of Millmerran or split the PoC substation such that a percentage of the VRE is connected radially to Middle Ridge Substation with the remainder connected radially to Millmerran Substation. Depending on the size (and operation) of the VRE generation the SPS may also need to post-contingent run-back the output of one or both of these radialised components.

For this report the proposed scheme was tested against the three base cases provided by AEMO. It was assumed that:

- Following the operation of the SPS, a maximum of 1200MW of generation would be connected radially to Middle Ridge Substation.
- The remainder of the VRE would be connected to Millmerran Substation.
- The SPS lands the power system in a satisfactory state which will require generation re-dispatch to resecure the network due to thermal constraints between Bulli Creek and Braemar substations and FCAS raise limits (due to the now credible contingency loss of the VRE connected to Middle Ridge Substation). The amount of generation that can be assumed to be in reserve to resecure the network following the operation of the SPS will be a critical consideration but is outside the scope of this report.

Power system analysis shows that the benefit of the SPS is sensitive to QNI flows and generation at Millmerran and Bulli Creek and the capacity and operating level of the VRE generation that may be connected east of Millmerran Substation. The results of this analysis are summarised in Table 3. A range of limit increases is shown. The lower number assumes that the capacity of the VRE that is radially connected to Middle Ridge is 750MW and the upper number maintains this VRE within the rating of the existing 4T transformer.

Table 3 – Special Protection Scheme limit increases

System Condition	Darling Downs REZ Capacity Increase (MW)
Summer Peak	300 - 800
Summer Typical	500 - 1000
Winter Typical	600 - 1100

Project schedule and staging

A high level staging plan for an assumed commissioning date of December 2026 is presented in Table 4.

Table 4 – High level schedule and staging

Activity	Target Completion
Project Approval – Delivery	June 2025
Substation Site Access	October 2026
Commission	June 2027

Cost estimates

The cost estimate is presented in Table 5. This is a class 5 estimate.

Table 5 – Estimate breakdown

Middle Ridge 330/275kV Transformer Replacement and SPS Class 5	Base Cost \$k, real 2023
Overheads	668
Project Management, Coordination and Other Support	668
Substations	19,431
Design	1,070
Procurement	13,923
Construction	3,503
Commissioning	932
Post Commissioning	3
Network Operations	145
Estimate Total	20,244
Total Contingency	8,098
Mitigated Risk (Known Risk)	4,049
Contingency (Unknown Risk)	4,049
Estimate Total (including Risk & Contingency)	28,342

A detailed summary of the risks considered and included in each estimate are not available at this stage of development, therefore estimate allowances and risk costs have been based upon the class of estimate presented.

Approvals and stakeholders

Stakeholder engagement plan

Powerlink is committed to genuine and timely stakeholder engagement that leads to improved decision-making and better outcomes for our stakeholders. A detailed stakeholder engagement plan will be developed prior to engagement activities commencing, which will apply the principles established in our Stakeholder Engagement Framework [3]. Key stakeholders include customers, consumer advocacy groups, communities, landholders, Traditional Owners, our Customer Panel, State and Local Government representatives.

Stakeholder assessment

Given that all works for this project is within the existing substation, the number of key stakeholders involved will be reduced to adjoining/ neighbouring interests.

Estimate of planning approval complexity

No planning approval is required for the proposed substation works.

References

1. 2022 Integrated System Plan, July 2022, <https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp>, accessed 19 March 2023, Australian Energy Market Operator.
2. 2022 ISP Appendix 5. Network Investments, July 2022, <https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/a5-network-investments.pdf?la=en>, accessed 19 March 2023, Australian Energy Market Operator.
3. Stakeholder Engagement Framework, <https://www.powerlink.com.au/engagement-framework>, accessed 19 March 2023, Powerlink Queensland.