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The 2024 ISP Preparatory Activities – QNI Connect

June 2023

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Contents

Executive Summary

In accordance with the 2022 Integrated System Plan (ISP), Transgrid has undertaken preparatory activities for the Queensland-New South Wales Interconnector, QNI Connect, for the purposes of the 2024 ISP. The final QNI Connect report is required to provide the outcome of preparatory activities including:

- Preliminary engineering design.
- Desktop easement assessment.
- Cost estimates based on preliminary engineering design and route selection.
- Preliminary assessment of environmental and planning approvals.
- Appropriate stakeholder engagement.

This report summarises the preparatory activities undertaken by Transgrid by 30 June 2023, including updated project scopes within the New South Wales region for the purposes of the 2024 ISP.

After publication of the 2022 ISP, both the QLD and NSW governments released blueprint documents for network Infrastructure development for their individual states. Substantial transmission and renewable generation investment will be delivered to transform the electricity network to enable decarbonisation of the existing electricity system. Considering these changes, the 2024 ISP QNI Connect preparatory activities give priority to optimising QNI Connect network options with New England REZ development[1] to maximise net economic benefits.

The following four network options are identified for QNI Connect:

- Option 1: 330 kV single circuit
- Option 2: 330 kV double circuit
- Option 3: 500 kV double circuit
- Option 4: 330 kV double circuit and Virtual Transmission Line

The preparatory activities evaluated the end-to-end transmission line routes identified including electrical options, and substation location options. Desktop easement assessment, preliminary designs and cost estimation have been undertaken to evaluate and identify the corridor/route selection. In addition, project schedule and staging, environmental and stakeholder assessment, engagement plan and planning approvals are presented in this 2024 ISP preparatory activities report for QNI Connect. The study identifies the transmission line route that presents the least risk on environmental planning, technical and cost grounds, while also helping the integration of renewable generation and sharing energy from QLD.

[1] The Network Infrastructure Strategy, May 2023, EnergyCo

Transgrid

1. Need for a Stronger QLD and NSW Interconnector

The NSW electricity network is currently facing significant challenges, as it facilitates decarbonisation with the growth of large-scale renewables seeking connection to the grid and the accelerated retirement of traditional coal generation. A stronger QLD and NSW interconnector could help the integration of renewable generation, allow for the efficient transport of electricity and enhance the reliability and stability of the electricity grid during the transition of the NSW transmission network to net zero emission by 2050.

1.1. Supporting integration of substantial REZ generation

After publication of the 2022 ISP, the QLD and NSW governments published blueprint documents for network infrastructure development for their individual states. The Network Infrastructure Strategy for NSW[2] outlines the roadmap to deliver REZ zones by coordinating transmission and renewable generation. New England REZ, to be connected to the QNI interconnector, is proposed with an intended capacity of 8 GW. New network infrastructure will be built to enable new generation and storage projects to connect and transport their energy to consumers, both in and outside the REZ.

The Queensland SuperGrid Infrastructure Blueprint[3], as optimal infrastructure pathway for the Queensland Energy and Jobs Plan (QEJP), outlines key areas to transform the QLD electricity system, including new foundational Pumped Hydro Energy Storage (PHES) assets, new backbone transmission and substantial new renewables in Queensland Renewable Energy Zones (QREZ). The Queensland Government has established three regions for developing QREZ in Northern, Central and Southern Queensland. This involves approximately 12 GW of new large-scale wind and 10 GW of new large-scale solar to be developed in the QREZ regions by 2035. The integration of the large-scale PHES and renewable generation projects will extend 500 kV transmission lines from north Queensland to Halys. With 500 kV transmission development proposed in NSW and Queensland to integrate individual REZ generation to QLD and NSW load centres separately, a stronger QLD and NSW interconnector will provide alternative flow paths for the REZ generation and ensure successful integration of REZs into existing networks.

1.2. Changes in fuel consumption arising through different generation dispatch

NSW and QLD regional demand is greater than 60 % of NEM total demand and the QNI flow limit of the existing QNI is up to 1450 MW[4]. Increasing QNI flow capacity could improve the sharing of generation between Queensland and the rest of the NEM, and harness clean low-cost renewable generation. Sharing of generation is expected to facilitate the substitution of high fuel cost plants with low fuel cost plants, which would reduce the overall cost of dispatch by reducing fuel costs and variable operation and maintenance costs.

[2] The Network Infrastructure Strategy, May 2023, EnergyCo
[3] Queensland SuperGrid Infrastructure Blueprint, Sep. 2022, Queensland Government Department of Energy and Public Works
[4] Final-inter-network-test-program-document.pdf (aemo.com.au), May 2022, AEMO

1.3. Alleviate risks due to accelerated coal generation retirement

The acceleration of coal generation retirement, for example, Eraring generation, will cause a reduction of dispatchable energy in NSW. Therefore, a greater diversity of energy sources will be required to ensure energy security for NSW, including high-capacity interstate connections. As the grid becomes more reliant on renewables, higher capacity of QNI and earlier delivery of the project is crucial to de-risk against renewable droughts, outages, as well as delays that may occur in the development of the NSW REZs.

1.4. NSW Energy Superhighway

The QNI Connect 500 kV option will establish a 500 kV Energy Superhighway with end-to-end continuity from Victoria through to Queensland (Figure 1).

Figure 1 NSW Energy Superhighway

The 500 kV Northern Superhighway (Figure 2) extends from Bayswater in the south to the New England REZ Central Hub (via New England Renewable Energy Zone project), and from Central Hub it runs north through the New England REZ to Dumaresq, to the state border (via QNI Connect). Powerlink continue the 500 kV double circuit onwards to Halys, north-west of Brisbane.

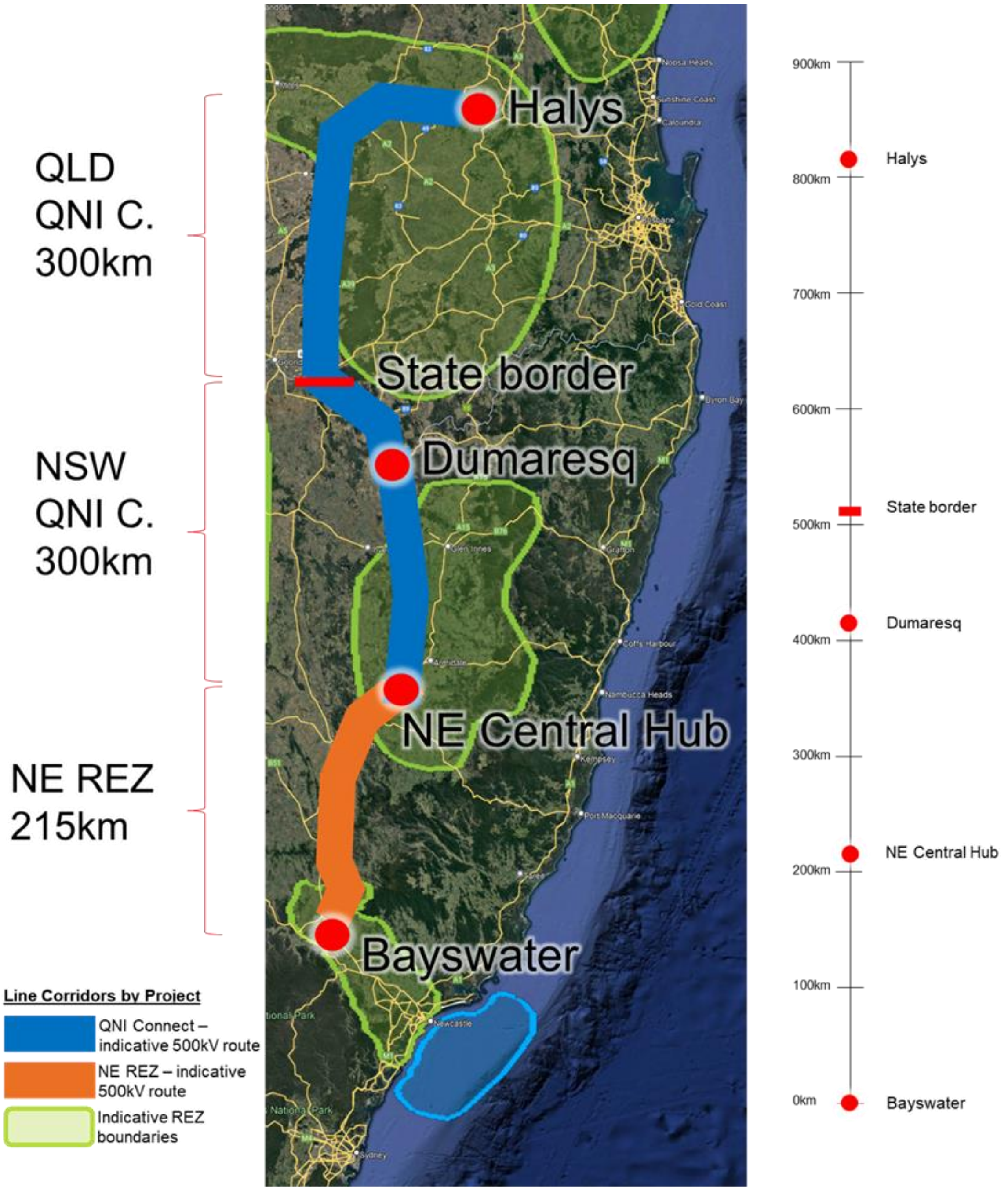

Figure 2: Northern Energy Superhighway

Note that line routes shown are indicative only, the REZ boundaries are indicative only (and have been sourced from AEMO Draft 2023 IASR data), and that other QNI Connect options including 330 kV transmission lines are considered and presented in this document.

2. Collaboration with Powerlink

To ensure the smooth development of the network and generation activities along the QNI Connect corridor and achieve the necessary milestones for preparatory activities, Transgrid and Powerlink are working together in collaboration to conduct detailed preparatory work as proposed by AEMO. The two organisations regularly hold joint planning meetings to discuss and develop planning options that are in alignment with each other as Transmission Network Service Providers (TNSPs). This collaboration ensures that each organisation is integrated into the QNI Connect project with respect to their respective components and stages of options under consideration. By continuing this collaboration, both parties can maintain a thorough understanding of the project's requirements as further options are considered.

3. Preliminary Engineering Design

This section discusses the preliminary engineering design for four proposed QNI Connect options.

3.1. Option 1: 330 kV single circuit

3.1.1. Network diagrams

This option involves constructing a new 330 kV single circuit line from the Queensland/ NSW state border – Dumaresq – New England Central Hub as shown in Figure 3 . This network option will connect to a Queensland 330 kV single circuit option at the state border which will terminate at Bulli Creek in Queensland.

The scope for this option includes:

- New 330 kV single circuit line from the state border to Dumaresq totalling a route length of 52 km (estimate).
- New 330 kV single circuit line from Dumaresq to New England Central Hub totalling a route length of 194 km (estimate).
- Modification of the planned New England Central Hub[5].
- Expansion of the existing Dumaresq 330 kV Switching Station.

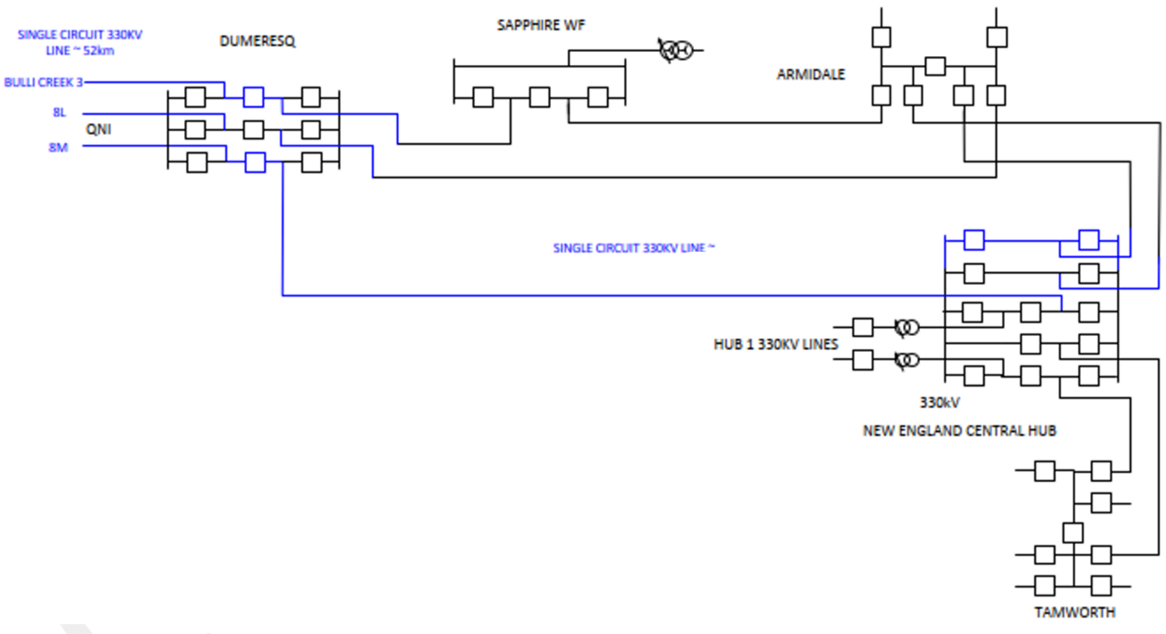

Figure 3 Network diagram for Option 1 – 330 kV Single Circuit

The diagrams for each substation involved in the augmentation are also provided to estimate the associated costs.

[5] New England Central Hub is proposed in the New England REZ network option. The detailed New England Central Hub location and substation design for all QNI network options are to be coordinated with EnergyCo.

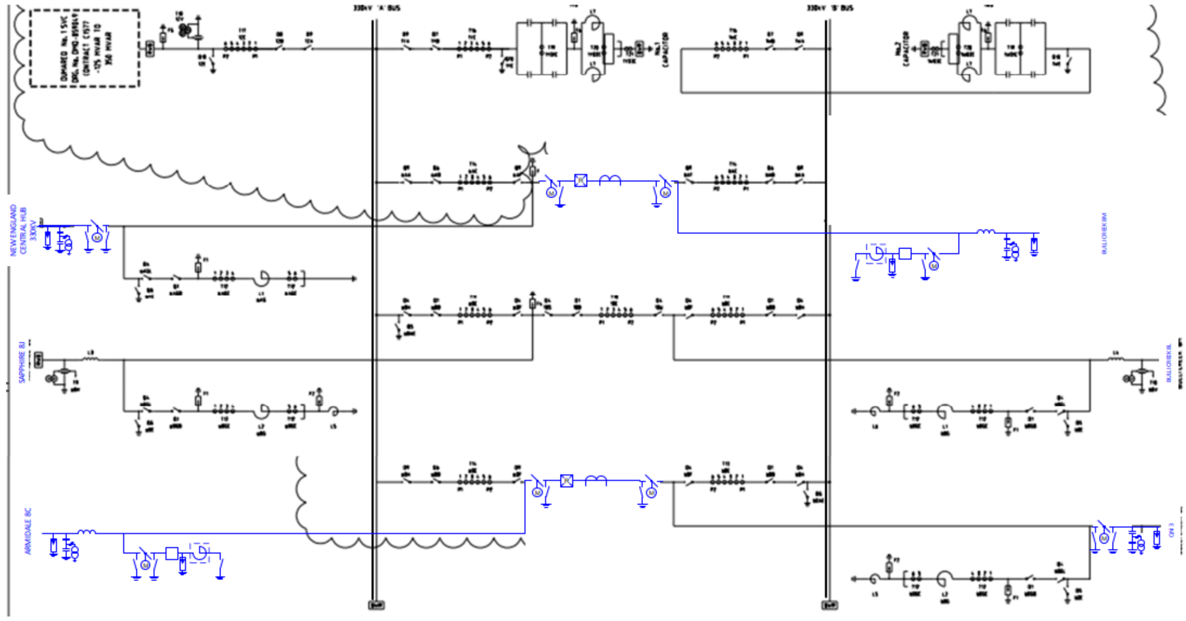

Figure 4 Augmentation diagram for Dumaresq substation

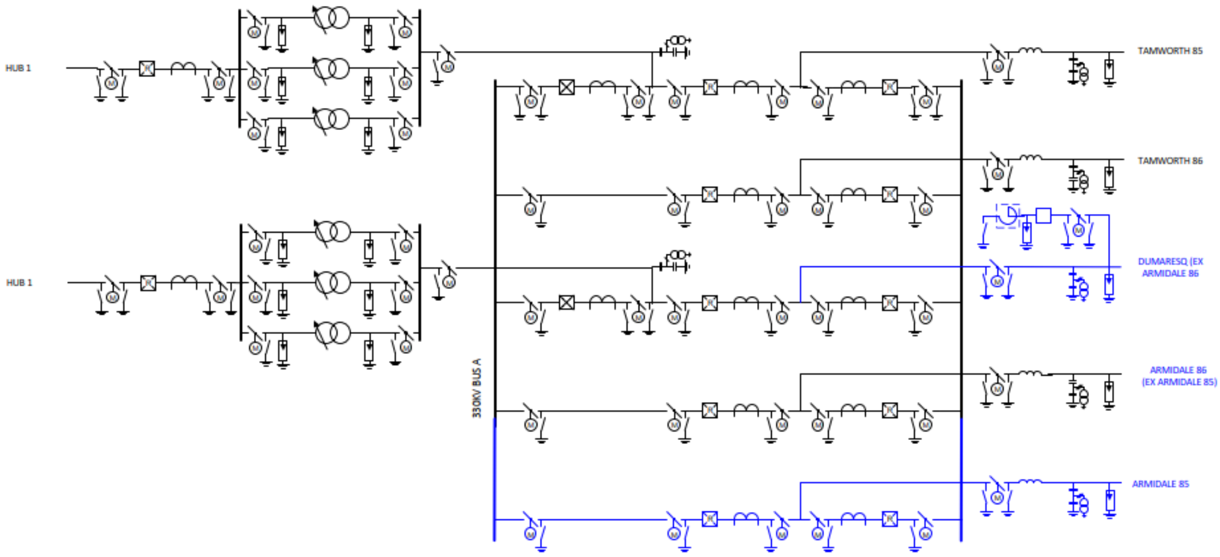

Figure 5 Diagram for planned New England Central Hub

3.1.2. Network parameters

Table 1 presents the electrical network parameters required to model the network augmentation and perform power system analysis.

Table 1: Transmission line electrical parameters using (100 MVA/330 kV base quantities)

Circuit	R (%)	X (%)	B (%)	R0 (%)	X0 (%)	B0 (%)
QNI Border – Dumaresq	0.146	1.405	20.450	0.671	3.620	12.659
Dumaresq – New England Central Hub	0.541	5.220	75.970	2.492	13.449	47.026

Thermal ratings for the lines are based on the 330 kV Twin Olive conductors in the QNI corridor. The normal and contingency ratings for the lines are shown in Table 2[6].

Table 2: Thermal ratings for the new transmission line

Season	Time	Normal (MVA)	Contingency (MVA)
Summer	Day	1232	1382
	Night	1319	1424
Autumn and Spring	Day	1220	1368
	Night	1343	1443
Winter	Day	1318	1437
	Night	1429	1513

3.1.3. Transfer limits

Power system analysis has been undertaken to identify the thermal limits before and after the proposed QNI Connect augmentation as part of the preparatory activities. The following generation and load assumptions were made in this analysis:

- Three different demand levels, including Summer Peak Day, Summer Typical Night and Winter Typical Night.
- Summer daytime, summer night-time, and winter night-time line ratings are used in respective 2029 PSSE study cases.
- The generation dispatch has been modified to maximise the QNI flow from NSW to Queensland. This includes maximum generation from existing coal generators (Bayswater and Mt Piper), no generation from retired coal generators, maximum generation from Snowy 2, Lower Tumut and Upper Tumut, generation from existing and committed wind farms, and generation from Central-West Orana REZ and New England REZ as required. All REZs generation are modelled assuming automatic access standard reactive power capability.
- New England REZ development is modelled as per the latest update from EnergyCo in NSW Network Infrastructure Strategy report[7]. New England REZ Option 1 would deliver 2.4 GW network capacity by 2029 and the augmentation of Option 1 includes new double circuit lines built at 500 kV from Bayswater to a Central South hub and then a Central hub. The Central South hub to the Central hub will operate at 330 kV first. Option 1 also include phase shift transformers on Central hub, which cut into the existing lines 85 and 86[8]. In addition, New England REZ highlights the need for additional long-duration storage in the region by 2029.
- The QNI Connect transfer limit are based on thermal limit calculation only and reactive power support may be required to maximize the QNI connect transfer capacity.
- The 900 MW Lower Creek pumped hydro generator is modelled at Armidale as a sensitivity analysis, with reactive power capability aligning automatic access standard.

The thermal transfer limits for the three typical cases without and with the Lower Creek pumped hydro are presented in Table 3 and Table 4.

[6] Transgrid's line ratings are slightly different from Powerlink's line ratings as different transmission line conductor type were used.
[7] NSW Network Infrastructure Strategy, May 2023, EnergyCo
[8] NSW Network Infrastructure Strategy – Appendix B: Network Infrastructure Options, May 2023, EnergyCo

Table 3: Transfer limits for Option 1 without Lower Creek pumped hydro

System Condition	Calculated QNI Northerly Limits (MW)		
	Pre-Upgrade	Post Upgrade	Limit Increase
Summer Peak	1090	1820	730
Summer Typical	1140	1800	660
Winter Typical	1220	1890	670

Table 4: Transfer limits for Option 1 with Lower Creek pumped hydro

System Condition	Calculated QNI Northerly Limits (MW)		
	Pre-Upgrade	Post Upgrade	Limit Increase
Summer Peak	1330	2480	1150
Summer Typical	1310	2490	1180
Winter Typical	1310	2410	1100

3.2. Option 2: 330 kV double circuit

3.2.1. Network diagrams

This option involves constructing a new 330 kV double circuit line from the Queensland/ NSW state border – Dumaresq – New England Central Hub as shown in Figure 6. The transmission line will connect to a Queensland double circuit 330 kV option that would terminate at Bulli Creek.

The scope for this option includes:

- New 330 kV double circuit line from the Queensland/ NSW state border to Dumaresq totalling a route length of 52 km (estimate).
- New 330 kV double circuit line from Dumaresq to the planned New England Central Hub totalling a route length of 194 km (estimate).
- Modification to the planned New England Central Hub.
- Expansion of the existing Dumaresq 300 kV Switching Station.
- The diagrams for each substation involved in the augmentation are also provided to estimate the associated costs.

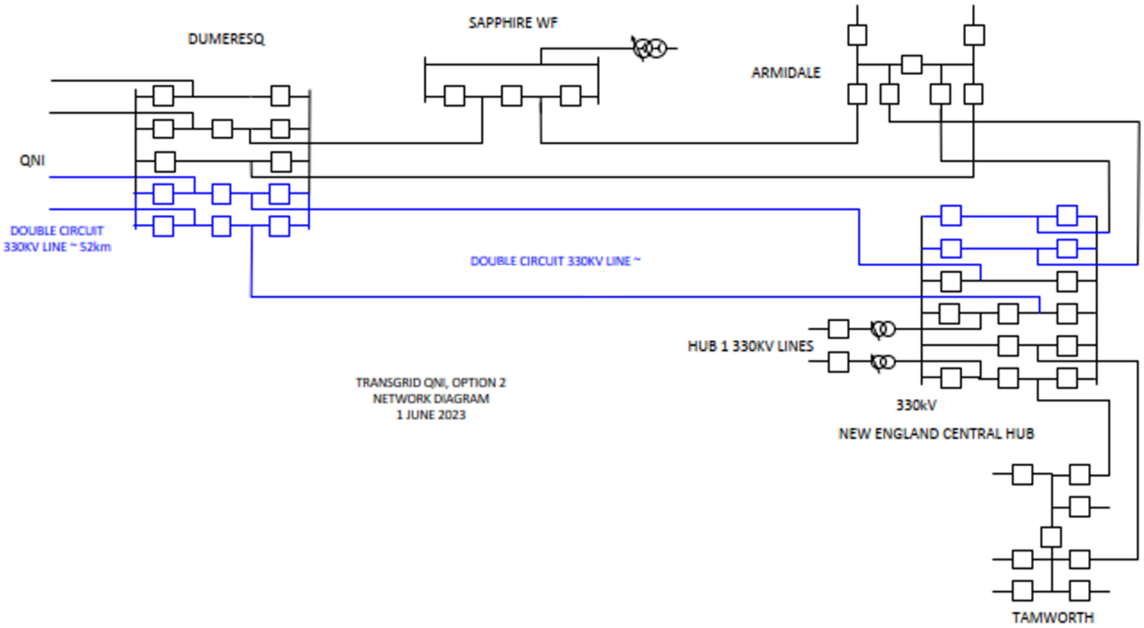

Figure 6: Network diagram for Option 2 – 330 kV Double Circuit

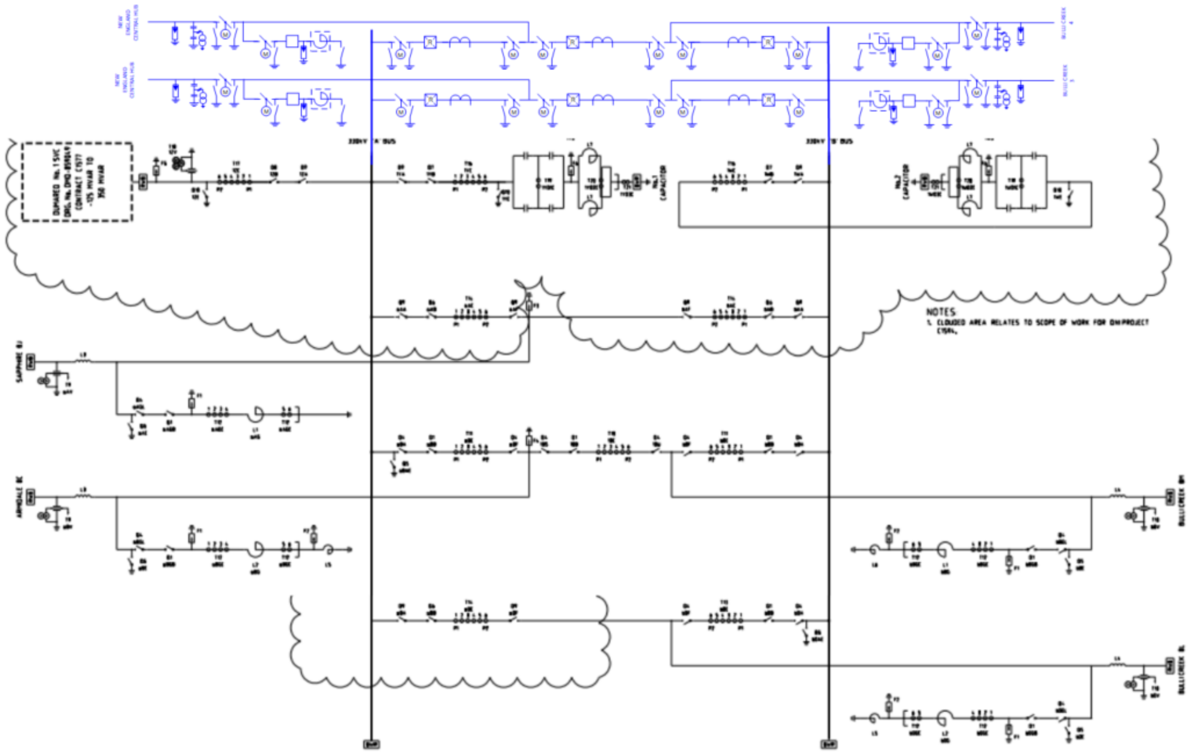

Figure 7: Augmentation diagram for Dumaresq substation

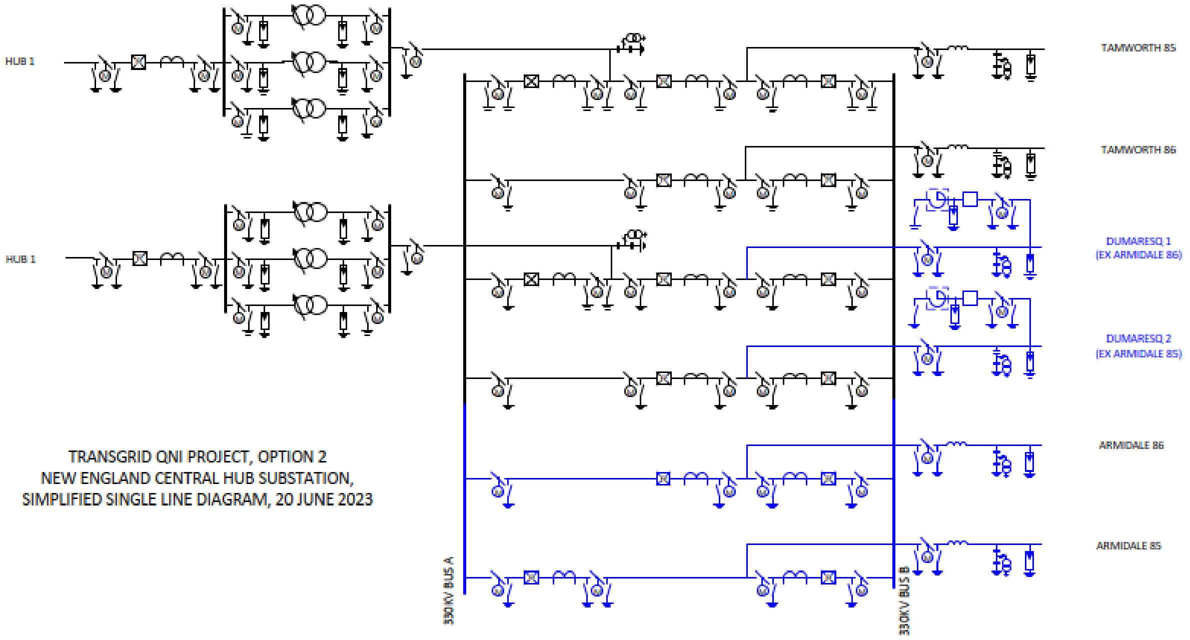

Figure 8: Diagram for planned New England Central Hub

3.2.2. Network parameters

Table 5 presents the electrical network parameters required to model the network augmentation and perform power system analysis.

Table 5. Transmission line electrical parameters using (100 MVA/330 kV base quantities)

Circuit	R (%)	X (%)	B (%)	R0 (%)	X0 (%)	B0 (%)
QNI Border – Dumaresq	0.146	1.405	20.450	0.671	3.620	12.659
Dumaresq – New England Central Hub	0.541	5.220	75.970	2.492	13.449	47.026

Thermal ratings for the lines are based on 330 kV Twin Olive conductors in the QNI corridor. The normal and contingency ratings for the lines are the same as in Option 1, as shown in Table 2.

3.2.3. Transfer limits

Power system analysis has been undertaken to identify possible thermal limits before and after the proposed QNI Connect augmentation as part of the preparatory activities. The same generation and load assumptions for Option 1 in Section 3.1.3 were considered for this analysis.

The thermal transfer limits for the three cases without and with the Lower Creek pumped hydro are presented in Table 6 and Table 7.

Table 6. Transfer limits for Option 2 without Lower Creek pumped hydro

System Condition	Calculated QNI Northerly Limits (MW)		
	Pre-Upgrade	Post Upgrade	Limit Increase
Summer Peak	1090	2350	1260
Summer Typical	1140	2290	1150
Winter Typical	1220	2330	1110

Table 7: Transfer limits for Option 2 with Lower Creek pumped hydro

System Condition	Calculated QNI Northerly Limits (MW)		
	Pre-Upgrade	Post Upgrade	Limit Increase
Summer Peak	1330	3440	2110
Summer Typical	1310	3320	2010
Winter Typical	1310	3510	2200

3.3. Option 3: 500 kV double circuit

3.3.1. Network diagrams

This option includes constructing a new 500 kV double circuit line from the Queensland/ NSW state border – Dumaresq – New England Central Hub. The transmission line will connect to a new 500 kV double circuit line in Queensland which will extend from the Queensland/ NSW state border through to Western Downs and Halys as shown in Figure 9.

The scope for this option includes:

- New 500 kV double circuit line from the planned New England Central Hub to an expanded Dumaresq 500/300 kV Switching Station totalling a route length of 194 km (estimate).
- New 500 kV double circuit line from Dumaresq to the Queensland / NSW state border totalling a route length of 102 km (estimate).
- Modifications to the New England Central South Hub 1 double circuit lines and construction of new 500 kV bays at New England Central South Hub.
- Upgrade and expansion of the planned New England Central Hub Substation to a 500/330 kV Substation and to enable the connection of two-off 500 kV lines to the Queensland border.
- Expansion of the existing Dumaresq Switching Station to include a 500/330 kV Substation.

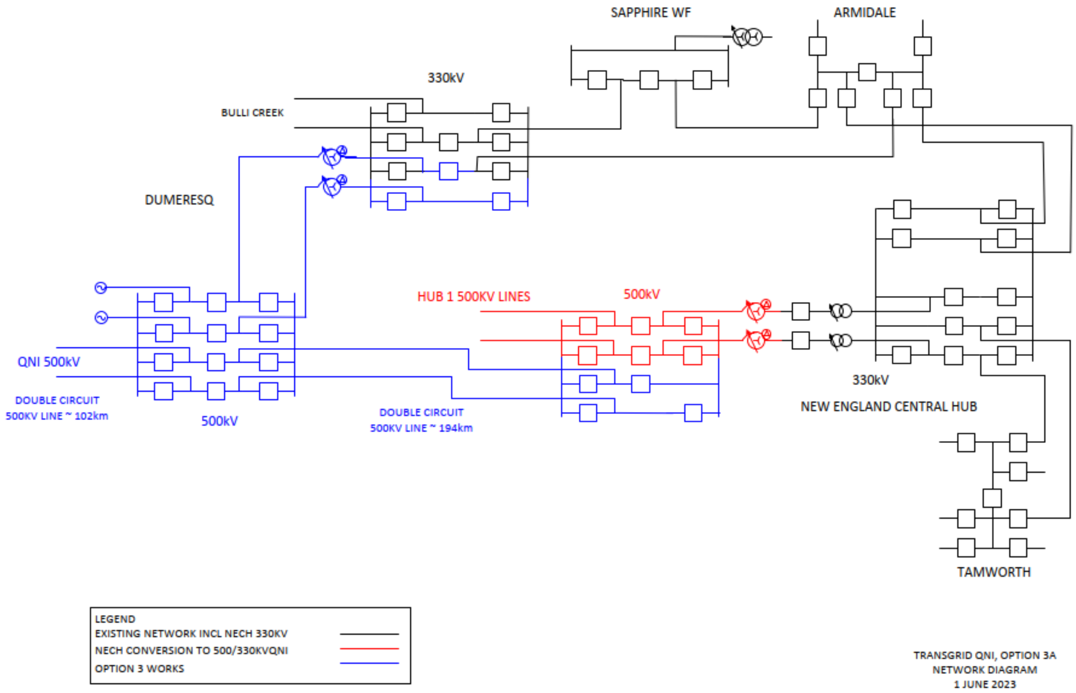

Figure 9: Network diagram for Option 3

The diagrams for each substation involved in the augmentation are also provided to estimate the associated costs.

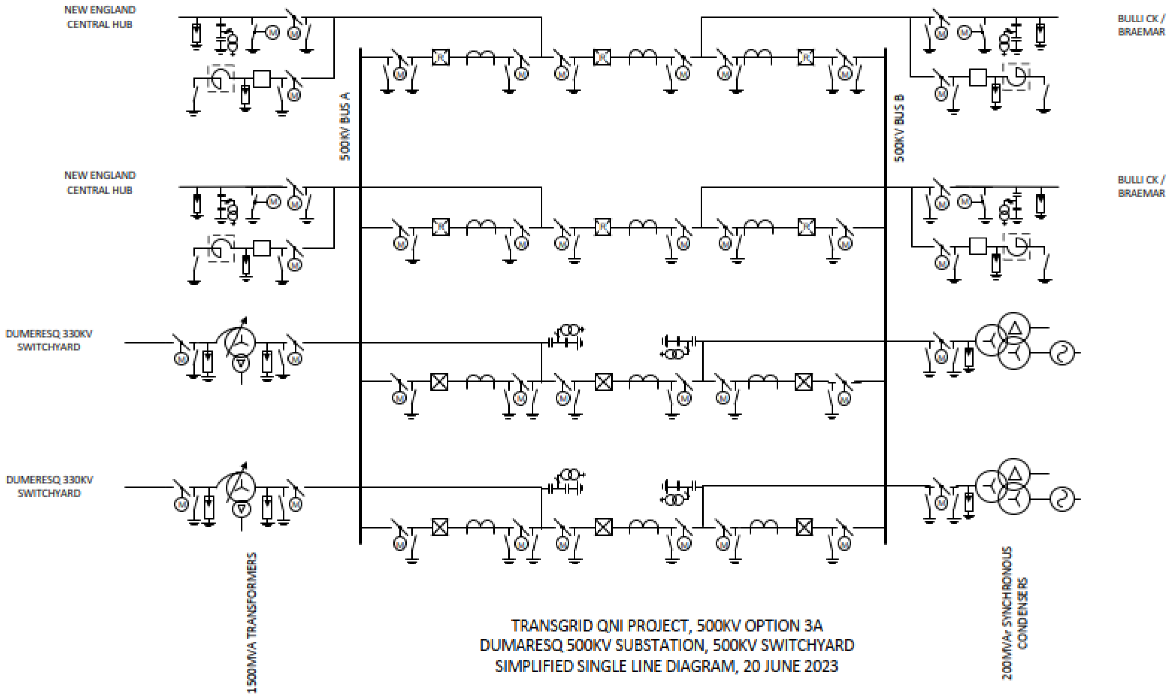

Figure 10: Diagram for Dumaresq 500 kV Substation

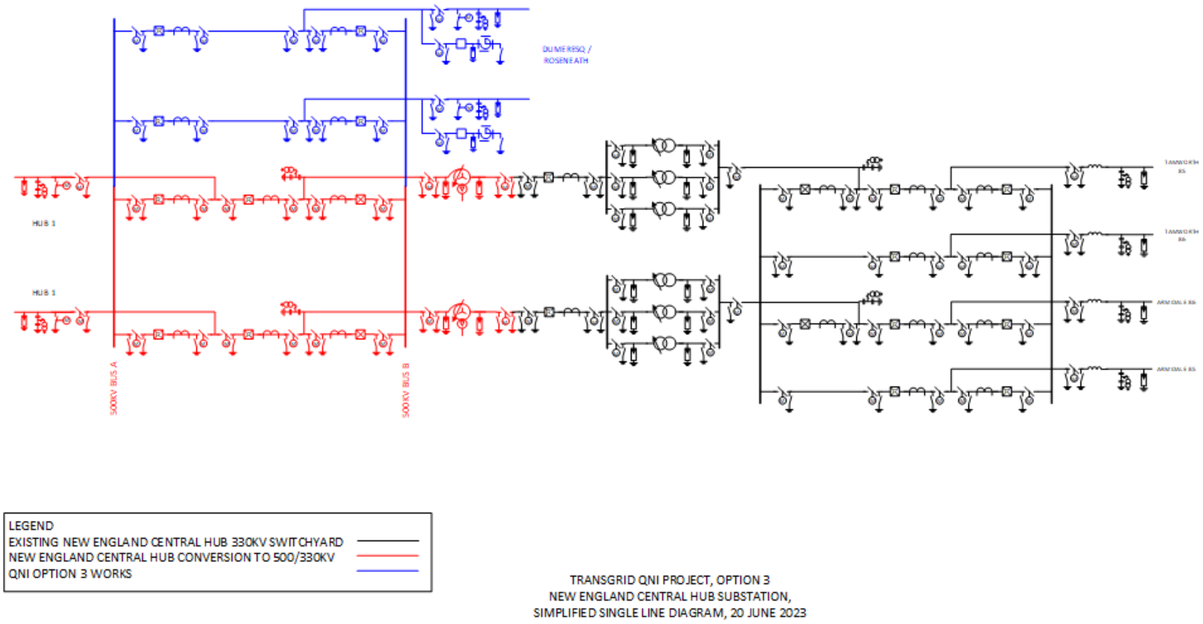

Figure 11: Diagram for modifications to New England Central Hub

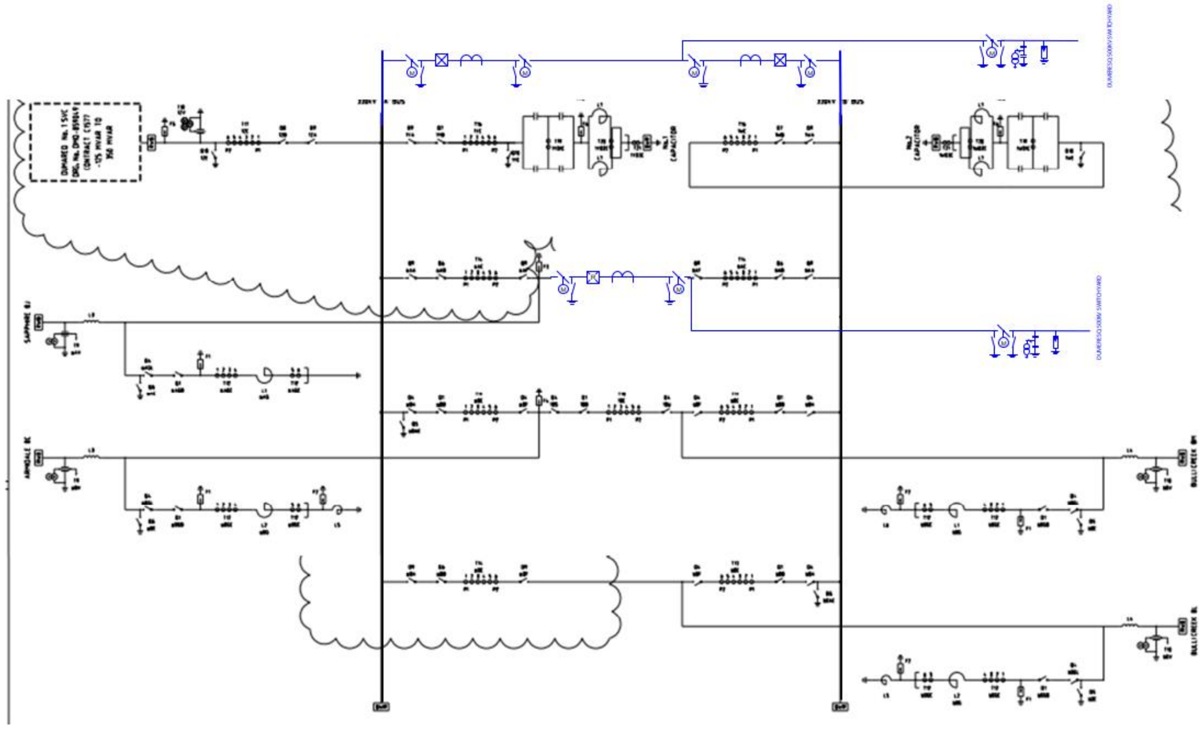

Figure 12: Augmentation diagram for Dumaresq 330 kV substation

3.3.2. Network parameters

Table 8 and Table 9 present the electrical network parameters required to model the network augmentation and perform power system analysis.

Table 8. Transmission line electrical parameters using (100 MVA/500 kV and 100 MVA/330 kV base quantities for 500 kV and 330 kV lines respectively)

Circuit	R (%)	X (%)	B (%)	R0 (%)	X0 (%)	B0 (%)
QNI Border – Dumaresq Substation	0.078	1.031	117.413	0.970	3.430	69.787
Dumaresq Substation – New England Central Hub	0.148	1.962	223.316	1.845	6.524	132.732

Table 9. Transformer electrical parameters (using 100 MVA/500 kV base quantities)

Circuit	RH (%)	XH (%)	RL (%)	XL (%)	RT (%)	XT (%)
1500 MVA 500/330/33 kV Dumaresq transformer	0.002	1.414	0.006	-0.293	0.077	5.295
1500 MVA 500/330/33 kV New England Central Hub transformer	0.002	1.414	0.006	-0.293	0.077	5.295

Thermal ratings for the lines are based on 500 kV Quad Orange conductors with 3281/3394 MVA continuous/contingency rating.

3.3.3. Transfer limits

Power system analysis has been undertaken to identify possible thermal limits before and after the proposed QNI Connect augmentation as part of the preparatory activities. The same assumptions for Option 1 in Section 3.1.3 were considered for this analysis, with the exception that the double circuit lines from the New England REZ Central to Central South are upgraded and operated at 500 kV.

The thermal transfer limits for the three cases without and with the Lower Creek pumped hydro are presented in Table 10 and Table 11.

Table 10: Transfer limits for Option 3 without Lower Creek pumped hydro

System Condition	Calculated QNI Northerly Limits (MW)		
	Pre-Upgrade	Post Upgrade	Limit Increase
Summer Peak	1090	4100	3010
Summer Typical	1140	3980	2840
Winter Typical	1220	4220	3000

Table 11: Transfer limits for Option 3 with Lower Creek pumped hydro

System Condition	Calculated QNI Northerly Limits (MW)		
	Pre-Upgrade	Post Upgrade	Limit Increase
Summer Peak	1330	4630	3300
Summer Typical	1310	4660	3350
Winter Typical	1310	4640	3330

3.4. Option 4: 330 kV double circuit and Virtual Transmission Line

3.4.1. Network parameters

The network augmentation for this option is similar to Option 2. Table 5 presents the electrical network parameters required to model the network augmentation and perform power system analysis. In addition, 200MW, 400 MWh battery energy storage systems are required in both northern NSW and south-western Queensland to operate as a virtual transmission line. The battery energy storage systems are estimated to provide an additional 200 MW to the transfer limit.

3.4.2. Transfer limits

The thermal limits for this option are expected to be equal to the limits delivered by Option 2 with an additional 200 MW capacity increase supplied by the virtual transmission line. The resulting limits for the three cases without and with the Lower Creek pumped hydro are presented in Table 12 and Table 13.

Table 12. Transfer limits for Option 4 without Lower Creek pumped hydro

System Condition	Calculated QNI Northerly Limits (MW)		
	Pre-Upgrade	Post Upgrade	Limit Increase
Summer Peak	1090	2550	1460
Summer Typical	1140	2490	1350
Winter Typical	1220	2530	1310

Table 13: Transfer limits for Option 4 with Lower Creek pumped hydro

System Condition	Calculated QNI Northerly Limits (MW)		
	Pre-Upgrade	Post Upgrade	Limit Increase
Summer Peak	1330	3640	2310
Summer Typical	1310	3520	2210
Winter Typical	1310	3710	2400

3.5. Discussion on QNI Connect northerly limits

The existing QNI Northerly limits are constrained by voltage and stability constraints dominantly as specified in the draft 2023 ISP Inputs and Assumption Workbook[9]. The existing QNI Northerly limits are between 685 MW to 745 MW, which are much lesser than the pre-upgrade QNI northerly thermal limitation. Therefore, QNI Connect network options could significantly increase the existing QNI Northerly limit than the thermal limits increase for the QNI Connect northerly limits studied in 2029. Future stability studies including detailed New England REZ network option and dynamic plants are required to identify the voltage and stability limit during RIT-T stages. To cover the cost estimation for additional reactive power compensation, QNI Connect provided separate cost for reactive power plants in the Section 5.

[9] Draft 2023 ISP Inputs and Assumption Workbook, Dec 2022, AEMO

4. Desktop Easement Assessment

This section describes the desktop transmission line corridor identification and assessment undertaken as part of the preparatory activities.

The QNI Connect preparatory activities take opportunities to select line routes which could enable shared benefits of connecting New England REZ hubs and being transmission backbone to transfer low-cost energy across from interstates.

Unless otherwise stated, the following assessment for Option 1, Option 2 and Option 4 are the same unless otherwise noted. They are all 330 kV transmission lines within the same width 60 m easement. There will be differences at the terminal locations as will be noted. Option 3 is treated separately looking to capitalise on future REZ expansions.

4.1. Corridor/Route selection

A technical, environmental and social constraints mapping and desktop assessment process was undertaken as part of the preparatory activities.

The key aims of this process were to:

- Establish a framework for identification and evaluation of a transmission line corridor
- Identify a transmission line corridor that satisfies agreed technical, environment and social criteria
- Identify a "least risk" transmission line corridor based on the desktop assessment, for the purposes of the preparatory activities.

The framework used to identify and evaluate transmission line routes and substation site options included the following key tasks:

- Determining the constraints criteria for the transmission line corridor
- Collation of available spatial data
- The identification and confirmation of a study area
- Desktop constraints and opportunities mapping
- Identification of nominated transmission line corridor
- Multidisciplinary workshops with Transgrid stakeholders, allowing a collaborative approach to evaluating the options on environmental, social, technical and cost.

To identify and evaluate a transmission line corridor, a triple-bottom line criteria that considers technical, environmental and social constraints was developed. The constraints were ranked high, moderate and low, with high and moderate constraints more significant in determining the risk and more influential in guiding decisions during the multidisciplinary workshops.

The criteria were grouped into tiers, as follows:

- **High (no-go)** – technical, environment and social constraints that would require unachievable approvals or access requirements to be able to meet project objectives or could result in project failure, or where the cost or practicality of impact mitigation, management or offset measures for these constraints make the project unfeasible.
- **Moderate (avoid)** – environmental, social, property and engineering constraints that should be avoided where possible, with a focus on avoiding more difficult areas as they pose some potential to conflict with the development of the project. If constraints cannot be avoided, then social, environmental, property and engineering impacts should be minimised. Moderate constraints did not conclusively dictate the location of the corridor.
- **Low** – areas where impacts should be minimised but are able to be mitigated

- **Opportunities** - areas that improve / benefit project outcomes.

These constraints are broadly categorised into two types: landscape-scale environmental constraints, such as National Parks, agricultural land, and point-specific constraints such as dwellings, airports, and major developments.

Further assessments of the nominated transmission line and substation location would require a more detailed constraints evaluation including field investigations and stakeholder and community consultation and feedback.

4.1.1. Option 1: 330 kV single circuit & Option 2: 330 kV Double Circuit

The corridors for Options 1 and 2 generally follow the existing 330 kV line except to run to the west and then south-west of Armidale to connect to the planned New England Central Hub.

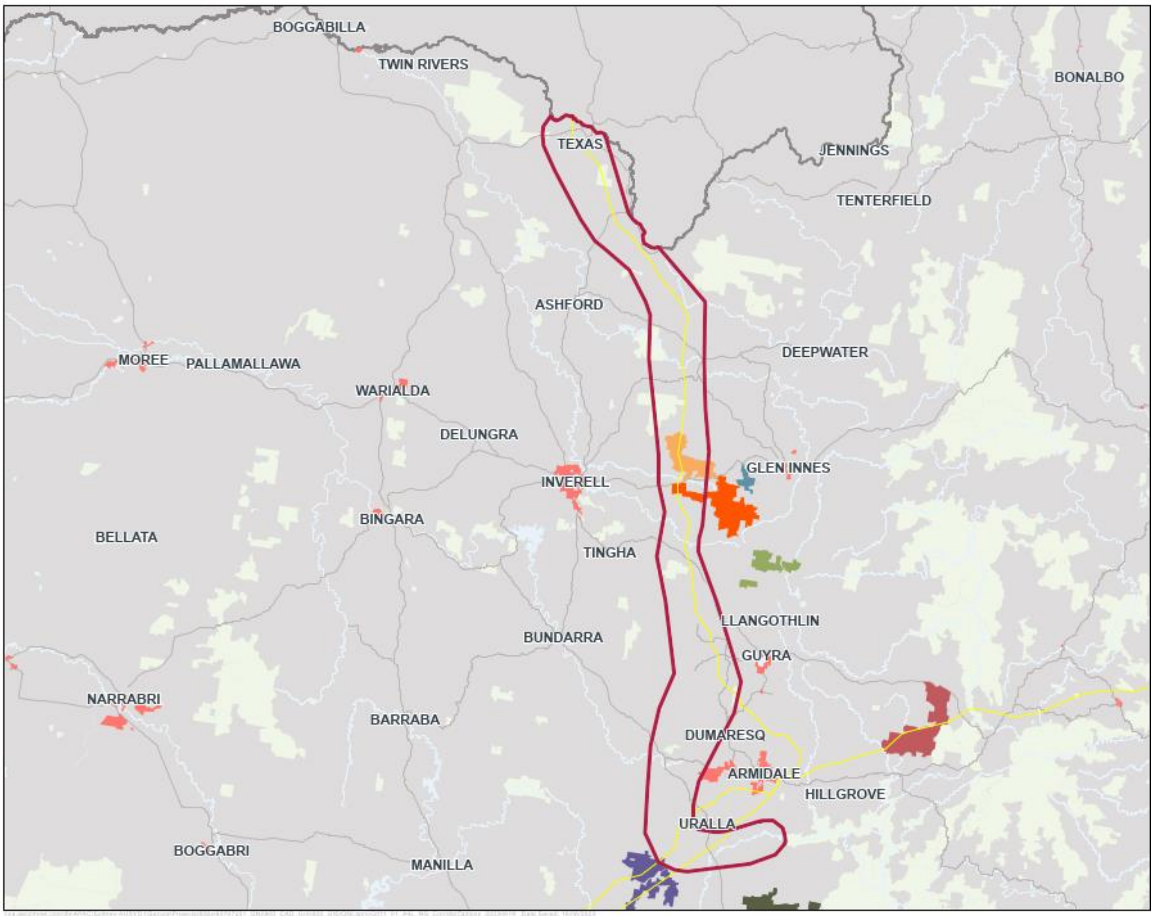

Figure 13: Options 1 and 2 Overall

The new 330 kV alignment needs to navigate around major towns such as Uralla, Armidale, Guyra and Inverell, whilst also avoiding smaller towns such as Tingha, Emmaville, Ashford and Bonshaw.

The following National Park managed areas are identified within the corridor or in close proximity and should be avoided with during identification of the proposed route:

- Single National Park
- Kings Plains National Park
- Severn River Nature Reserve
- Crooked Creek National Park.

In determining the route for Options 1 and 2, avoidance of dwellings, homesteads and rural airstrips (both registered with CASA and not) have been considered with suitable buffer.

A number of potential BSAL (biophysical strategic agricultural land) defined areas may be impacted by the proposed QNI Connect alignment, particularly in the areas between Single and Kings Plains National Parks bisected by the Gwydir Highway between Glen Innes and Inverell. Another area of farming to be considered is along the valley north of Ashford containing alluvial plains of the Severn River.

The proposed corridor in seeking co-location with existing transmission line corridors has potential interaction with the Sapphire Wind Farm.

By seeking to co-locate with the existing 330 kV transmission line, the already established access can be utilised for the new build with minor extensions to the access, particularly in the area between Kings Plains Road and Dumaresq 330 kV Switching Station, where the proposed alignment and existing QNI connection traverses the remote and moderately vegetated country.

The outcome of the desktop indicative alignment produces the following estimated details:

- Option 1 – 330 kV Single Circuit Tower Line:
  - 330 kV single circuit steel tower line
  - Twin Olive ACSR conductor, strung at 22 % UTS and designed for 120 deg C maximum operating temperature
  - Twin OPGW
  - 60 m easement
  - Indicative alignment length of 246 km
  - Based on an assumed span length of 400 m (dependent on structure spotting and consistent with Transgrid 330 kV single circuit tower line designs and respective wind and weight span ratings), we have approximately 628 structures for the two line lengths.

The existing Dumaresq 330 kV breaker and a half arrangement requires an additional centre breaker installation and the shifting of lines 8C and 8J from Armidale/Sapphire to allow the 330 kV connection to New England Central Hub. The additional connection to Bulli Creek requires a further centre circuit breaker installation and the shifting of lines 8L and 8M from Bulli Creek.

- Option 2 – 330 kV Double Circuit Tower Line:
  - 330 kV double circuit steel tower line
  - Twin Olive ACSR conductor, strung at 22 % UTS and designed for 120 deg C maximum operating temperature
  - Twin OPGW
  - 60 m easement
  - Indicative alignment length of 246 km
  - Based on a assumed span length of 400 m (dependent on structure spotting and consistent with Transgrid 330 kV double circuit steel tower line designs and respective wind and weight span ratings), we have approximately 628 structures for the two line lengths.

The augmentation at Dumaresq will require the extension of the existing footprint by two bay elements to secure 2 additional breaker and a half elements.

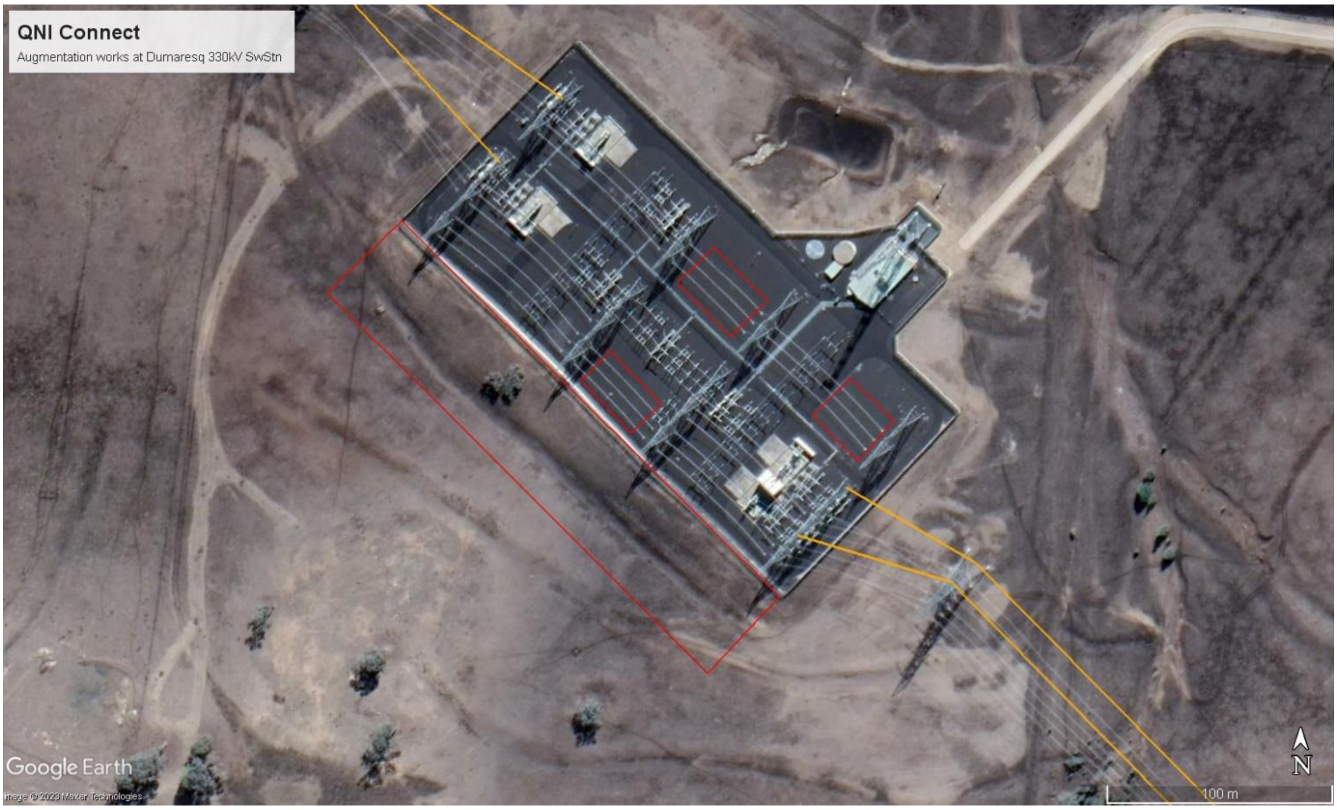

Figure 14: Dumaresq 330 kV Switching Station augmentations

The location of the New England Central Hub is indicative but the establishment of a 330 kV switching station is presumed to bring lines 85 & 86 in and out. As well as the two new 330 kV connections to Dumaresq.

The proposed corridor in seeking co-location opportunities with the New England Renewable Zone to allow for future connection opportunities and support for interconnection to load centres across the border with Queensland.

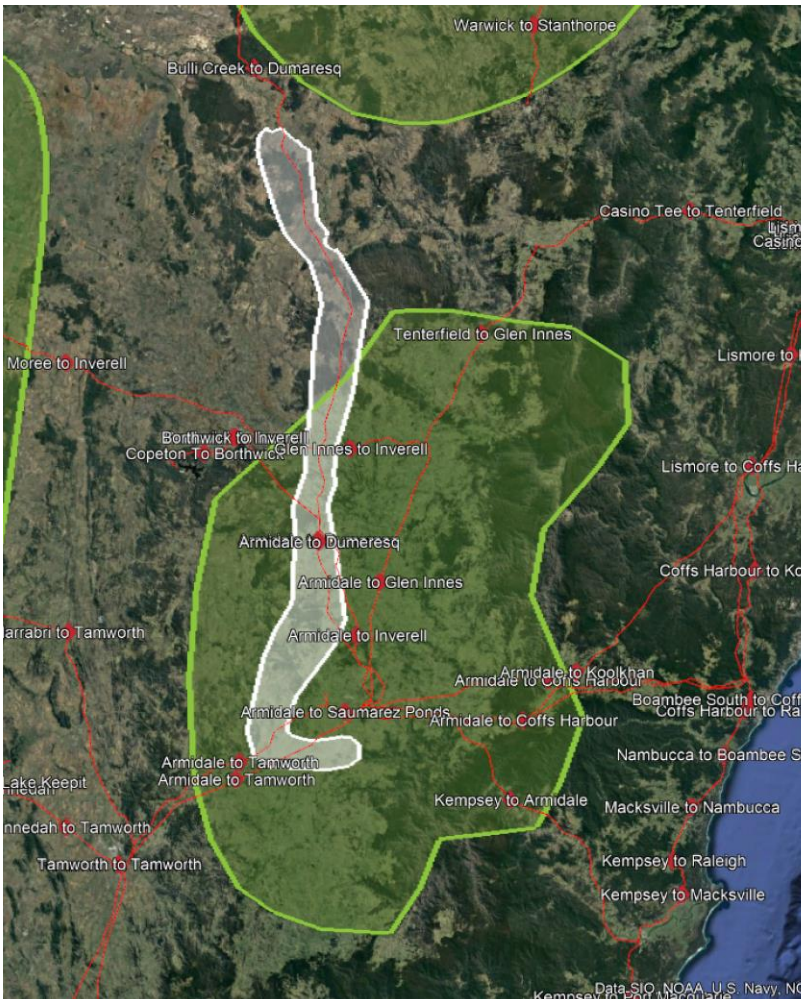

Figure 15 : Option 1 and 2 with ISP REZ boundaries

4.1.2. Option 3: 500 kV double circuit

The corridor for Option 3 largely follows the existing 330kV transmission line with an extension connecting north of Dthinna Dthinnawan National Park to Twin Rivers. The corridor runs west and then south-west of Armidale to connect to the planned New England Central Hub.

As per the Option 1 and 2 analysis to get access to the New England Central Hub location the corridor analysis showed that circling around to the east of Armidale and staying on the eastern side of the existing QNI connection resulted in higher impacts than navigating a westerly location. This was especially more so for a 500 kV alignment where a higher visual impact is assumed.

The new 500 kV route will need to navigate around major towns such as Uralla, Armidale, Guyra and Inverell, whilst also avoiding smaller towns such as Tingha, Emmaville, Ashford and Bonshaw.

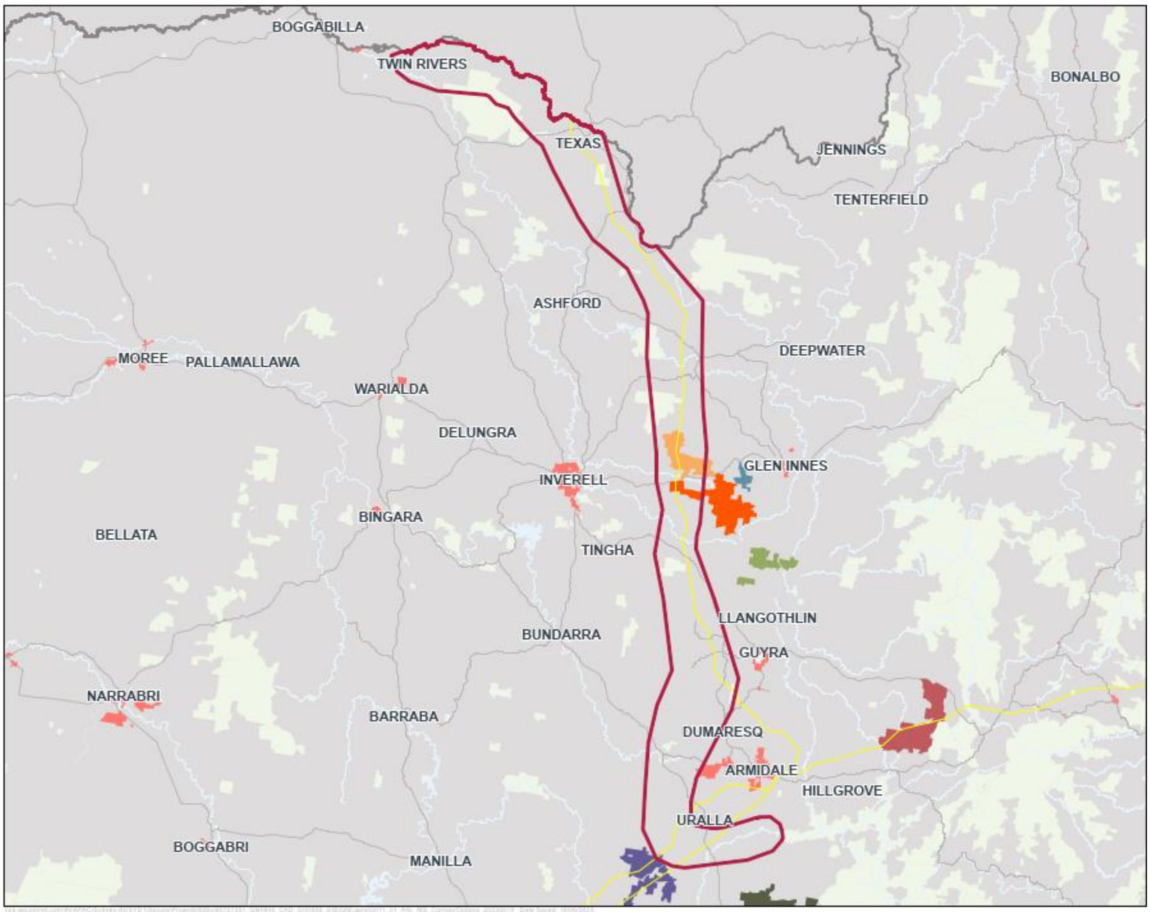

Figure 16: Option 3 overall

As per the Option 1 and 2 analysis to get access to the New England Central Hub location the corridor analysis showed that circling around to the east of Armidale and staying on the eastern side of the existing QNI connection resulted in higher impacts than navigating a westerly location. This was especially more so for a 500 kV alignment where a higher visual impact is assumed.

The new 500 kV route will need to navigate around major towns such as Uralla, Armidale, Guyra and Inverell, whilst also avoiding smaller towns such as Tingha, Emmaville, Ashford and Bonshaw.

The following National Parks and Wildlife managed areas are identified within the corridor or in close proximity and should be avoided with further concept alignment designs:

- Single National Park
- Kings Plains National Park
- Severn River Nature Reserve
- Crooked Creek National Park.
- Maroomba State Conservation Area
- Dthinna Dthinnawan National Park and Nature Reserve.

In determining the indicative alignment, avoidance of dwellings, homesteads and rural airstrips (both registered with CASA and not) have been considered with suitable buffer and location of the alignment within valleys to minimise visual impacts to communities.

A number of potential BSAL (biophysical strategic agricultural land) defined areas may be impacted by the proposed QNI Connect route, particularly in the areas between Single and Kings Plains National Parks bisected by the Gwydir Highway between Glen Innes and Inverell. Another area of farming to be considered is along the valley north of Ashford containing alluvial plains of the Severn River.

Outcome of the desktop indicative alignment produces the following estimated details:

- Option 3 – 500 kV Double Circuit Tower Line
- New England Central Hub to Dumaresq 500 kV Transmission Line Scope
  - 500 kV double circuit steel tower line;
  - Quad Orange ACSR conductor, strung at 22 % UTS and designed for 120 deg C maximum operating temperature;
  - Twin OPGW;
  - 70 m easement;
  - Indicative alignment length of 194 km for the New England Central Hub to Dumaresq section;
  - Based on an assumed span length of 400 m (dependent on structure spotting and consistent with Transgrid 500 kV double circuit steel tower line designs and respective wind and weight span ratings), we have approximately 495 structures for the two line lengths.
- Dumaresq to Queensland Border 500kV Transmission Line Scope
  - 500 kV double circuit steel tower line;
  - Quad Orange ACSR conductor, strung at 22% UTS and designed for 120 deg C maximum operating temperature;
  - Twin OPGW;
  - 70 m easement;
  - Indicative alignment length of 102 km for Dumaresq to the Queensland border;
  - Based on an assumed span length of 400 m (dependent on structure spotting and consistent with Transgrid 500 kV double circuit steel tower line designs and respective wind and weight span ratings), we have approximately 261 structures for the two line lengths.

The Dumaresq 330 kV switchyard augmentation for Option 3 utilises an existing bay with an additional centre circuit breaker installation and an extra double switched bay for the second connection.

A new 500/330 kV substation with two-off 500/330 kV transformers is proposed to be constructed adjacent the existing Dumaresq switching station to allow two 330 kV connections.

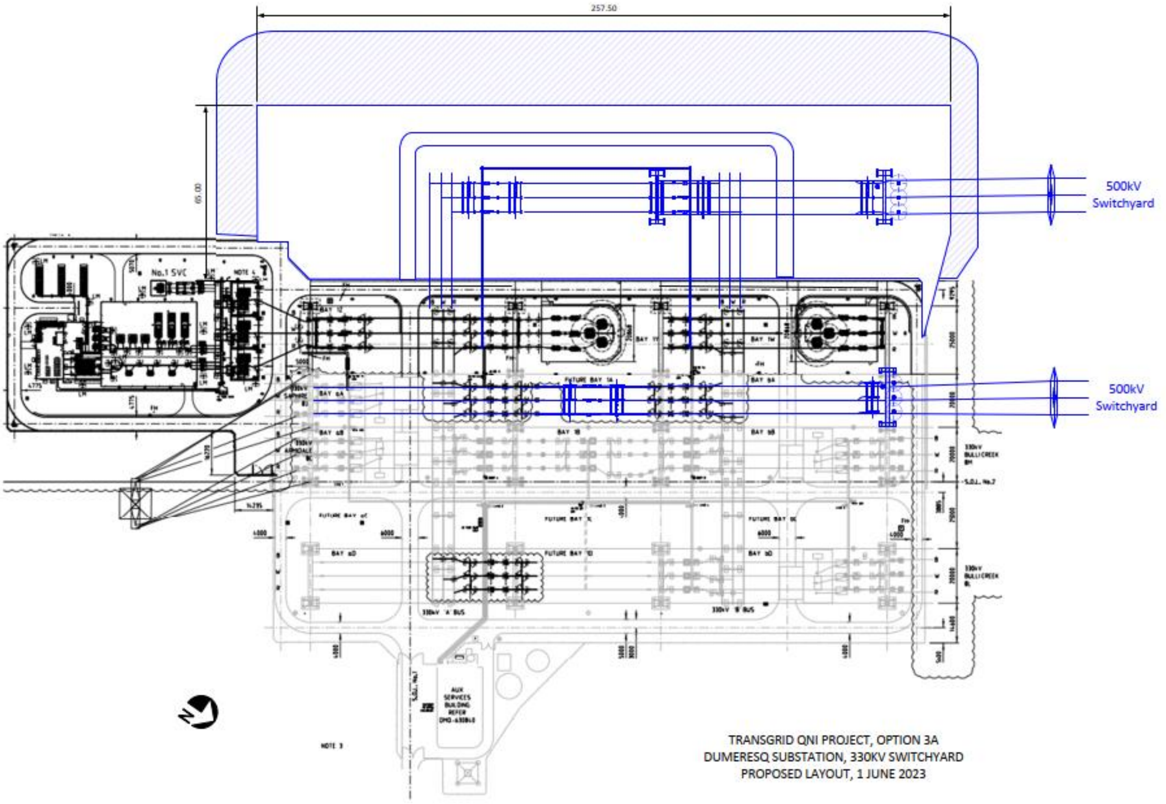

Figure 17: Option 3 Dumaresq 330 kV augmentations

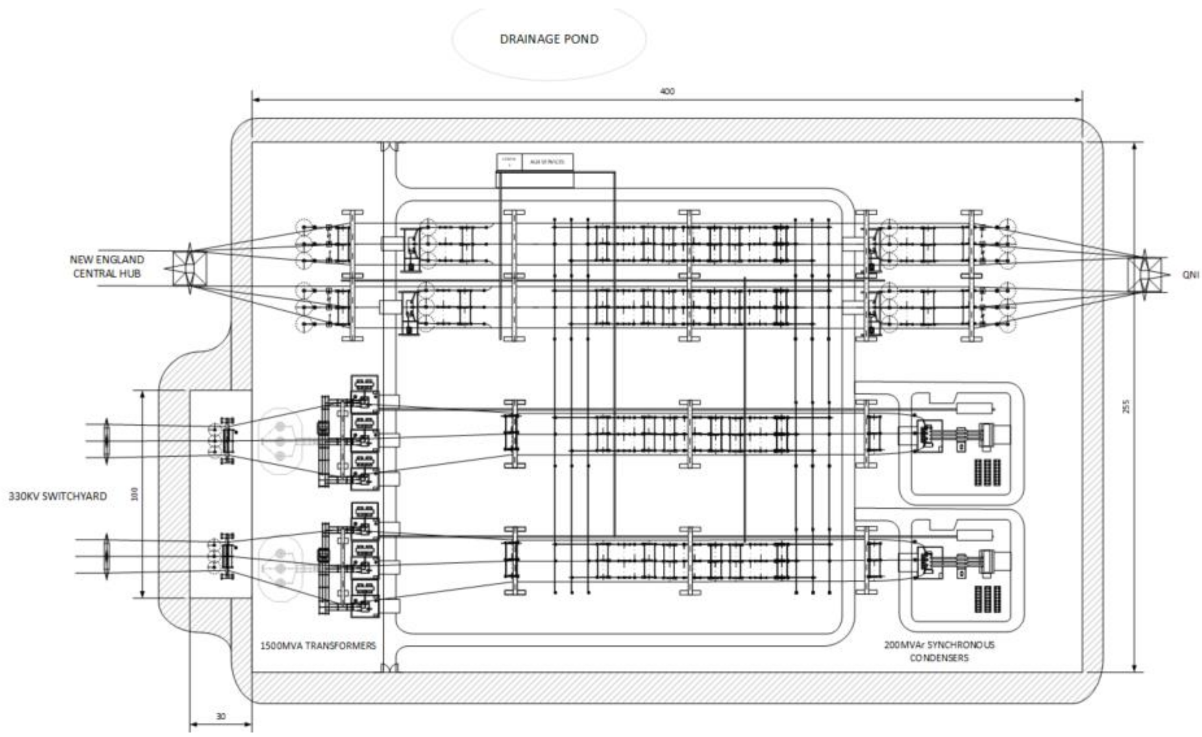

Figure 18: Option 3 Proposed Dumaresq 500/330 kV Substation

The location of the New England Central Hub is indicative but the establishment of a 330 kV switching station is presumed to bring lines 85 and 86 in and out. It is assumed that the New England Central Hub will require augmentation to provide a 500 kV yard with 500/330 kV transformers. For this assessment, it is assumed an additional two-off 500 kV double switched bays will also be required for the Dumaresq connections.

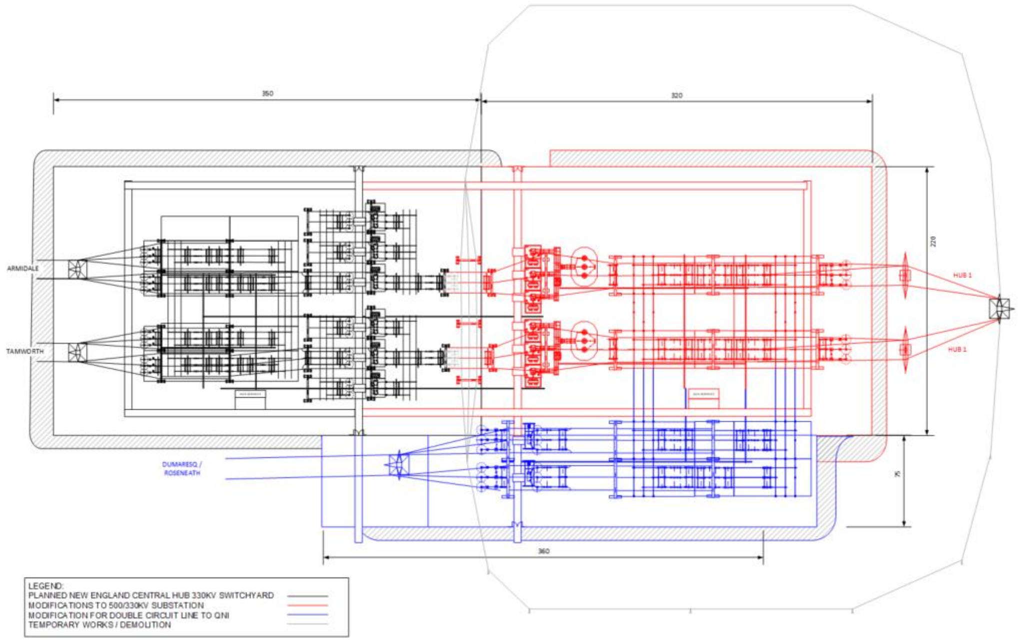

Figure 19: Option 3 New England Central Hub augmentations

4.1.3. Option 4: 330 kV double circuit and Virtual Transmission Line

Details for Option 4 330 kV alignment details are as per Option 2 previously described.

The only additional detail for Option 4 is the virtual transmission line component and where the battery is likely to be located.

4.2. Project schedule and staging

A high-level staging plans for all network option are summarized in this section.

An assumed commissioning date of October 2029 for QNI Connect Option 1 - 330kV Single circuit is presented in Table 14.

Table 14: High level schedule and staging for Option 1 – 330kV Single Circuit

Activity	Target Completion
Project Approval – Property Acquisition	April 2026
Project Approval – Delivery	April 2026
Substation Site Access	April 2026
Transmission Line Site Access	December 2026
Substation Construction Complete	April 2028
Complete Transmission Line	July 2029
Commission	October 2029

An assumed commissioning date of October 2029 for QNI Connect Option 2 - 330kV Double circuit is presented in Table 15.

Table 15: High level schedule and staging for Option 2 - 330kV Double Circuit

Activity	Target Completion
Project Approval – Property Acquisition	April 2026
Project Approval – Delivery	April 2026
Substation Site Access	April 2026
Transmission Line Site Access	December 2026
Substation Construction Complete	April 2028
Complete Transmission Line	July 2029
Commission	October 2029

An assumed commissioning date of August 2030 for QNI Connect Option 3 - 500kV Double Circuit is presented in Table 16.

Table 16: High level schedule and staging for Option 3 - 500kV Double Circuit

Activity	Target Completion
Project Approval – Property Acquisition	April 2026
Project Approval – Delivery	April 2026
Substation Site Access	July 2026
Transmission Line Site Access	December 2026
Substation Construction Complete	April 2030
Complete Transmission Line	June 2030
Commission	August 2030

An assumed commissioning date of October 2029 for QNI Connect Option 4 - 330kV Double circuit with Virtual Transmission Line is presented in Table 17.

Table 17: High level schedule and staging for the QNI Connect Option 4 - 330kV Double circuit and Virtual Transmission Line

Activity	Target Completion
Project Approval – Property Acquisition	April 2026
Project Approval – Delivery	April 2026
Substation Site Access	April 2026
Transmission Line Site Access	December 2026
Substation Construction Complete	April 2028
Battery Energy Storage Systems Complete	January 2029

Complete Transmission Line	July 2029
Commission	October 2029

5. Cost Estimates

This section presents the cost estimates for QNI Connect based on preliminary engineering design and route selection.

The cost estimates for QNI Connect options are presented in Table 18 through

Table 21. These are class 5 estimates.

Table 18: Estimate breakdown for Option 1 – 330 kV Single Circuit

QNI Connect Option 1 – 330 kV Single Circuit	Cost ($, real 2023)
Overheads	$80,000,000
Line Works	$399,000,000
Station Works	
NEREZ Central Hub	$15,000,000
Dumaresq	$21,000,000
Biodiversity	$229,000,000
Easements	$101,000,000
Total	**$845,000,000**
P50 Risk Component	$85,000,000
TOTAL PROJECT	**$930,000,000**
Indicative Camp Cost (not included in total project cost)	*$120,000,000*

Table 19: Estimate breakdown for Option 2 – 330 kV Double Circuit

QNI Connect Option 2 – 330 kV Double Circuit	Cost ($, real 2023)
Overheads	$119,000,000
Line Works	$561,000,000
Station Works	
NEREZ Central Hub	$30,000,000
Dumaresq	$49,000,000
Biodiversity	$229,000,000
Easements	$101,000,000
Total	**$1,090,000,000**
P50 Risk Component	$120,000,000
TOTAL PROJECT	**$1,210,000,000**
Indicative Camp Cost (not included in total project cost)	*$130,000,000*

Table 20: Estimate breakdown for Option 3 – 500 kV Double Circuit

QNI Connect Option 3 – 500kV Double Circuit	Cost($, real 2023)
Overheads	$301,000,000
Line Works	$1,108,000,000
Station Works	
NEREZ Central Hub	$171,000,000
Dumaresq	$322,000,000
Biodiversity	$301,000,000
Easements	$147,000,000
Total	**$2,350,000,000**
P50 Risk Component	$250,000,000
TOTAL PROJECT	**$2,600,000,000**
Indicative Camp Cost (not included in total project cost)	*$150,000,000*

Table 21: Estimate breakdown for Option 4 – 330 kV Double Circuit Option with Virtual Transmission Line

QNI Connect Option 4 – 330kV Double Circuit Option with Virtual Transmission Line	Cost($, real 2023)
Overheads	158,000,000
Line Works	$561,000,000
Station Works	
NEREZ Central Hub	$30,000,000
Dumaresq	$49,000,000
BESS	$275,000,000
Biodiversity	$229,000,000
Easements	$106,000,000
Total	**$1,410,000,000**
P50 Risk Component	$150,000,000
TOTAL PROJECT	**$1,560,000,000**
Indicative Camp Cost (not included in total project cost)	*$130,000,000*

Cost estimation for additional reactive power compensation

To cover the cost estimation for additional reactive power compensation, the following additional reactive plants and their cost estimation in Table 22 and Table 23 will be considered in the RIT-T stage.

Table 22. The additional reactive plant cost for the 330kV network option

Description	Reactive Power plant cost ($, real 2023)
-200/+400MVAr Reactors and Capacitor Banks	39,000,000

Table 23. The additional reactive plant cost for the 500kV network option

Description	Reactive Power plant cost ($, real 2023)
2 x 200MVAr Synchronous Condensers	121,000,000
2 x 200MVAr Static Var Compensators only	93,000,000
±400MVAr Reactors and Capacitor Banks	50,000,000

6. Stakeholders and Approvals

This section describes Transgrid's community engagement policy, route selection process and phases of engagement for QNI Connect.

6.1. Transgrid's community engagement policy

6.1.1. Transgrid's commitment:

We recognise the vital role that landowners and the community have in the planning and delivery of our projects and network operations.

- We work with the communities in which we operate in a meaningful, accountable, responsive and equitable way through effective and inclusive practices.
- We are dedicated to continuously improving our engagement, in our decision making and delivering community benefits.
- We seek to minimise the social impacts of our projects and operations. We will do this by engaging with all of our communities to understand what matters most, to build trust and beneficial relationships.
- We strive to build positive and lasting relationships with our local communities and create long-term benefits to our customers, community and the environment as part of our commitment to building a sustainable future.

6.1.2. Stakeholder engagement and communication objectives

Our community engagement practices comply with the international participation standards (IAP2) and aim to forge strong working relationships with current and future stakeholders. Having effective links with our community and stakeholders is part of building and nurturing trust. Our commitment to engagement is underpinned by our value to nurture trust as we build a better power system for Australians.

Effective community and stakeholder engagement will be critical to the success of QNI Connect. To achieve this, the following engagement and communication objectives must be set for the project:

- We engage and collaborate with our customers, community, and stakeholders to empower them and support informed decision-making.
- We aim to build positive relationships and nurture trust with community and stakeholders.
- Clearly communicate intended benefits and objectives of the project in context of the renewable energy agenda and the transformation of the energy sector.
- Provide opportunities for community and stakeholders to be engaged and involved with regularly throughout the project lifecycle, ensuring that negotiable aspects of the project reflect feedback received.
- Minimise, where possible, project impacts on stakeholders and the community.
- Appropriately address stakeholder and community issues and work towards resolution.
- Ensure communities and stakeholders have access to up-to-date, regular and ongoing, inclusive and accessible information about the project including progress, findings, upcoming activities and key public dates.
- Maximise the opportunity to give back to communities and leave a positive lasting legacy that benefits the landowners and communities that are impacted by our infrastructure.
- Ensure engagement and communication process is undertaken in a manner that addresses regulatory requirements

- Put in place an approach and processes that align to industry standards and regulatory requirements which enables robust engagement with all stakeholders and the community
- Maintain and grow social licence for Transgrid and the project by, building trusted relationships, and optimising social benefits.

6.1.3. Overarching approach

Our approach aligns with Transgrid's Community Engagement Policy (detailed above in Section 6.1) and Transgrid's Route Selection Guideline. It is informed by lessons learnt from previous projects and a commitment to continuous improvement, as well as our responsibility to meet regulatory requirements and industry best practice standards.

Our approach seeks to achieve the stakeholder engagement and communication objectives outlined in Section 6.1.1, and in practice will involve:

- Early engagement with community and stakeholders.
- Being transparent – ensuring there is a clear, consistent process for collecting stakeholder feedback and reporting on how feedback / concerns / opportunities will be integrated into project planning and the route selection process (read more about Transgrid's route selection process below).
- Communication and engagement tailored to stakeholder needs and expectations.
- Working closely with the community and stakeholders to identify and resolve key issues.
- Providing a range of opportunities and methods for engagement, keeping people informed and enabling them to provide meaningful and informed feedback.
- Using uncomplicated language.
- Engaging broadly including with individuals and groups that fall into harder to reach categories.

To achieve the above objectives, communication and engagement will be ongoing during all project stages. As shown in Figure 20 the approach is based on:

- **Transparency:** we will be open and honest
- **Credibility:** we will present facts not "spin" and we will adopt processes and provide information that stands up to scrutiny
- **Trust:** we will provide a consistent point of contact to build relationships
- **Inclusivity:** we will implement methods and activities that enable all stakeholders and members of the community to be informed and have their say
- **Responsiveness:** we will listen, consider and act.

The approach is also based on Transgrid's Route Selection Guideline which sets out a process for undertaking progressively more detailed investigation and filtering of available information to identify, select and confirm a final location for new electrical infrastructure (linear and site-based). The phases of the option evaluation process for linear and site-based infrastructure are generally similar, and any differences (such as specific constraints) are highlighted in this guideline. The route selection process is carried out over the following project phases:

- Identification of the project need
- Identification of feasible technical options and determination of the project solution that may meet this need within a broad geographical area of interest
- Systematically and progressively refining the area of interest to a preferred corridor or site
- Systematically and progressively refining the corridor to a single preferred route
- Narrowing the preferred route as part of the relevant environmental approvals process

- Identifying the easement area of a transmission line for the preferred route or refining the boundary of a site.

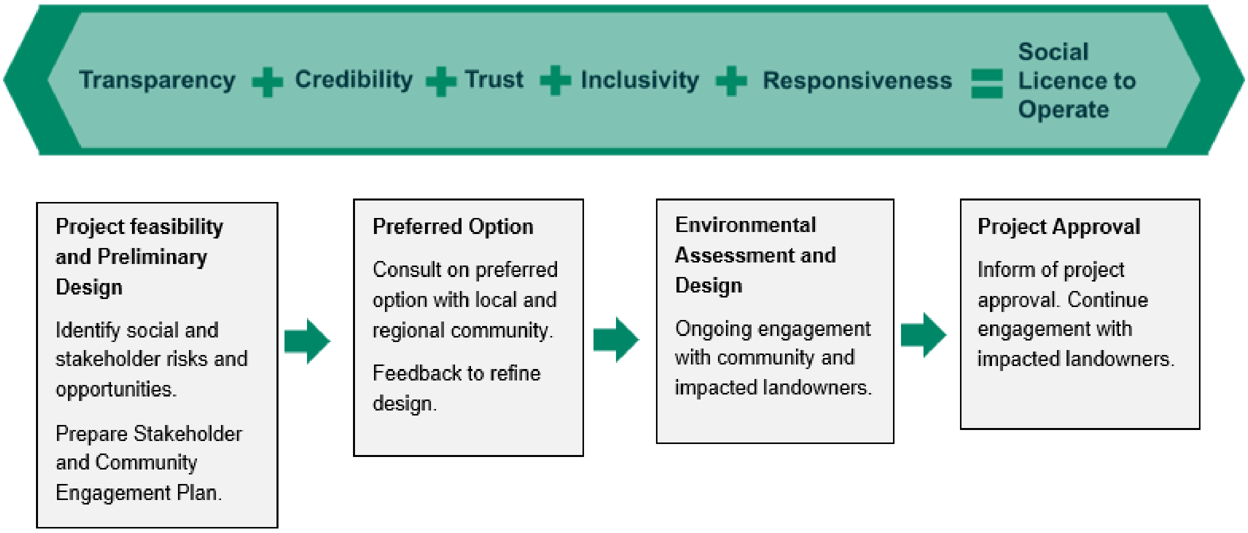

Figure 20: Approach to achieve social licence to operate

To build a social licence and acceptance of the nominated route, Transgrid will adopt the above principles from the outset providing information on what routes were considered, how the nominated route was chosen, what assessments were undertaken, and how the process aligns with industry standards.

Consultation on the nominated route will be undertaken to understand key issues and what aspects the community would like to see managed in the scoping report and Environmental Impact Statement (EIS).

Should the project receive environmental approval, Transgrid would offer the community the opportunity to share in the benefits of the development. This could take the form of a community benefit scheme, local employment procurement program, or initiatives for local Aboriginal communities.

6.1.4. Guidance documents

The approach adopted in this Strategy are informed by the following:

- Landowner and Community Better Practice Engagement Guide, The Energy Charter (2021)
- Better Practice Engagement Guide on transmission development by Energy Networks Australia (2023)
- Transgrid Route Selection Guidelines (2023)
- The Clean Energy Council's Community Engagement Guidelines for Building Powerlines for Renewable Energy Developments (2018)
- 2023 – 2028 Stakeholder Engagement Plan, Transgrid (2021)
- International Association for Public Participation (IAP2) Consultation Spectrum
- Review of Humelink engagement process: findings of the review landowner and Community Advocate, Transgrid (2021)
- Lessons learnt from AusNet Services' Western Renewables Link

6.1.5. The International Association of Public Participation

The International Association of Public Participation (IAP2) provides a framework for engaging stakeholders and the public, endorsed by Transgrid as the best-practice approach to community engagement.

Public participation for QNI Connect will range from informing people about the project to consulting and/or involving them in decisions about key aspects of the project such as the route selection process. Throughout the engagement process, stakeholders will be informed on how their feedback was considered.

Figure 21 below provides an overview of the levels of engagement, which can support recommended approaches to engagement for each stakeholder.

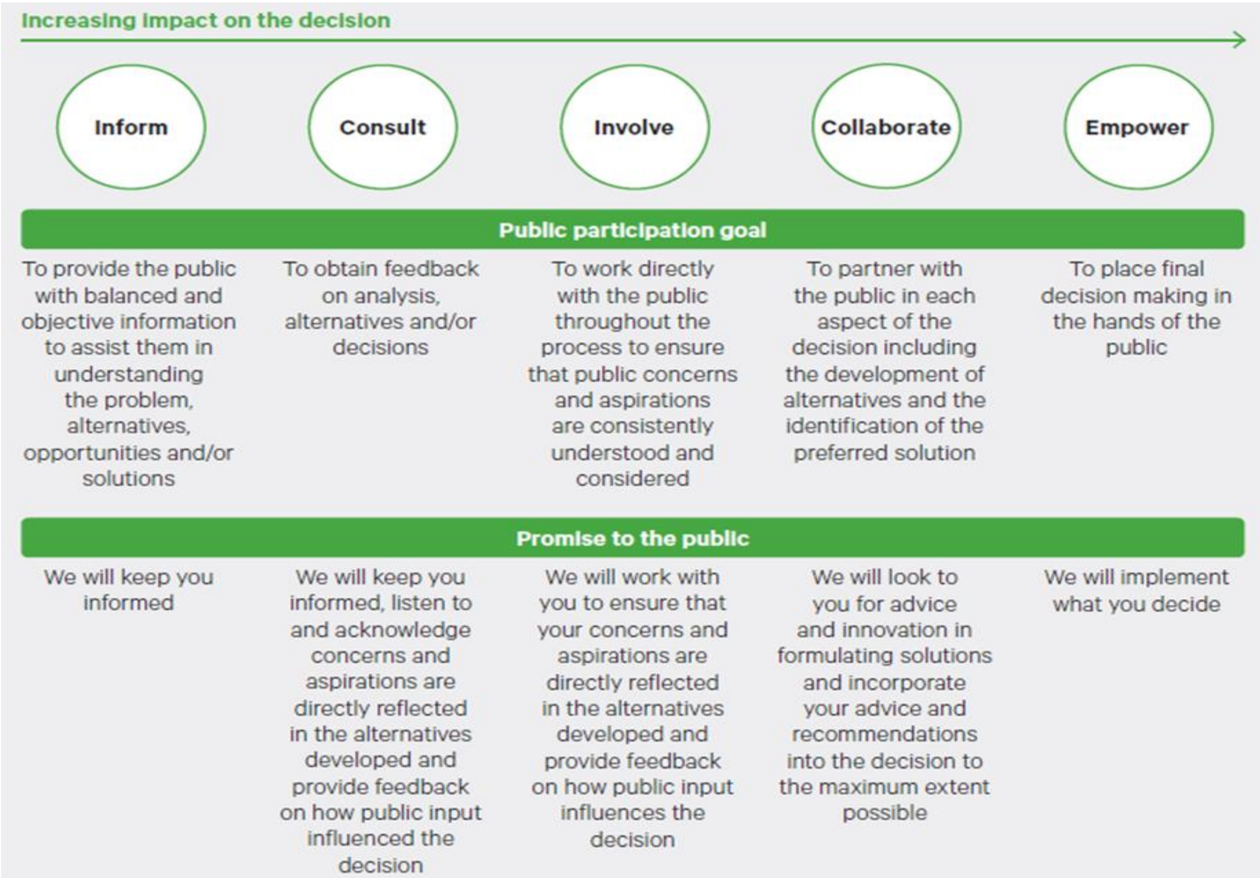

Figure 21: IAP2 public participation spectrum

6.1.6. Route selection process

Transgrid is responsible for developing the preferred route for QNI Connect.

Community and stakeholder engagement will be critical throughout the route selection process - from gathering local input to understand the potential risks of the route options and developed study corridor to identifying a narrowed route and easement alignment. This will be an iterative process where feedback from stakeholders is incorporated into the decision-making process.

The preferred route will be developed by assessing technical, environmental and social considerations. Key considerations for developing and refining the preferred route will be:

- Environmental and social constraints and opportunities
- Network objectives
- Legislative requirements
- Commonwealth and State energy policy
- Landholder views, property access and property acquisition
- Biodiversity offset calculations

- Value for money
- Construction constraints, requirements and opportunities.

6.1.7. Phases of engagement

The engagement for QNI Connect will be carried out in distinct stages (see Table 24 below).

Table 24. Phases of engagement

Stage
1: Desktop research and constraints and opportunities mapping to understand historical community and social issues, values, interests and stakeholder sentiment. Also, to map known social / community constraints and potential opportunities in the project area.
2: Early engagement with key stakeholders, including Commonwealth & State agencies, local councils and major landowners to inform a high-level list of constraints. Establishment of a Regional Reference Group and engagement with community on identified options to identify a preferred corridor
3: Approvals engagement including at the scoping report, EIS preparation, exhibition and Submissions Report, negotiating conditions of approval, and securing approvals for any early works
4. Land/easement access and acquisition including securing access for surveys/investigations and early works, and ensuring this engagement is closely co-ordinated with the broader engagement undertaken
5. Post approval engagement including securing the secondary approvals and finalising the relevant environmental management plans for the project
6. **Construction & operation engagement** including keeping key stakeholders and the community informed about construction works and any impacts

6.2. Planning approval

This section outlines the current statutory planning and approvals processes likely to be applicable under NSW legislation and Commonwealth legislation, including secondary environmental approvals. At the time of preparing this report, it is noted that planning and approvals requirements applicable to the project, should it become actionable, may change over time due to:

- General changes in planning and environmental legislation or policy between now and seeking approval for the project in the future
- Specific changes in planning and environmental legislation or policy that may be targeted at facilitating planning for and/ or delivering the project.

It would be prudent to periodically review and confirm the statutory planning and approvals processes applicable to the project, particularly if there is a significant period of time prior to seeking approval for the project.

It is also important to recognise that the complete QNI Connect transmission project, should it become actionable, would span both NSW and Queensland jurisdictions, with the potential for additional Commonwealth assessment and / or approval in one or both states. Although this report considers the NSW component of the QNI Connect, it is relevant to note the implications that coordination of approvals across multiple jurisdictions may have on the scope and timing of approvals in NSW.

Based on the review of applicable environmental impact assessment and approval requirements under NSW and Commonwealth legislation presented in the preceding sections, should the project become actionable it is anticipated it would be State Significant Infrastructure under Division 5.2, Part 5 of the Act or Critical State Significant Infrastructure under Division 5.2, Part 5 section 5.13 of the Act. Table 25 summarises anticipated approvals processes.

Table 25. Summary of anticipated approvals process

Principal NSW Approval (*Environmental Planning and Assessment Act 1979*)	**Implications under the *National Parks and Wildlife Act 1974***	**Secondary NSW Environmental Approvals**	**Commonwealth Approval (*Environment Protection and Biodiversity Conservation Act 1999)***
Should the project become actionable, the Project would likely be State Significant Infrastructure under Division 5.2, Part 5 of the Act or Critical State Significant Infrastructure under Division 5.2, Part 5 section 5.13 of the Act	The corridors for each option contain, or come close to, National Parks Estate. However, due to the width of the corridors, it is assumed that should the project become actionable, the preferred route would avoid National Parks Estate through design and therefore would not affect land reserved under the *National Parks and Wildlife Act 1974*.	Approvals no longer required under section 5.23 of the Act: > An Aboriginal heritage impact permit under section 90 of the *National Parks and Wildlife Act 1974* > Approval under the *Fisheries Management Act 1994* if infrastructure such as an access track directly affects a watercourse > Approval under the *Water Management Act 2000* if infrastructure such as an access track would be located within 40 metres of an affected watercourse > A bushfire safety authority under section 100B of the *Rural Fires Act 1997*. Approvals that must be issued substantially consistent with environmental planning approval under section 5.24 of the Act: > Consent under section 138 of the Roads *Act 1993* (classified and Crown roads).	Should the project become actionable, avoidance of all matters of national environmental significance may not be possible, and a referral may therefore be required or desirable. Subject to further investigation, it may be possible to design infrastructure to avoid a significant impact on a matter of national environmental significance and therefore avoid the need for Commonwealth approval (or minimise the scope of required environmental assessments if approval is required). If a referral is required, the NSW Assessment Bilateral Agreement would be used to streamline the assessment process. The agreement allows the NSW Government to assess development applications on behalf of the Australian Government, with the Australian government remaining as the ultimate decision-maker for the EPBC Approval based on the assessment report prepared by NSW's Department of Planning and Environment.