TransGrid

Specification and Scope Description – BAFO

Contingent Project Application for Project EnergyConnect

30 September 2020

Contents

1. Introduction

On 29 June 2020, we provided the Australian Energy Regulator (AER) with our Contingent Project Application (Application) for Project EnergyConnect (the Project or PEC), which included our Specification and Scope – RFT phase A document.

At the time of submitting our Application, we were part way through our competitive tender process for the Project. The Specification and Scope Description provided to the AER on 29 June 2020 was based on:

- a concept design prepared by us, based on independent expert reports
- outcomes from the three short-listed tenders from Request for Tender (RFT) Phase A that we received on 11 November 2019 (RFT Phase A tender proposals), and
- quotations from suppliers for the large specialist equipment.

We committed to provide the AER with an updated capex forecast and project scope once we obtained final tender outcomes in the second half of 2020.

We have now completed the final stage of our procurement process, the best and final offer (BAFO) stage. On 1 September 2020, we received responses from the two short listed tenderers (BAFO proposals). These proposals include:

- a detailed concept design prepared by each tenderer to meet the functional requirements specified by us, and
- a specification and pricing for the large specialist equipment.

On 10 September 2020, the Tender Evaluation Panel met to identify a preferred tenderer and on 24 September 2020, our Board endorsed the Tender Evaluation Report and approved the preferred tenderer (Bidder 2).

This Specification and Scope Description document details scope and specification for PEC based on the design prepared by the successful tenderer (Bidder 2) from the BAFO process.

This document forms part of our Application for PEC. It should be read in conjunction with our Principal Application document and other supporting documents, including our Supplementary Capex Forecasting Methodology for Project Energy Connect – BAFO.

1.1 Scope of document

The scope of this document is limited to the forecast scope for PEC that is attributable to our network, being the components of PEC in NSW and the connection to Red Cliffs in Victoria. The project specification details the work necessary to meet this scope of works.

It excludes:

- the scope of works for PEC that is attributable to ElectraNet such as the new transmission line between Robertstown and the NSW border and the communications link between Buronga and Monash
- extensions to the scope that are necessary to meet project risks – these are identified and discussed in the Forecasting Methodology attachment to the CPA.

As noted above, this document supersedes our Specification and Scope document – RFT Phase A, provided to the AER on 29 June 2020.

1.2 Structure of the document

The structure of this document is as follows:

> Section 2 provides an overview of the PEC project
> Section 3 describes how the project specification was derived
> Section 4 details our detailed project specification
> Section 5 provides a high-level summary of key materials.

1.3 Summary of the Project specification

Our project specification for PEC entails:

- Construction of the following three new transmission routes:
  - South Australia border to Buronga
  - Buronga to Dinawan
  - Dinawan to Wagga Wagga
- Upgrading of the existing Buronga to Red Cliffs in Victoria transmission route
- Establishment of the Dinawan switching station, including reactive plant
- Modification of the following three existing substations to terminate lines:
  - Buronga substation, including 330/220 kV transformation
  - Red Cliffs substation in Victoria
  - Wagga 330 kV substation.

The key transmission line and substation materials are summarised in section 5.

Portion	Description
L1	135 km of 330 kV double circuit transmission line from the SA Border to the Buronga substation. Diversion and alteration of lines associated with the Works
L2	376 km of 330 kV double circuit transmission line from Buronga substation to the Dinawan switching station
L3	159 km of 330 kV double circuit transmission line from Dinawan switching station to the existing Wagga 330 kV substation Diversion and alteration of lines associated with the Works
L4	Reconstruction of the existing approximately 24 km 220 kV single circuit line from Buronga substation to the Red Cliffs substation as 220 kV double circuit
S1	Establishment of a new 330 kV yard at the existing Buronga substation
S2	Establishment of the new Dinawan 330 kV switching station
S3	Augmentation of Wagga 330 kV substation
S4	Augmentation of Red Cliffs 220kV substation
SPC	Special Protection and Communications and balance of the Works to support the operation of EnergyConnect

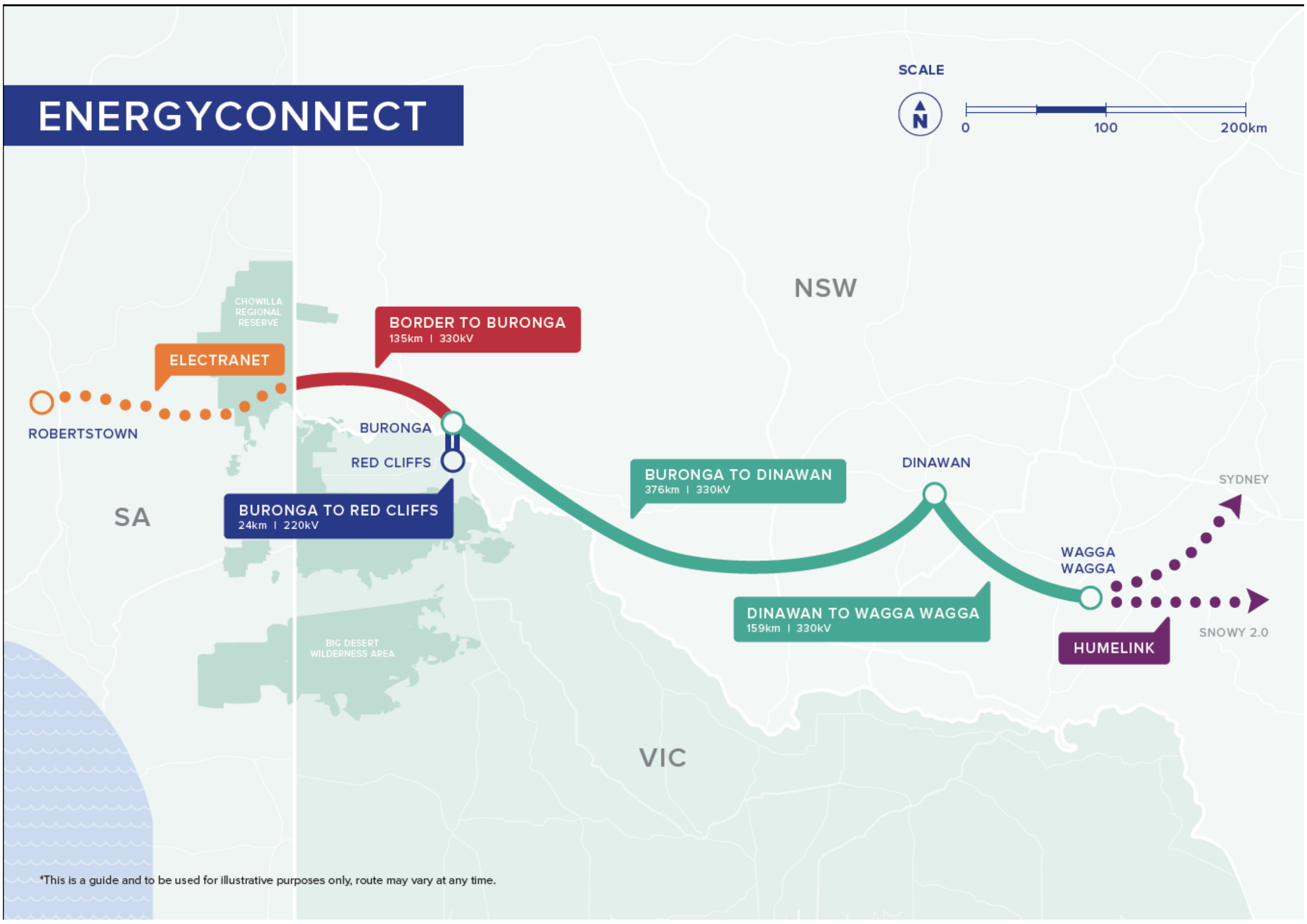
2. Background

Together with ElectraNet, we have investigated options aimed at reducing the cost of providing secure and reliable electricity supply and enhancing power system security in SA, while facilitating the longer-term transition of the energy sector across the National Electricity Market (NEM) to low emission energy sources (the requirements).

The selected option entails a high voltage 900 km interconnector with 800 MW capacity between the power grids of SA and NSW with an added connection to Victoria (Red Cliffs), known collectively as Project EnergyConnect. The Project will involve the construction of a high voltage above ground transmission line as shown in Figure 2.1.

We will partner with ElectraNet to deliver PEC. We are responsible for the planning and construction of PEC in NSW, being 670 km of new 330 kV line and 24 km of new 220 kV line to Red Cliffs.

Figure 2.1 – PEC route



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3. Our process to reach the project specification

This section describes how the project specification was developed.

3.1 Approach

The benefits of providing a stronger link between the electricity transmission networks in SA and NSW were identified by AEMO as part of its long term planning activities and confirmed in AEMO's inaugural 2018 Integrated System Plan (ISP). Concurrently, ElectraNet commenced the formal Regulatory Investment Test for Transmission (RIT-T) process and investigated a number of options to meet the requirements, including an option for strengthening the interconnection between SA and NSW.

The options analysis undertaken as part of the RIT-T process considered four broad options to meet the requirements:

Option A – least cost non-interconnector option in South Australia

Option B – new interconnector between South Australia and Queensland

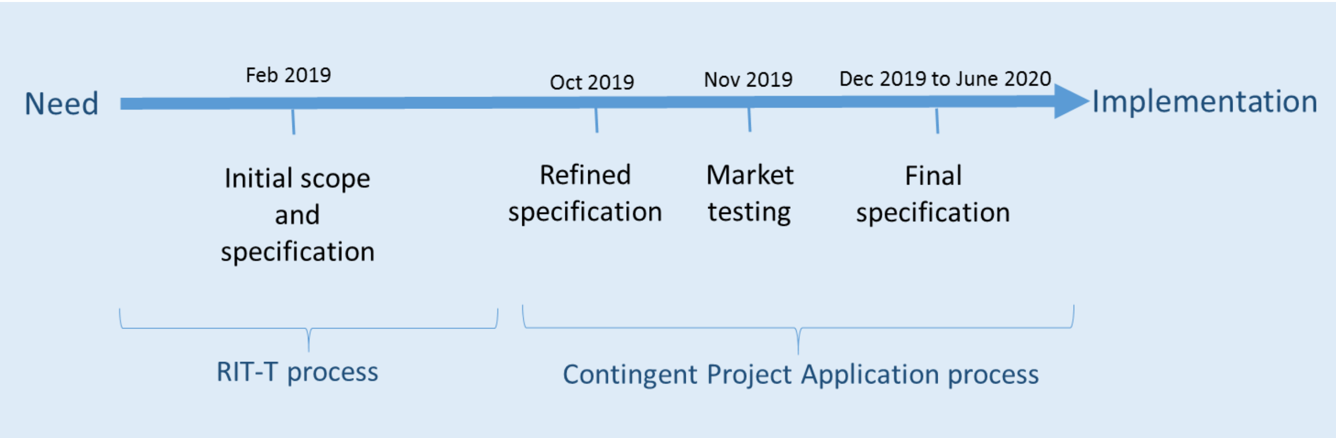
Option C – new interconnector between South Australia and New South Wales

Option D – new interconnector between South Australia and Victoria

These options were tested in an economic assessment that was validated through public consultation on both the technical requirements of the options and the economic evaluation of costs and benefits. Option C (PEC) was selected as providing the greatest net benefit.

The development of the project specification from that assumed in the RIT-T assessment to the current specification that underpins this Application is shown in Figure 3.1.

Figure 3.1: Development of the project specification for PEC



Each of the four key phases is discussed in the following sections.

3.2 Project specification adopted for the RIT-T

The earlier RIT-T process was undertaken by ElectraNet with input from us. The outcome for the overall PEC option was a high-level project scope that included:

> an extra high voltage interconnector between Robertstown in SA and Wagga Wagga in NSW, via Buronga and Darlington Point, approximately 900 km in total length and providing additional capacity of 800 MW.

> additional interconnection between Buronga in NSW and Red Cliffs in Victoria

> inclusion of reactive plant to maintain network stability.

For the portion of works in NSW, we developed an initial project specification from which a forecast of the associated expenditure was developed for inclusion in the RIT–T economic analysis. We applied a top down approach to developing the initial project specification. It entailed starting from the high-level requirements, defining key design parameters, and developing a forecast of land, materials and resources required.

In summary, the initial project specification consisted of:

> Construction of the following four new transmission routes:

  – SA border to Buronga, 140 km of 330 kV double circuit line strung both sides with twin Mango conductor providing a capacity of 800 MVA each circuit

  – Buronga to Darlington Point, 399 km of 330 kV double circuit line strung both sides with twin Mango conductor providing a capacity of 800 MVA each circuit

  – Buronga to Red Cliffs in Victoria, 24 km of 220 kV double circuit line strung one side only with twin Lemon conductor to match the existing line providing a capacity of 417 MVA

  – Darlington Point to Wagga Wagga, 152 km of 330 kV single circuit line strung with twin Mango conductor providing a capacity of 800 MVA

> Modification of the following four existing substations to terminate lines:

  – Buronga substation, including three 330 kV 400 MVA phase-shifting transformers (PST) rated to ±30 degrees phase shifting and automatic on-load MW control capability, two 330/220 kV transformers, and on the 330 kV bus - two 100 MVAr synchronous condensers, two 50 MVAr shunt capacitor banks and two 50 MVAr reactors

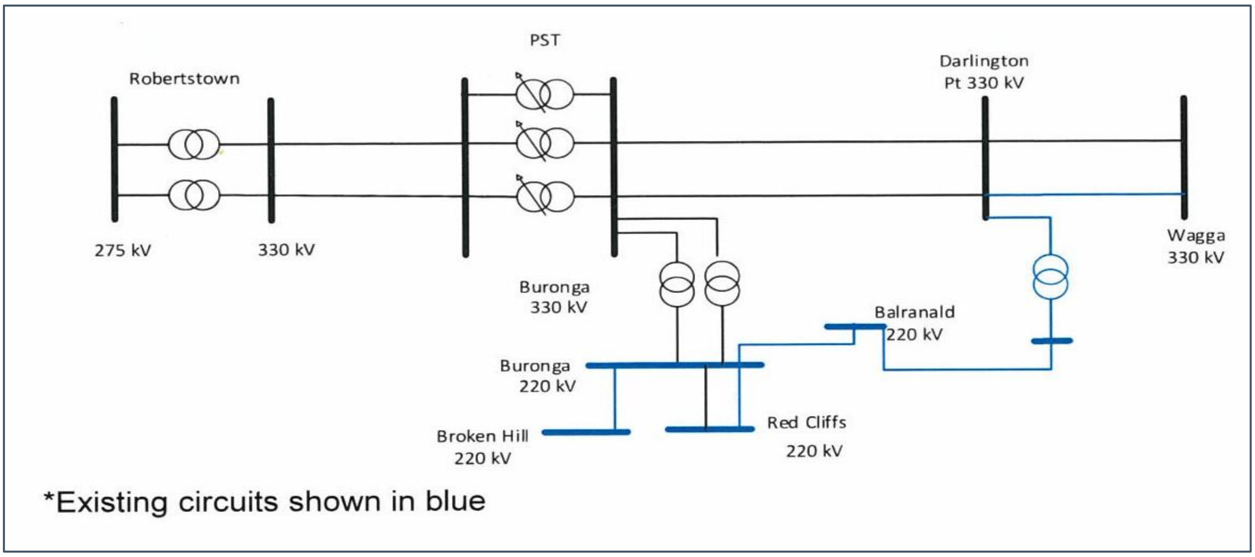
  – Darlington Point substation, including two 100 MVAr synchronous condensers, two 50 MVAr shunt capacitor banks and two 60 MVAr line shunt reactors

  – Red Cliffs substation in Victoria

  – Wagga 330 kV substation.

The electrical arrangements are shown in Figure 3.2.

Figure 3.2: PEC electrical arrangement



The initial project specification was based on an assessment of the likely line routes by consultants Jones Lang LaSalle who undertook a detailed study from SA border to Buronga and a high level desktop study from Buronga to Wagga Wagga.

The initial project specification contained several simplifying assumptions:

> The specification of the new 330 kV line was based on a straight-line estimate of line length, ignoring any land use and other constraints, the impact of which could not be estimated with the information available at the time.

> The specification of the 220 kV line was based on a scaled down 330 kV tower design, as we had no recent information on the installation of 220 kV assets.

> The specification of reactive compensating equipment (phase shifting transformers at Buronga and synchronous condensers) was derived from manufacturers' price lists.

These assumptions were made with consideration to the costing accuracy required for the RIT-T economic analysis, and the fact that the RIT-T assessment reflects a ranking of different options (and so similar specification and costing exercises were also being undertaken for the other options considered).

3.3 Refined project specification for the Contingent Project Application

In developing a refined project specification for this Application, we have adopted an approach of ensuring that the specification is efficient and addresses the limitations and simplifying assumptions in the earlier RIT-T scope.

3.3.1 Ensuring an efficient project specification

The process we used in developing the detailed project specification focusses on ensuring that the specification is prudent and efficient. This is achieved by:

> Ensuring the project specification is just sufficient to meet the identified need

> Adopting a well-defined design basis

> Considering deliverability and constructability

> Undertaking validation by internal review and market testing.

Each of these aspects is discussed below.

3.3.1.1 Project specification is just sufficient to meet the need

The detailed project specification was developed to just meet the requirements as set out in the PACR[1]. For completeness, some of the considerations that were identified in the PACR are repeated here. The key aspects of the project specification are:

1. **Route selection and length**

   The selected route minimises capital works by capitalising on our existing assets in the south west area of NSW. Sections of the route are where possible along our existing lines considering existing land use and constraints, which will reduce access development costs for those sections. Where possible, new lines will terminate at our existing substations, which require extensions of existing substations instead of the establishment of new substations, which would cost more.

2. **Voltage selection**

   The PACR identifies that a new 330 kV interconnector between Robertstown in mid-north South Australia and Wagga Wagga in New South Wales via Buronga along with an augmentation between Buronga and Red Cliffs in Victoria is expected to deliver the highest net market benefit. Options for DC interconnection or alternate voltages were rejected. We note that 330 kV also has lower operating costs (losses) than lower voltage options.

   Further, the number of new power transformers required has been minimised by the selection of 330 kV operating voltage.

3. **Number of circuits**

   The number of circuits required has been optimised:

   a. New double circuit from South Australia to Buronga to Dinawan to Wagga Wagga – a single circuit line would not have sufficient capacity, necessitating that double circuit lines be used

   b. New double circuit 220 kV line from Buronga to Red Cliffs (AEMO's assessment determined a double circuit line will provide additional net market benefits over a single circuit line by allowing for future expansion).

4. **Line Length Optimisation**

   By selecting the Dinawan switching station option over using Darlington Point, the overall line length between Buronga and Wagga Wagga has been reduced by approximately 16 km.

5. **Conductor size**

   The smallest conductor size (Mango) has been selected to deliver the required 800 MW.

6. **Required reactive plant for network stability**

   The reactive plant has been selected based on technical needs for transient stability of the SA and NSW power grids as determined in a study undertaken by ElectraNet[2].

3.3.1.2 Well-defined design basis

The design has been optimised:

> The design and specification for all equipment is compliant with relevant Australian Standards. The standard 330 kV tower design has been modified to be compliant to AS 7000 (see section 3.3.2.3). Additionally, tenderers have considered the use of alternative support structures and the final specification adopts a guyed tower solution to replace some self-supporting suspension towers, thus reducing costs.

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[1] https://www.electranet.com.au/wp-content/uploads/projects/2016/11/SA-Energy-Transformation-PACR.pdf

[2] https://www.electranet.com.au/wp-content/uploads/projects/2016/11/SAET-RIT-T-Network-Technical-Assumptions.pdf

- We have adopted best practice Safety in Design principles to ensure safe operation over the lifetime of the assets
- Key elements of the design have been confirmed by specialist consultants, including:
  - Land – desktop geotechnical assessments have been conducted by Douglas Partners
  - Access tracks – basis of design and cost estimation by Beca
  - Structures – concept designs by Beca and optimised by Tenderers
  - Foundations – concept design by Beca and optimised by Tenderers
  - Conductor selection – electrical and mechanical performance study by Beca.

3.3.1.3 Design considers deliverability and constructability

Deliverability and constructability constraints have been overlayed on the key design parameters to ensure the design is practical and realistic and truly reflects expected works.

- **Safety considerations**

  We have a very low risk appetite in relation to safety as per stated in our Risk Appetite Statement[3]. We consider stringing of conductors on towers using helicopters poses unacceptable level of safety risk and hence, we will not use this approach to string PEC's transmission lines. We will utilise proven ground based stringing techniques for the Project.

- **Earthworks**

  Earthworks are normally undertaken on a cut and fill basis as this lowers the cost of transporting materials to site. We have identified that both the Buronga substation and Dinawan switching station sites are relatively flat and are in flood zones. Hence, opportunity for the cut-fill approach is unlikely and will require fill to be imported to the sites (see section 4.3.1).

- **Access issues for phase shift transformer (PST) delivery**

  Loading constraints on roads to Buronga substation place a 200 tonne restriction on the specification of the PSTs at Buronga and impact how they can be transported to site.

3.3.2 Changes since the RIT-T PACR

Following issue of the RIT-T PACR, we have worked to refine the project specification. Importantly, a change in the proposed route has occurred to bypass Darlington Point and hence avoid traversing intensive irrigation areas. This matter is discussed further in section 3.3.2.1.

We have also sought to address the simplifying assumptions made in the initial forecast, to improve the accuracy of the estimating approach and to validate the specification where possible.

Table 3.1 summarises the changes in specification between the original RIT-T submission and the present specification.

[3] TransGrid, 2019, TransGrid Risk Appetite Statement, pg. 4

Table 3.1 – Change in project specification since RIT-T

Item	Comment
Route change to avoid intensive irrigation areas	The original route used the existing substation at Darlington Point to locate reactive control equipment. Bypassing Darlington Point lowers the overall project cost (including risk costs) – although has a similar base cost as it lowers the risk to timely project delivery in negotiating suitable easements and access rights through the intensive irrigation zones around Darlington Point township.
Line route deviations	Original equipment volumes based on straight-line estimate of line length. No allowance for line route deviations was made
Redesigned 330 kV transmission towers	Modifications to 330 kV tower design primarily to meet AS:7000 standards which increases tower steel and foundations
Increased 330 kV span length	The changes to transmission tower design has increased the design span, reducing the number of towers required
Revised 330 kV PST specification	The phase shift transformers specification changed from three 400 MVA 3-phase units to five 200 MVA 3-phase units, due to road transport weight limitations
Shunt reactors	Original scope was for two 50 MVAr reactors at each of Buronga substation and Darlington point substation. This has been changed to add two 60 MVAr reactors at Buronga and Dinawan substations.
Redesigned 220 kV transmission structures	Original design based on a scaled down 330 kV tower. Specification now adopts a double circuit steel pole
Change in 220 kV scope	Original scope was for a double circuit 220 kV line strung one side only to provide a capacity of 417 MVA. The current specification is based on stringing both sides providing 800 MVA capacity each circuit and decommissioning the existing 220 kV line. Additionally, the 330/220 kV transformer specification at Buronga has be revised from 2 x 400 MVA to 3 x 200 MVA transformers
Additional land purchases	The land required to establish the new assets at Buronga and Dinawan has been extended to accommodate future extensions of the substations to allow for new connections.

3.3.2.1 Route change to avoid intensive land use (irrigation) areas

The original transmission line route used as the basis for the RIT-T assessment passed through Darlington Point so as to take advantage of the existing substation located there. The substation was to be extended to accommodate the transmission line connections to the required reactive control equipment. The new transmission lines entering and exiting the substation were therefore proposed to be located adjacent to existing transmission line assets.

The existing transmission line assets traverse land that is under intensive land use and irrigation. Our internal assessment on land use and line route options indicates that the costs of obtaining suitable easements and access to a line route adjacent to existing assets is high and there is a high risk that negotiations with land owners may not be successful and require instances of compulsory acquisition. As an alternative route is available south of Darlington Point, we prefer to adopt this route as a risk mitigation measure to minimise the risk of compulsory acquisition of land.

The revised route proposed is shown in Figure 3.3. The route avoids the irrigated agricultural land around Darlington Point and minimises the prime agricultural land traversed by the transmission lines.

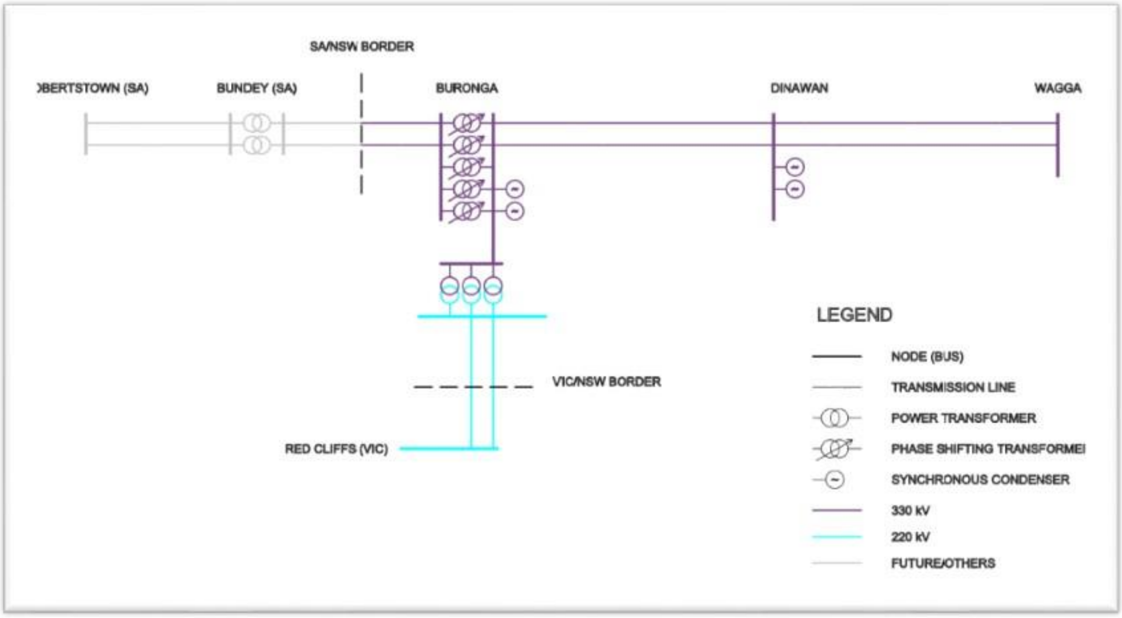
Figure 3.3: Transmission line alignment optimisation

Our internal assessment suggests that the southern alternative route would be cost neutral when compared with the forecast cost of a route through Darlington Point. In addition, the southern alternative route has the following attributes:

- lower risk profile than negotiating suitable easements and access rights through the intensive irrigation zones around Darlington Point township. This also lowers the risk that project delivery might be delayed. The new proposed route is estimated to reduce the overall transmission line route length by 16 km between Buronga and Wagga Wagga but requires land to be acquired south of Darlington Point to accommodate the required reactive control equipment
- impacts a lower number of recorded Aboriginal cultural heritage sites based on AHIMS
- avoids known property constraints and developments around the existing Darlington Point substation, which is effectively land locked by renewable energy developments
- greater connectivity in the Dinawan region and increases feasibility of future connection into VNI West 500 kV transmission lines.

The revised electrical arrangement is shown in Figure 3.4.

Figure 3.4: PEC revised electrical arrangement

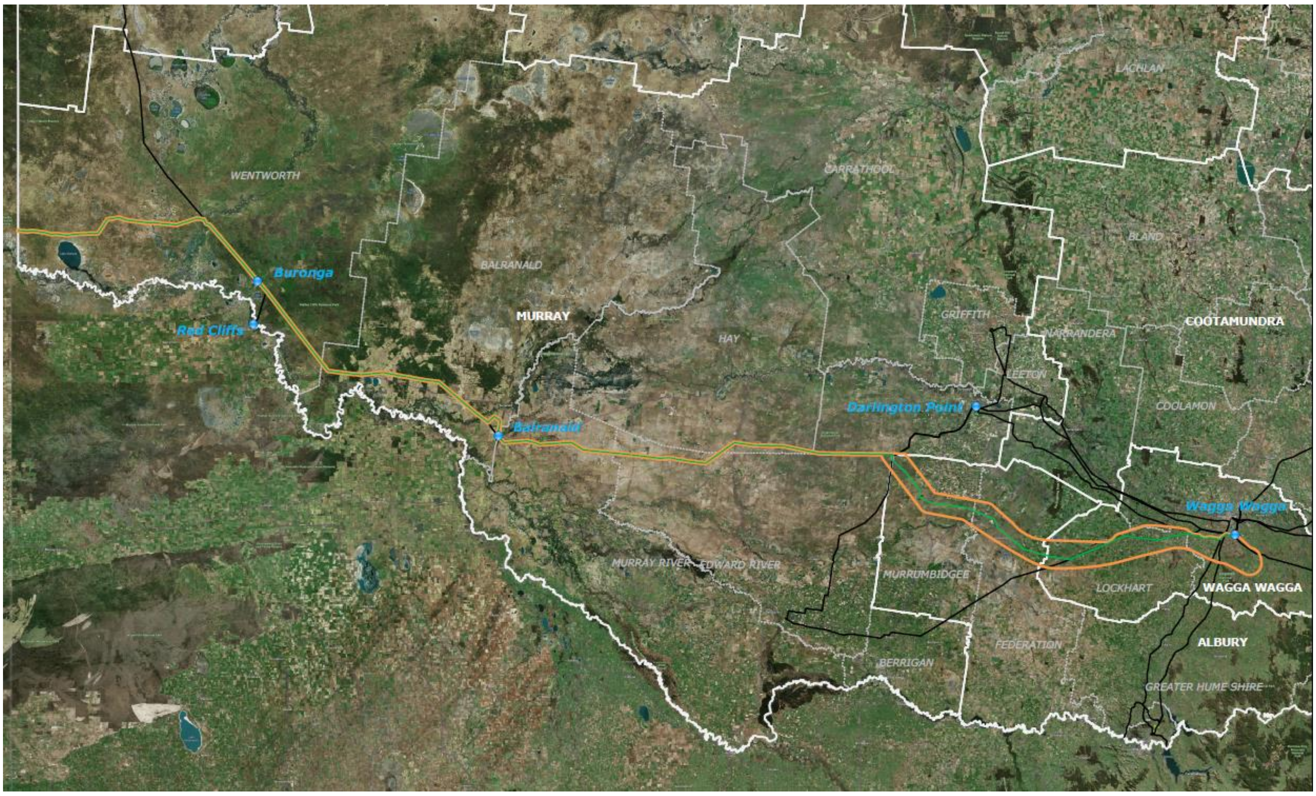


3.3.2.2 Line route deviations

The estimated volumes of equipment required in the RIT-T PACR were based on a straight-line estimate of line length. This was appropriate given the then current knowledge of the line route and accuracy of estimation.

Since the PACR was issued, the line route has been firmed-up (see Figure 3.5). The estimate of straight-line length for the new 330 kV line from the SA border to Buronga has been revised from 140 km to 135 km.

Figure 3.5: Refined PEC line route within NSW



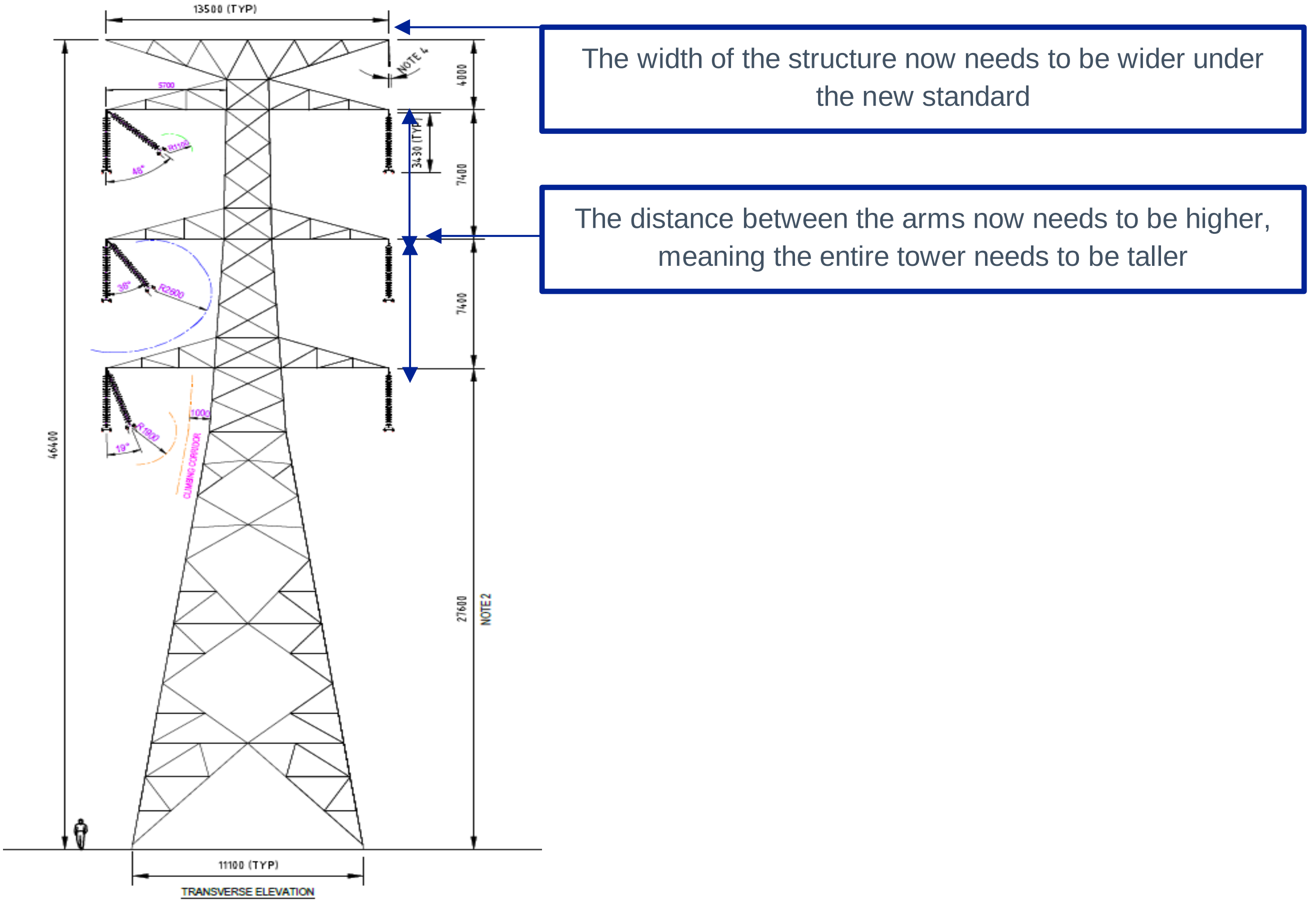
Some sections are adjacent to existing lines between Buronga and Wagga Wagga and this has enabled an estimate of line deviations to be made, to avoid (for instance) terrain undulations and sub-optimal location of angle points due to route constraints.

Line deviations add about 5 per cent more suspension structures to the forecast. By adopting the route via Dinawan, however, an overall reduction in 330 kV line route length of 3% is achieved.

3.3.2.3 330 kV tower structure design change

The specification at the time of the RIT PACR was based on our then current tower designs. We have now updated our 330 kV tower designs to meet revised standard as set out in AS 7000 for overhead line design.[4] A key change in the AS7000 standard is the clearance requirements between the structure, conductors and insulators. This means that a 330 kV tower must now be 2.4 metres wider than the towers installed in the past. The distance required between the phases is also greater, meaning that the tower is taller. Figure 3.8 below shows the internal clearances for a 330 kV suspension tower under the new design standards.

Figure 3.8 Simple diagram showing change in tower construction to meet new clearance standard



The increase in tower height and width has led to an increase in the overall tower weight and resultant increase in foundation requirements.

3.3.2.4 330 kV tower span change

We have determined that the average suspension tower design span could be increased from 400 metres. The range of spans actually used is decided by the tenderers in their final concept designs. The final specification has an average span of 464 metres.

[4] Standards Australia, Australian/New Zealand Standard: Overhead line design AS/NZS 7000:2016

3.3.2.5 Revised 330 kV PST specification

Special 330 kV to 330 kV phase shift transformers (PSTs) are required to be installed to adjust for the phase difference between the points of connection in SA and NSW. Without these transformers, the required load transfer capacity of 800 MW cannot be achieved. The initial specification was for three phase (3-phase) shift transformers to be installed at Buronga substation.

Due to the weight of transporting a 3-phase PST on loading constrained roads to Buronga substation, the scope was changed from three 3-phase transformers to nine single-phase transformers. Three single phase transformers are required to form one 3-phase PST. Subsequent investigation shows that an alternative of installing five 200 MVA 3-phase transformers may lower costs and tenderers were asked to provide final quotations based on a configuration that lowers overall costs. The final specification adopts five 200 MVA 3-phase transformers.

3.3.2.6 Shunt reactors

The original scope was for two 50 MVAr reactors at each of Buronga substation and Darlington point substation. Shunt reactors are required to provide reactive support to the lines to achieve the required load transfer capability. We have determined that a further four 60 MVAr reactors are required, two each at Buronga substation and Dinawan substation.

3.3.2.7 220 kV structure refined

The initial estimate used our standard 330 kV towers as a base for estimating the steel required for construction and used a scaling factor to reduce the expected amount of steel to suit a 220 kV tower. The short-listed tenderers have specified a revised tower design and a steel pole design that each appear to efficiently meet the placement of the current structures on the existing 220 kV line Buronga to Red Cliffs.

The final specification adopts a steel pole design. Placing the new structures adjacent to the existing structures eases construction issues and reduces the number of outages required on the existing line during construction of the new line.

3.3.2.8 Change in 220 kV scope

The scope of the 220 kV transmission line used as the basis for the RIT-T assessment was for a double circuit 220 kV line strung one side only with twin Lemon conductor providing 417 MVA. The current specification is based on stringing both sides and decommissioning the existing 220 kV line.

Site investigations highlighted a constrained corridor and easement due to orchards and other property developments in NSW, along with the Victorian portion being within a National Park. These make the establishment of a new 50m wide easement for the proposed new line likely to be difficult and a significant programme risk to the projects ability to use this line upgrade as part of the provision of first power to SA by Nov 2022.

To mitigate this property risk, an option was identified to re-build the existing 220 kV line on the existing easement, with a temporary 20 metre construction easement width extension. This change would require that the proposed double circuit line now be strung on both sides and the existing line dismantled, reducing the design from three circuits to two circuits. Dismantling the existing line returns 20 metres of easement back to the property owners, thus resulting in net zero change to the existing 50 metre easement width at the end of the project.

Reducing the design from three circuits (two now, one in the future) down to two circuits means altering the design capacity of the two circuits to address AEMO capacity requirements planned in the RIT-T. This necessitated a line rating of 800 MVA per circuit (twin Pawpaw) on the re-built line, and no future circuit provisions.

This change was agreed between AEMO and our system planners who noted that it better leverages the use of the double circuit line proposed under the RIT-T.

Additionally, the 330/220 kV transformer specification at Buronga has be revised from 2 x 400 MVA to 3 x 200 MVA transformers due to road transport weight limitations.

3.3.2.9 Additional land for substation extension

The land required to establish the new assets at Buronga has been extended to accommodate changes to the substation to create a larger buffer zone. The need to do so was not recognised at the time of the PACR forecast.

3.4 Market testing and validation of project specification

The refined project specification seen in Figure 6 was validated through a combination of internal review and market testing to provide additional rigour and confidence in the specification.

Figure 6 Simple diagram showing project specification market tested

3.4.1 Internal analysis

We have undertaken significant internal review of the initial specification, involving ElectraNet and AEMO as appropriate, to remove assumptions and to refine costs. This review has included:

> Analysis of the proposed line route within NSW and preliminary location of towers to inform the tendering process, resulting in the straight line route from SA border to Buronga being revised from 140 km to 135 km.

> Assessment of land impacts and likely easement costs and/or compulsory land acquisitions, resulting in a revised 330 kV route to avoid the intensive irrigation areas around Darlington Point and a change in scope for the 220 kV line between Buronga and Red Cliffs to minimise easement requirements and associated risks to project delivery.

> Assessment of deliverability issues, resulting in changes to the 330/220kV transformers and PSTs at Buronga to suit weight restrictions on roads.

> Development of a new 220 kV monopole design to optimise the concept design of the tie-line between Buronga and Red Cliffs.

We have also established a Major Projects Governance Framework to manage PEC and other major projects – this is described in the Capex Forecasting Methodology for Project EnergyConnect attachment to the Application.

3.4.2 External validation

The project specification was validated through market testing by requesting tenders from EPC entities to provide the engineering, design, procurement, required testing, commissioning and delivery of our portion of PEC. This included providing quotations for:

- design of the civils, lines and substations including large specialist equipment
- development of the corridor wide staging plan and program strategy for delivery
- provision of construction phase design services
- construction of the works
- pre-commissioning of the works.

Five tenderers submitted pricing information on our Concept Design during the RFT Phase A process. Three short listed tenderers submitted detailed concept designs and pricing during the RFT Phase B process. Two short listed tenderers submitted refined concept designs and pricing in the BAFO process. The final scope and specification are based on the concept design of the preferred tenderer (Bidder 2), identified by the Tender Evaluation Panel on 10 September 2020.

3.5 Final specification

The final project specification is set out in the next section.

4. Project specification

This section describes the specification for the PEC project within NSW with an added connection to Red Cliffs in Victoria. The specification has been classified into the following categories:

> Land and easements

> Substation works

> Transmission lines

> Large specialist equipment (phase shifting transformers, synchronous condensers)

> Other equipment.

4.1 Land and easements

About 700 km of new transmission line easements will be required for PEC, between the SA/NSW Border, Buronga, Dinawan and Wagga Wagga and including the augmentation of the existing Buronga to Red Cliffs connection.

Property will be needed at Buronga and Dinawan for the development of substation facilities.

4.2 Transmission Lines

To meet the primary need to deliver an additional 800 MW transfer capacity, overhead transmission lines are required between Wagga Wagga in NSW and Robertstown in South Australia. As set out in the RIT-T PACR, the lines will operate at 330 kV. A tie line between Buronga substation in NSW and Red Cliffs substation in Victoria is also required at 220 kV.

Tower designs are as specified by each tenderer and comply with our requirements and AS7000 as discussed in section 3.3. The final specification replaces some self-supporting suspension towers with a guyed tower solution, thus reducing costs. The final specification also adopts a new steel pole design to optimise the line design of the tie-line between Buronga and Red Cliffs.

The transmission line scope includes the following:

4.2.1 South Australian Border to Buronga

The transmission line from the South Australian border to Buronga substation requires:

> Design and construction of a 330 kV double circuit transmission line, strung on both sides with twin Mango ACSR conductor for a rating of 800 MVA per circuit at an operating temperature of 85°C

> Provision of both OPGW and overhead earth wire. Conductor and earth wire stringing to employ ‘non-helicopter’ method

> Acquisition of easements required for the new 330 kV transmission line between the South Australian border and Buronga substation

> Construction of access tracks and installation of gates as required

> Undergrounding of local distribution lines as required

> Biodiversity offset payments for disturbance to Environmentally Sensitive areas

> Deviation of existing X2 Line (220 kV Buronga to Broken Hill) at Ellerslie to facilitate the construction of the new 330 kV line.

The final specification has the attributes shown in Table 4.1.

Table 4.1 South Australian Border to Buronga Substation

Item	Value
Route length (km)	135
Easement width (m)	80
Average span (m)	461
Total structures	293
➢ Self-supporting suspension tower	52
➢ Guyed suspension tower	200
➢ Strain tower	41

4.2.2 Buronga to Dinawan

The transmission line from the Buronga substation to the new Dinawan switching station requires:

> Design and construction of a 330 kV double circuit transmission line, strung on both sides with twin Mango ACSR conductor for a rating of 800 MVA per circuit at an operating temperature of 85°C

> Provision of both OPGW and overhead earth wire. Conductor and earth wire stringing to employ ‘non-helicopter’ method

> Acquisition of easements required for the new 330 kV transmission line between Buronga substation and Dinawan switching station

> Construction of access tracks and installation of gates as required

> Biodiversity offset payments for disturbance to Environmentally Sensitive areas

> Undergrounding of local distribution lines as required

> Diversion of existing X2 Line (220 kV Buronga to Broken Hill) at Buronga as required to facilitate the construction of the new 330 kV line entry to the Buronga substation.

The final specification has the attributes shown in Table 4.2.

Table 4.2 Buronga Substation to Dinawan Substation

Item	Value
Route length (km)	376
Easement width (m)	80
Average span (m)	471
Total structures	799
➢ Self-supporting suspension tower	66
➢ Guyed suspension tower	650
➢ Strain tower	83

4.2.3 Dinawan to Wagga Wagga

The transmission line from the Buronga substation to Wagga 330 kV substation requires:

> Design and construction of a 330 kV double circuit transmission line, strung on both sides with twin Mango ACSR conductor for a rating of 800 MVA per circuit at an operating temperature of 85°C

> Provision of both OPGW and overhead earth wire. Conductor and earth wire stringing to employ 'non-helicopter' method

> Acquisition of easements required for the new 330 kV transmission line between Dinawan switching station and Wagga 330 kV substation

> Construction of access tracks and installation of gates as required

> Biodiversity offset payments for disturbance to Environmentally Sensitive areas

> Undergrounding of local distribution lines as required

> Reconfigurations for line entries into Wagga 330 kV substation.

The final specification has the attributes shown in Table 4.3.

Table 4.3 Dinawan Substation to Wagga Substation

Item	Value
Route length (km)	159
Easement width (m)	80
Average span (m)	450
Total structures	353
➢ Self-supporting suspension tower	148
➢ Guyed suspension tower	151
➢ Strain tower	54

4.2.4 Buronga to Red Cliffs

The transmission line from Buronga substation to Red Cliffs substation requires:

> Design and construction of a 220 kV double circuit transmission line strung on both sides with twin Pawpaw ACSR conductor for a rating of 800 MVA for each circuit at an operating temperature of 100°C

> Provision of both OPGW and overhead earth wire. Conductor and earth wire stringing to employ 'non-helicopter' method

> Acquisition of easements required for the new 220 kV transmission line between Buronga substation and Red Cliffs substation

> Decommissioning and demolition of existing Buronga to Red Cliffs single circuit line

> Construction of access tracks and installation of gates as required.

The final specification has the attributes shown in Table 4.4.

Table 4.4 Buronga 220 kV Substation to Red Cliffs

Item	Value
Route length (km)	24
Easement width, additional to existing 50m (m)	18 (for 18km)
Average span (m)	382
Total structures	62
➢ Strain/Termination steel pole (Twin)	9
➢ Strain/Termination steel pole (Single)	2
➢ Suspension steel pole	51

4.3 Substation works

Substation works are required at:

> Buronga substation to terminate the 330 kV line from Robertstown in SA, to transform from 330 kV to 220 kV and to terminate the 220 kV line from Red Cliffs in Victoria. Substation works at Robertstown are the responsibility of ElectraNet

> Red Cliffs substation in Victoria to terminate the uprated 220 kV lines from Buronga

> a new switching station at Dinawan to terminate the 330 kV lines from Buronga and Wagga 330 kV and to install reactive compensation plant, and

> Wagga 330 kV substation to terminate the 330 kV line from Dinawan.

The works at each substation are set out below.

4.3.1 Buronga substation

The works at Buronga substation are:

> Establishment of a new 330 kV switchyard adjacent to the existing substation to accommodate the new high voltage equipment and new line circuits

> Acquisition of property interests surrounding the Buronga substation to accommodate the expansion

> Land acquisition, bulk earthworks, civil and structural works, drainage, internal and external palisade fencing including earthing of the entire substation and electrical connection to the existing Buronga 220kV switching station

> Internal roads, pavements, conduits and pits

> Four (4) new 330 kV busbars

> Five (5) new 330 kV 200 MVA phase shifting transformers & associated switchbays

> Two (2) new 330 kV 100 MVAr synchronous condensers, associated transformers and switchbays (see 4.4.2 below).

> Two (2) new 330 kV 50 MVAr shunt reactors & associated switchbays

> Two (2) new 330 kV 60 MVAr shunt reactors & associated switchbays

> Two (2) new 330 kV 50 MVAr capacitors & associated switchbays

> Three (3) new 330/220 kV 200 MVA power transformers & associated switchbays

- Two (2) new Auxiliary transformers
- Four (4) new 330 kV line bays, in breaker and a half layout
- Two (2) new 220 kV busbar extensions and associated bus sections
- One (1) new 220 kV line bay
- One (1) new or upgraded 220 kV line bay
- Upgrade to existing Buronga Earthgrid to cater for increased fault rating
- Spill oil containment tank/s and associated connections
- Two (2) Secondary Systems Buildings and associated building services
- Site services
- A diesel generator connection point
- A storage shed
- Associated secondary systems including protection, control, metering, communications, LV cabling and equipment required for the substation and its interfaces.

4.3.2 New Dinawan switching station

The works at Dinawan are:

- Establishment of a new 330 kV switchyard at Dinawan to accommodate the new high voltage equipment and new line circuits.
- Acquisition of property interests to accommodate the new station
- Land acquisition, bulk earthworks, civil and structural works, drainage, internal and external palisade fencing including earthing of the entire station
- Internal roads, pavements, conduits and pits
- Two (2) new 330 kV busbars
- Large specialist equipment (synchronous condensers, see 4.4.1 below).
- Two (2) new 330 kV 50 MVAr shunt reactors & associated switchbays
- Two (2) new 330 kV 60 MVAr shunt reactors & associated switchbays
- Two (2) new 330 kV 50 MVAr capacitors & associated switchbays
- Four (4) new 330 kV line bays, in breaker and a half layout
- Spill oil containment tank/s and associated connections
- A Secondary Systems building and associated building services
- Associated secondary systems including protection, control, metering, communications, LV cabling and equipment required for the substation and its interfaces.

4.3.3 Wagga 330 kV substation

The works at the Wagga 330 kV substation are:

- Two (2) new 330 kV busbar extensions within the existing Wagga 330kV substation
- Four (4) new 330 kV transmission line switchbays to suit:
  - termination of double circuit line to Dinawan
  - relocation of the existing Jindera circuit to a double circuit breaker bay configuration

  - relocation and conversion of the existing Darlington Point circuit to a double circuit breaker bay configuration
- Associated secondary systems including protection, control, metering, communications, LV cabling and equipment required for the 330 kV line bay and its interfaces.

4.3.4 Red Cliffs substation

The works at Red Cliffs substation are:

- One (1) new 220 kV transmission line switchbay within the existing Red Cliffs (AusNet) 220 kV substation
- One (1) upgraded transmission line switchbay within the existing Red Cliffs (AusNet) 220 kV substation
- Associated secondary systems including protection, control, metering, communications, LV cabling and equipment required for the 220 kV line bay and its interfaces.

4.4 Large Specialist Equipment

Reactive compensation equipment is required at Dinawan switching station and Buronga substation.

4.4.1 New Dinawan switching station

Supply and installation of:

- Two (2) new 330 kV 100 MVAr synchronous condensers, associated transformers and switchbays.

4.4.2 Buronga Substation

Supply and installation of:

- Five (5) 330 kV 200 MVA ±40° phase shifting transformers
- Two (2) 100 MVAr synchronous condensers.

4.5 Other works

The following additional works are required:

- Reactive power controllers at Buronga and Dinawan to orchestrate the operation of synchronous condensers, capacitor banks and shunt reactors to maintain 330 kV busbar voltages
- Special control scheme for fast switching of line shunt reactors at Dinawan and Buronga on detection of over-voltage conditions at either substation’s 330 kV buses
- A special control scheme that facilitates network operations in South Australia based on the status of equipment throughout South Western NSW.

5. Summary of key materials

The key overhead line materials are summarised in Table 5.1 below.

Table 5.1 - Overhead line scope

Transmission line	SA border to Buronga	Buronga to Dinawan	Dinawan to Wagga Wagga	Buronga to Red Cliffs
Distance (km)	135	376	159	24
Voltage (kV)	330	330	330	220
No. of circuits	Double	Double	Double	Double
Conductor	Twin ACSR Mango	Twin ACSR Mango	Twin ACSR Mango	Twin ACSR Pawpaw
OPGW	Yes	Yes	Yes	Yes
OHEW	Yes	Yes	Yes	Yes
Route	Part new and part along existing line X2	Part new and part along existing line X5 and X3	Part new and part along existing lines 63 and 99A	Rebuild of existing 0X1 as double circuit
Average span (m)	461	471	450	382
Structure type	Double circuit towers	Double circuit towers	Double circuit towers	Double circuit steel poles
Total number of structures	293	799	353	62
No. of suspension structures	252	716	299	51
No. of strain structures	41	83	54	11

The key substation materials are summarised in Table 5.2 below.

Table 5.2 - Substation scope

Substation	Buronga	Dinawan	Wagga 330kV	Red Cliffs
Existing voltage (kV)	220	-	330/132	220
New voltage (kV)	330/220	330	-	-
New transformers (and switchbays)	3 * 330/220 kV 200 MVA	-	-	-
Phase Shift Transformers	5 * 200 MVA 40 deg	-	-	-
330 kV Synchronous condensers	2 * 100 MVAr	2 * 100 MVAr	-	-
330 kV shunt capacitor bank (and switchbays)	2 * 50 MVAr	2 * 50 MVAr	-	-
330 kV line shunt reactors (and switchbays)	2 * 50 MVAr 2 * 60 MVAr	2 * 50 MVAr 2 * 60 MVAr	-	-
Line bays	4 * 330 kV 1 * 220 kV 1 * 220 kV (new or upgraded)	4 * 330 kV	4 * 330 kV	1 * 220 kV 1* 220kV upgraded
Busbars	3 * 330 kV	2 * 330 kV	extend 2 * 330 kV	-
Secondary (Prot'n & Control)	All new 330 kV	New 330 kV	New 330 kV line bays	New 220 kV line bays
New secondary systems building	2	1	-	-
Civil works	New 330kV bulk earthworks and civil works adjacent to 220kV.	New 330kV bulk earthworks and civil works	-	-

Appendix A – Supporting documents

Tenderers returnable schedules

TransGrid Option Feasibility Study (OFS 000000001570 Option C.2 Revision 5)

Jones Lang LaSalle, October 2019, Desktop Assessment of Compensation

Beca, August 2019, EnergyConnect - Basis of Design and Cost Estimation - Access Tracks for Dry Weather Access Only

Beca, Sept 2019, EnergyConnect - Structure Concept Design Report - 220kV Double Circuit

Beca, Sept 2019, EnergyConnect - Structure Concept Design Report - 330kV Double Circuit

Beca, Sept 2019, EnergyConnect - Structure Concept Design Report - 330kV Single Circuit

Beca, Sept 2019, EnergyConnect - Structure Selection Study Buronga to RedCliffs

Douglas Partners, July 2019, Report on Preliminary Geotechnical Investigation

> 2019 DP 86737.R.001.Rev0 Stage 1 Phase 1
> 2019 DP 86737.R.002.Rev1 Stage 1 Phase 2
> 2019 DP 86737.R.004.Rev0 Stage 2 Memo
> 2019 DP 86737.0.R.003.Rev0.Stage 2 Phase 1
> 2019 DP Combined - Phase 1 & 2 - Geology Overview - Drawing A Rev0
> 2019 DP Combined - Phase 1 & 2 - Geology Overview - Drawing B Rev0

Beca, May 2019, SAET Interconnector - Conductor Selection Study