GHD Advisory

PEC - Scope Independent Verification and Assessment

TransGrid

30 September 2020

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1. Executive summary

The proposed Project EnergyConnect (PEC) is a core component of the priority Group 2[1] "RiverLink" interconnector project identified in the Australian Energy Market Operator's ('AEMO') first Integrated System Plan ('ISP') published in July 2018.

The ISP recommended a new interconnector between New South Wales (NSW) and South Australia (SA) by 2025, which would allow:

- Renewable and baseload generation in other National Energy Market (NEM) regions to be transported to SA
- Access to new Renewable Energy Zones (REZ)
- More efficient use of resources across the NEM with greater supply sharing.

ElectraNet led the investigation into the network and non-network options in conjunction with TransGrid and an assessment of options were detailed in the SA Energy Transformation RIT-T Project Assessment Draft Report (PADR) dated 29 June 2018.

The SA Energy Transformation RIT-T Project Assessment Conclusions Report (PACR) dated 13 February 2019 further evaluated and refined the options with the estimated cost for the preferred option at $1,531M (Real 2017-18) for the new 330 kV interconnector between SA and NSW.

TransGrid's Contingent Project Application (CPA) covers the NSW component of this project from the SA border to TransGrid's Wagga 330 Substation.

The Capex Forecasting Methodology for PEC 29 June 2020 advises that the PACR estimate was based upon:

- Specification of the new 330 kV line with 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
- Specification of the new 220 kV line with a scaled down 330 kV tower design due to the lack of available information at the time
- The specification of reactive compensating equipment (synchronous condensers) and Phase Shifting Transformers (PST) at Buronga derived from manufactures' price lists
- Minimal easement acquisition cost that did not account for landholder negotiations as this could not be estimated based on the information available at the time
- The PACR capex forecast that did not include an allowance for environmental offset and project risk costs.

Since the publication of the PACR:

- TransGrid have progressively refined the scope, adopting the Southern Alternative Route option.

[1] Group 2 Developments in the medium term to enhance trade between regions, provide access to storage, and support extensive development of REZs

The Southern Alternative Route has been justified on the basis that the incremental cost of the Southern Alternative Route is negligible, that the route near Darlington Point would involve a risk to timely project delivery in negotiating suitable easements and access rights through the intensive irrigation zones around the township.

- Further refinement changes were also made to the scope with respect to substation works, the reactive plant requirements and refinements to the transmission line structures and span length designs carried forward by TransGrid to establish the final alternate routes and solutions. These changes are defined as the Final PACR Solution.

GHD considers that the adjustments made to the scope relating to the Final PACR Solution and the Southern Alternative Route are efficient and prudent steps to final scope development. GHD built comparative estimates for what would have been the Final PACR Solution compared to the Southern Alternate Route. Our findings suggest that the Final PACR Solution would have been marginally lower in costs - around 1%. Hence this supports TransGrid finding of cost neutrality between the two route options.

The Phase A tender was released in September 2019 with submissions received 11 November 2019. The tender included cost elements that would be typically reflected in contracts.

The Phase A tender issued included key changes related to:

- Structural upgrades to transmission line structures and the shorter span lengths that were necessary to meet increased clearance requirements in the revised AS/NZS 7000 standard
- Changes to address the simplifying assumptions made in the initial PACR forecast to provide more accurate scope specifications
- The adoption of the Southern Alternative Route
- Substation works, the reactive plant requirements and refinements to establish the final alternate routes and solutions.

The RFT Phase A Capex Forecast of $2,271M (Real 17-18) was based upon:

- $1,531.5M (Real 2017-18) for the estimate (Phase A estimate) based on the tendered works for the Phase A RFT. This capex reflects:
  - The average tender prices of the three short-listed tenders that were received on 11 November 2019 for substations and transmission lines
  - Quotations from suppliers for the Large Specialist Equipment (LSE), which TransGrid considered a more reasonable and realistic cost estimate than the tender prices
- $275.4M (Real 2017-18) for estimates of additional scope and costs identified that will be need to be shared between the successful tenderer following the Phase B RFT and TransGrid for the final direct EPC construction costs for the project
- $464.1M (Real 2017-18) additional project direct and indirect project costs.

Three bidders where short listed from the Phase A tender submissions to respond to the Phase B tender issued in February 2020. Phase B tender submissions were received in June 2020 and based upon initial evaluations TransGrid selected two bidders to progress to a Best and Final Offer (BAFO) process.

The BAFO Capex Forecast of $1,894.6M (Real 17-18), detailed in Table 1, includes:

- The outcomes of the BAFO process
- Updated information on other construction costs following tender evaluation
- Updates to easement costs and environmental offset costs, based upon expert reports from Jones Lang LaSalle (JLL) and WSP, which reflect the new PEC route via Dinawan, the current process of acquisition negotiations and on site investigations
- TransGrid's actual indirect cost to 31 July 2020.

Table 1 BAFO forecast

Cost element	Description / section reference	BAFO forecast (2017/18 $ million)
Substations and transmission lines, including access tracks.	Refer section 5.3	1,270.2
Large specialist equipment	Refer section 5.3	140.2
Other construction costs	Refer section 5.7	58.2
BAFO outcome		***1,468.6***
TransGrid direct costs	Property and easement acquisition and costs considered in section 6.	121.5
	Biodiversity 'offset' costs considered in section 7.	127.4
TransGrid indirect costs	Corporate and Network overheads, including property portfolio considered in section 8.	135.8
Biodiversity risk costs	Biodiversity risk allowances considered in section 9.	38.2
Real input escalators	Detailed in section 10.	3.2
Total Capex		**1,894.6**

PEC is a large and complex project that has undergone scope refinement since the PACR. As detailed in section 4, GHD have progressively assessed the scope changes and the resulting capex forecast in section 5. This has resulted in comparative estimates which have been considered against the BAFO outcome.

Section 5.3 includes GHD's analysis of the BAFO outcome against these comparative estimates. GHD needed to re-allocate project management, provisional sums and other TransGrid construction costs to the EPC contractor's direct costs to allow an appropriate comparison by cost and scope elements with GHD's estimates. This resulted in different totals respectively for the transmission line scope and the substation scope compared with TransGrid's allocation in the Supplementary Capex Forecasting Methodology - BAFO, with the BAFO outcome remaining at $1,468.6 million.

Following this process variances were identified where scope or cost elements exceeded a nominal ±20% variance. We provide an analysis of these variances in section 5 of the report. GHD's comparative estimates were based on TransGrid's concept designs and scope defined in the Phase B RFT documentation. The final review for this report found areas where adjustments where needed on the basis of scope definition and changes which increased GHD's comparative estimate for defined scope items. After these adjustments and at the high level:

- The overall variance is 10% ($160.0 million) between the adjusted GHD comparative estimate ($1,628.6 million) and the BAFO outcome for the corresponding scope ($1,468.2 million).
- For the transmission lines scope, the overall variance is 9% ($99.1 million) between the adjusted GHD comparative estimate ($1052.9 million) and the adjusted BAFO outcome for the corresponding scope ($953.8 million).[2]
- For the substations scope, the overall variance is 11% ($61.0 million) between the adjusted GHD comparative estimate ($573.2 million) and the adjusted BAFO outcome for the corresponding scope ($512.2 million).[2]

GHD considers the scope and forecast capital expenditure in TransGrid's CPA forecast are prudent and efficient having regard to National Electricity Rules capex criteria and objectives.

Summary

Table 2 shows a summary of the key findings from the GHD review.

Table 2 Summary of GHD review

Verification	
Scope	The PEC Scope and Specification Description (SSD) dated 29 June and 14 September 2020 adequately defines the project investment scope originally defined in the PACR and further modified by scope changes related to the Final PACR Solution and the Southern Alternative Route. The PEC scope has been refined since the PACR and is considered efficient and the minimum required to meet the asset performance requirements. The defined investment need is consistent with the investment need defined in the PADR and PACR. The scope definition in the SSD and Supplemental Capex Forecast Methodology - BAFO did not reference an allowance made for an additional 20km of route realignment for the DInawan to Wagga 330kV transmission line. GHD was not able to verifiy the justification for this late change of scope except that it is consistent with TransGrid's experience in developing the route in the initial PACR solution near Darlington Point. The scope changes since the PACR have been detailed in section 4.

[2] TransGrid's split of overheads into transmission lines and substations will differ

Verification	
Performance requirements	GHD considers that the asset performance requirements were adequately and appropriately defined in documents for both the Phase A and Phase B tender processes - for the scopes matching the tendered works for the Initial PACR Solution in Phase A and for the Southern Alternative Route in Phase B. The final tender specifications were predominately performance based.
BAFO Capex Forecast – Tendered Capex	The BAFO Capex Forecast is 10% lower than the aggregate GHD comparative estimate which is expected through design options developed during the procurement process while remaining within our expected range of costs.
BAFO Capex Forecast – Other construction costs	The other construction costs allowances made by TransGrid represents 4.0% of the BAFO outcome. The commissioning and safety assurance program are specific costs while the other components can be considered allowances for risk, amounting to 2.8% all of which GHD considers reasonable for a linear infrastructure project.
BAFO Capex Forecast – TransGrid direct costs	Property acquisition costs are based upon a desktop estimate provided by JLL. The analysis to determine potential and likely biodiversity offset costs are based on a sound methodology and approach, especially at this stage of the project.
BAFO Capex Forecast - TransGrid indirect costs	GHD is of the view that the 7% margin included by TransGrid in the CPA is within an acceptable range of owner cost margins for projects of this large relative size and complexity. Project overheads for transmission projects can typically range from 5% to over 20% depending on scale and complexity. PEC is at the highest end of project scale within this range and hence the lowest percentage margin. GHD's top down comparison, after adjusting for the scale of the project, closely aligned with TransGrid's forecast overhead costs. TransGrid reported RIN capex overhead margin from FY15 to RY18 was an average of 14.0%.
Project schedule	The profile of capital expenditure broadly aligns with that set out in Supplementary Capex Forecasting Methodology - BAFO.
Procurement process	TransGrid has adopted industry appropriate procurement strategies and practices.

Verification	
	The specifications included within tender documents represent standards expected for transmission infrastructure and good electricity industry practice. The specifications consider the need to operate reliability over the life expectancy of the transmission interconnector. The performance based scope and specifications defined in the Phase B tender is consistent with the scope defined in the TransGrid's SSD document and the Supplemental Capex Forecast Methodology - BAFO. The procurement process has achieved cost savings through early contactor involvement in the design and optimisation of technical solutions.

2. GHD scope

GHD has been engaged by TransGrid to perform an independent verification and assessment of specific elements to support their PEC CPA submission.

GHD's work scope included the following elements.

2.1 PEC scope review

An assessment of project scope, having regard for key project elements such as substations, towers, synchronous condensers, PSTs to consider reasonableness and appropriateness given the projects objectives.

2.2 Capex forecast review

An assessment of the reasonableness of the forecasts for the CPA:

- Unit costs and total capex forecast including overheads and risk allowances
- Timing of the profile of capex forecast

The work scope excluded a detailed assessment of risk identification, quantification and risk management strategy.

2.3 Variance to RIT-T PACR forecast

A consideration of RIT-T and the capex forecast variances having regard to the refinement of costs through the project phases.

2.4 Procurement

Assessment of the proposed procurement process to achieve the required outcomes TransGrid for PEC.

2.5 Limitations

This report: has been prepared by GHD for TransGrid and may only be used and relied on by TransGrid for the purpose agreed between GHD and the TransGrid as set out in section 2 of this report.

GHD otherwise disclaims responsibility to any person other than TransGrid arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described thought out this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by TransGrid and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has prepared comparative estimates using information reasonably available to the GHD employee(s) who prepared this Report, and based on assumptions and judgments made by GHD.

The comparative estimates has been prepared for the purpose of supporting TransGrid in their CPA submission and must not be used for any other purpose.

The comparative estimates are a preliminary estimate only in 2019 real Australian dollars. Actual prices, costs and other variables may be different to those used to prepare the comparative estimates and may change. Unless as otherwise specified in this Report, no detailed quotation has been obtained for matters identified in this Report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the comparative estimates.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for expenditure modelling purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile."

3. Background

3.1 The RIT-T process

"RiverLink", as it was initially known as, was first listed as a priority Group 2[3] project in the AEMO ISP published in July 2018 to establish new transfer capacity between NSW and SA of 750 MW. The now AER approved project is known as PEC and has been listed in the Draft ISP 2020 published in December 2019 as a Group 1[4] priority grid project.

The ISP 2018 recommended a new interconnector between NSW and SA by 2025 which would allow:

- Renewable and baseload generation in other NEM regions to be transported to SA
- Access to new REZ
- More efficient use of resources across the NEM with greater supply sharing.

ElectraNet led the investigation into the network and non-network options in conjunction with TransGrid and assessments of wider scope interstate options were documented in the PADR (titled South Australian Energy Transformation – SAET). The stated aim of a transmission augmentation investment in this report was to reduce the cost of providing secure and reliable electricity to SA in the near term, while facilitating the longer-term transition of the energy sector across the NEM to low emission energy sources.

As stated in the PADR, this investigation was undertaken in consultation with, and with the support of AEMO as the national planning body and Jurisdictional Planning Bodies AEMO (Victoria), Powerlink (Queensland) and TransGrid (NSW).

The PADR assessments showed that of the four broad and credible options considered, a new 330 kV interconnector between mid-north SA and Wagga Wagga in NSW, via Buronga, was expected to deliver the highest net market benefits.

The investment need for a preferred option stated in the PADR was to deliver net market benefits and support energy market transition through:

- Lowering dispatch costs, initially in SA, through increasing access to supply options across regions
- Facilitating the transition to a lower carbon emissions future and the adoption of new technologies, through improving access to high quality renewable resources across regions
- Enhancing security of electricity supply, including management of inertia, frequency response and system strength in SA.

The preferred option identified in the PADR outlined the developing scope definition for an interconnector between SA and NSW and formed the starting point for TransGrid's PEC investment. The capital costs for this option was estimated in the PADR to be in the order of $1.5 billion across both SA and NSW.

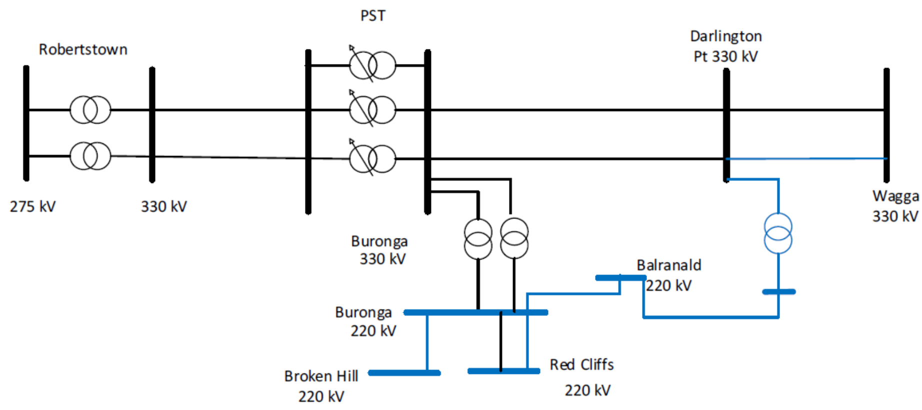
[3] Developments in the medium term to enhance trade between regions, provide access to storage, and support extensive development of REZs

[4] Projects critical to address cost, security and reliability issues and are to commence immediately after the publication of the final 2020 ISP, if not already underway.

Following stakeholder engagement and comments received from 36 parties, all of the wider scope options were further refined for consideration in the PACR. The PACR is the final formal step in the RIT-T process and takes into account stakeholder feedback received during all earlier stages of the RIT-T process.

The PACR process confirmed that the 330 kV interconnector between Robertstown in SA and Wagga Wagga in NSW, via Buronga and Darlington Point with a 220 kV augmentation between Buronga and Red Cliffs in Victoria was the preferred option to satisfy the RIT-T (Option C.3). The general electrical arrangement is shown in Figure 1.

Figure 1: The RIT-T PEC RIT-T electrical arrangement



Source: TransGrid - Specification and scope description

This option was scoped to provide 800 MW of transfer capacity and to increase transfer capacity on the existing Heywood interconnector to 750 MW, while delivering combined transfer capacity modelled at 1,300 MW. The project scope requirements included a wide area protection scheme to prevent cascaded tripping of the new interconnector and the Heywood interconnector following non-credible loss of either one.

The option was the same as that specified in the PADR with the exception of the addition of a new 24 km 220 kV line from Buronga to Red Cliffs in Victoria and removal of series compensation and further refined the scope for the current PADR Solution. GHD has defined the scope (and associated capital costs estimated for the RIT-T) as the RIT-T PEC capex estimate.

In January 2020[5], the AER determined that the preferred option is likely to maximise net economic benefits and satisfies the regulatory investment test for the South Australian Energy Transformation proposal.

[5] https://www.aer.gov.au/system/files/AER%20-%20Determination%20-%20SAET%20RIT-T%20-%2024%20January%202020.pdf

3.2 The phase A tendered prices

The initial project specification commensurate with the RIT-T PACR scope were based on an assessment of the likely line routes by consultants JLL who undertook a detailed study from SA border to Buronga and a high level desktop study from Buronga, via Darlington Point to Wagga Wagga and contained several simplifying assumptions. 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).

Following issue of the RIT-T PACR, TransGrid worked to refine the project specification details with respect to the same route and general electrical configuration. TransGrid also sought to address the simplifying assumptions made in the initial PACR forecast to improve the accuracy of the scope specifications which was also developed for a RFT (Phase A RFT) that went to the market in September 2019 with respect to this refined scope.

The key refinement impacting the cost of the solution were changes / structural upgrades to transmission line structures and the shorter span lengths that were necessary to meet increased clearance requirements in the revised AS/NZS 7000 standard.

GHD initially reviewed these refinements and tender prices (the "Phase A Estimate") with respect to considering efficiency in meeting the investment need. We developed comparative estimates against this scope of work and this enabled us to develop comparative estimates commensurate with further changes in scope that TransGrid have made since the tendered scope and costs were established that would have been relevant in the original proposed route defined in the PACR. The electrical arrangement at this point was the same as shown in Figure 1 for the RIT-T PACR configuration.

3.3 The PACR solution and the southern alternative route

The PACR solution

GHD identified the refinements in scope that were made for the Initial PACR Solution issued to the market as part of the Phase A RFT and which resulted in the RFT Phase A Capex Forecast. We then separately identified further changes since - namely with respect to substation works, the reactive plant requirements and refinements to the transmission line structures and span length designs carried forward by TransGrid to establish the final alternate routes and solutions; the Final PACR Solution and the Southern Alternative Route.

We have carried out a review of the respective scopes in section 4.6 for both options including the further scope refinements made during the development of the Southern Alternative Route, and to the respective project costs in sections 5.8 and 5.9.

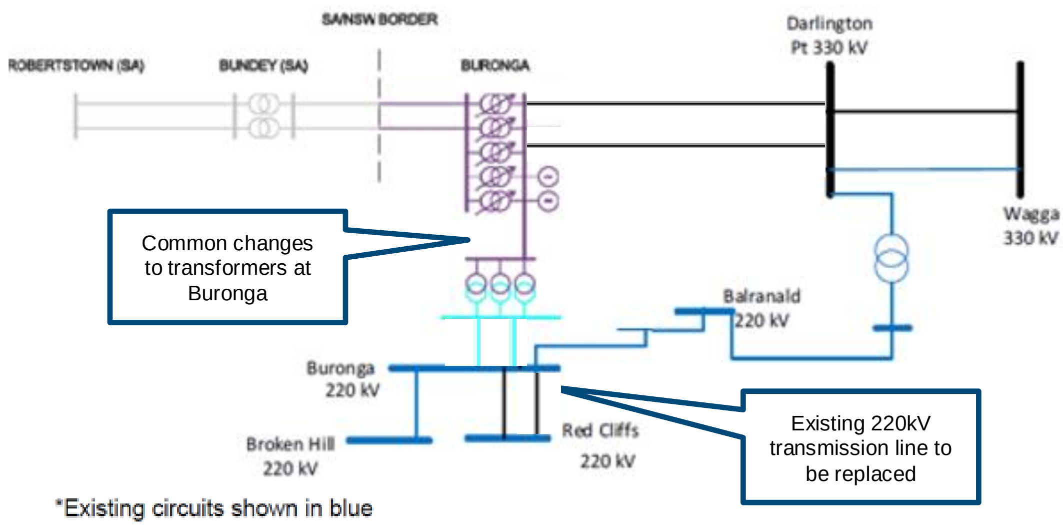
The line route for this Final PACR Solution is the same as the preferred option in the RIT-T PACR and is depicted in Figure 2. The general electrical arrangement for the Final PACR Solution is shown in Figure 3 which indicates configuration changes to power transformers at Buronga substation and further design changes made by TransGrid which would result in some increase in costs since the initial scope of work defined for the Phase A Tender.

GHD has had to consider scope changes and developed comparative estimates for both the Final PACR Solution and the Southern Alternative Route, and ultimately to validate the preferred solution selected by TransGrid. These comparative estimates were prepared prior to the Phase B Tender evaluation outcome.

Figure 2 The PACR solution route

Source: TransGrid - Specification and scope description

Figure 3 The final PACR solution - electrical arrangement



Source: GHD amended from TransGrid - Specification and scope description

The southern alternative route

TransGrid began considering this alternate route as it became evident that the route near Darlington Point would involve a risk to timely project delivery in negotiating suitable easements and access rights through the intensive irrigation zones around the township.

The SSD explains that 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 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 approaching Darlington Point traverses land that is under intensive land use and irrigation.

The SSD 29 June 2020 in section 3.3.2.2 outlines TransGrid's preference for the alternative route south of Darlington Point. TransGrid's 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:*

- *A lowered 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 9 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 the Aboriginal Heritage Information Management System*
- *Avoidance of 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*."

GHD's comparative estimates detailed in section 5 indicates that the Southern Alternative Route (a difference of around 1% of total project costs) confirming TransGrid's own cost neutral assessment of the two route options.

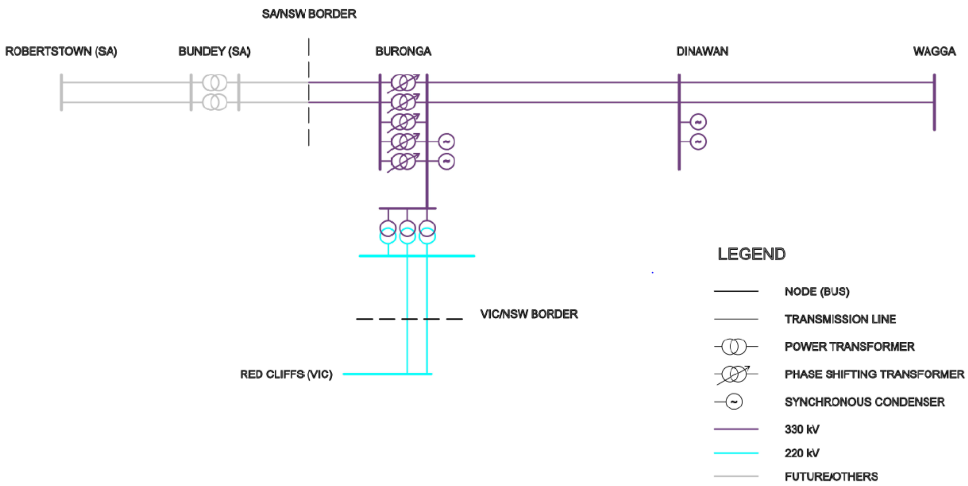
The revised route proposed is depicted in Figure 4 and a revised electrical arrangement is shown in Figure 5.

TransGrid has identified greater strategic benefits associated with the Southern Alternative Route. While our project cost assessments for each option will not directly consider these benefits in determining the efficiency of meeting the original PACR investment need, we recognise that the benefits are of interest to TransGrid and consumers in terms of a long term network efficient solution.

Figure 4 – The PEC selected route (the southern alternative route)

Source: TransGrid - Specification and scope description

Figure 5 – The PEC CPA electrical arrangement (southern alternative route)



Source: TransGrid - Specification and scope description

3.4 Capex forecast review

For our review of the scope and capex build up for the Final PACR Solution and the Southern Alternative Route it has been necessary to make adjustments for some further refinements in the scope that TransGrid had made since formulation of the RFT Phase A Capex Forecast. This assessment was required by GHD to make a direct comparison of costs between the two options in line with the findings TransGrid has arrived at in selecting the Southern Alternative Route as the preferred option.

GHD has independently reviewed and identified the changes to arrive at both the Final PACR Solution and the Southern Alternative Route to verify that TransGrid has allowed for all changes in the BAFO Capex Forecast (refer section 4).

TransGrid has applied an estimate for property acquisition, biodiversity offsets, project overheads and biodiversity risk in the BAFO Capex Forecast build up as illustrated in Table 3. GHD has reviewed these estimates in sections 6, 7, 8 and 9 of our report.

GHD has also independently assessed the scope definition in the original RIT-T PACR scope to review step changes to the scope and capital cost forecasts from the RIT-T PACR to the CPA final scope to verify whether the changes are reasonable based on meeting the investment need at the lowest costs. This assessment is provided in section 11. This assessment considers the costs relative to the Southern Alternate Route option.

Section 4.3.1 of TransGrid's Capex Forecasting Methodology 29 June 2020 document describes how TransGrid has built the capital forecast for the CPA submission according to the key categories shown in Table 3. GHD has had to take an alternative approach to build comparative estimates and to confirm that the Southern Alternative Route is preferable from a cost efficiency perspective (noting also that TransGrid has identified other network and market benefits with this route over the Final PACR Solution).

Table 3 - CPA capex build categories and GHD's comparative review

TransGrid key capex categories	GHD's review categories	GHD report sections
BAFO outcome[6]	Review of Southern Alternative Route GHD Comparative Cost Estimate	• In section 5 GHD provides comparative estimates which were based on the RFT Phase B concept designs for the Southern Alternative Route and cost difference between the two alternative routes after adjusting for changes applicable to both routes[6] • Other construction costs are considered in section 5.7 • In section 5.10 we compare the efficiency of each route option
Property costs	Property/Biodiversity capex review	• Property and biodiversity costs estimates are reviewed in section 6 and 7.
Indirect costs	Indirect capex review	• Indirect costs are reviewed in section 8.
Risk event costs	Risk event capex review	• Biodiversity risk allowances are reviewed in section 9.

[6] To compare the *Final PACR solution* to the *Southern Alternative Route* adjustments to the *Phase A Estimate* have been necessary including TransGrid's defined "Other construction costs" reference Capex FM Table 2.2 pp. 7-8

Source: Figure 4.3 PEC capex building blocks and GHD related review sections.

3.5 GHD definitions

GHD has defined specific terms used in this report in Table 4 to assist the reader. These terms are intended to provide clarity for the development of our comparative estimates and our conclusions.

Table 4 Definitions

GHD terms	Definition
Tendered Works (Phase A)	Corresponds to the scope for the Phase A RFT and the RFT Phase A Capex Forecast.
Tendered Works (Phase B)	Corresponds to scope for the Phase B RFT.
Initial PACR Solution	The scope of work included in the Phase A RFT process undertaken to obtain market prices to obtain a better true reflection of the cost to construct and deliver the Initial PACR Solution. The scope of the tender was based on the SSD description and reviewed by GHD shown in Appendix A to this report.
Final PACR Solution	The scope of work included in the Phase A RFT process plus additional scope identified in the Phase B RFT documentation that would apply to both the PACR Solution and the Southern Alternative Route. The scope has been reviewed by GHD in section 4.6 of this report.
Adjusted BAFO outcome	The adjusted BAFO outcome results in different split of BAFO costs between transmission lines and substations compared to TransGrid’s totals. This was necessary to ensure a valid comparison with GHD’s estimates of cost.

4. PEC scope review

4.1 Scope assessment methodology

GHD has used the following methodology and steps to consider the project scope:

1 The project investment scope

Determine if TransGrid has identified the functional requirements to meet the project investment need identified in the SAET RIT-T process and the PACR findings. This will provide the definition for the scope requirements for TransGrid's PEC capital expenditure investment and CPA.

2 Asset performance requirements

The specified performance parameters of the asset (the interconnector) have been assessed to verify that the performance requirements defined for the transmission line, substations, LSE and reactive plant represent an efficient approach to meeting the objectives of the project.

3 Scope refinement and options assessment

The planning and options assessments have been considered to verify that TransGrid has reviewed reasonable options and refinements within the overall investment scope and that those options have been systematically assessed to determine the most efficient solutions.

4 Scope definition for procurement of work packages (preferred southern alternative route)

The specified work packages for procurement have been assessed to verify alignment to the designed scope and specifications, and that the specifications are efficient to provide the asset performance requirements.

5 Comparison of work packages (the initial PACR solution and the preferred southern alternative route)

The specified work packages for procurement have been compared to verify the scope changes that reflect the expenditure adjustments in the RFT Phase A Capex Forecast for the Southern Alternative Route compared to the RFT Phase A Capex Forecast for the Initial PACR Solution scope.

6 CPA scope

GHD considered the final scope definition pertaining to the BAFO Capex Forecast to verify that it adequately defines the scope in line with the optimally planned Southern Alternative Route. The assessment considered the changes and refinement in scope to verify the CPA scope can be considered efficient in meeting the investment need.

7 Submissions to tendered works phase B

GHD considered whether the BAFO tender submission for the Southern Alternative Route meets the requirements of the Southern Alternative Route and was prudent. In addition GHD reviewed whether the BAFO selected tenderer optimised and offered an efficient design.

8 Summary of the scope review

Section 4.8 summarises the key findings from GHD's scope assessment. Table 13 presents findings for each of the above steps and verification outcomes with respect to whether:

- The optimised project scope reflects the approach a prudent Transmission Network Service Provider (TNSP) would adopt
- Procurement work packages have been developed to align with the work scope requirements and are clearly specified in the Phase B RFT for the preferred option (the Southern Alternative Route)
- The schedule quantities developed for the scope align with the Phase B RFT defined requirements
- Scope requirements and specifications provided to tenderers are appropriate and cover the requirements to enable competitive pricing.

4.2 The project investment scope

TransGrid prepared the SSD with the aim to:

- Detail how TransGrid's forecast scope of works and project specification was prepared
- Demonstrate the project specification is prudent and efficient
- Set out the variance in the project specification from that developed for the RIT-T in the PACR (the RIT-T PACR scope).

The SSD document supports TransGrid's PEC CPA in detailing scope changes since the PACR and both the SSD clearly state the exclusions, being the scope of works for PEC that is attributable to ElectraNet - the new transmission link between Robertstown and the NSW border and the communication system between Buronga and Monash.

In reviewing whether the project investment scope meets the investment need, GHD started with a review of the stated investment need defined in various key documents.

In the PADR, the investment need for the PEC interconnector (and the other options) was stated as:

"to deliver net market benefits and support energy market transition through:

- *lowering dispatch costs, initially in South Australia, through increasing access to supply options across regions*
- *facilitating the transition to a lower carbon emissions future and the adoption of new technologies, through improving access to high quality renewable resources across regions*
- *enhancing security of electricity supply, including management of inertia, frequency response and system strength in South Australia."*

The investment need in the PACR stated that options reviewed were aimed at:

"*reducing the cost of providing secure and reliable electricity to South Australia in the near term, while facilitating the longer-term transition of the energy sector across the National Energy Market (NEM) to low emission energy sources."*

The SSD document states the need as:

"*TransGrid and ElectraNet 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 (PEC). PEC will involve the construction of a high voltage above ground transmission line as shown in Figure 2.1.

TransGrid will partner with ElectraNet to deliver PEC. TransGrid is responsible for the planning and construction of PEC in NSW, being 678 km of new 330 kV line and 24 km of new 220 kV line to Red Cliffs."

In this section, the purpose is to determine if TransGrid has adequately identified the high level functional requirements for the transmission interconnector to meet this project investment need. This then provides the definition for more detailed options that have been considered for the TransGrid's PEC capital expenditure investment and the CPA.

The following two documents were compared and noted in terms of how the PEC investment scope was defined:

- The Option Feasibility Study (OFS - dated 11 October 2019)
- Specification and scope description (SSD - dated 29 June 2020)

The OFS was prepared following the PACR submission, and precedes the SSD which is a component document to the CPA. The OFS provided a detailed breakdown for the scope of work commensurate with the Initial PACR Solution, including substation schematics and equipment schedules, transmission line routes, structure types and quantities.

The description of the option in the OFS was titled, "1570 C.2 NSW to SA Interconnector known as Project Energy Connect" and was updated in response to the "Option Screening Analysis 1570 Rev 6.1 – Reinforcement of Southern Western Network – Option C.2 – Darlington Point via Buronga 330kV High Capacity Double Circuit Connection without series compensation."

The SSD has provided the overarching functional requirements for the PEC project being:

- Extra high voltage interconnector between Robertstown in SA and Wagga Wagga in NSW
- 800 MW capacity
- Additional interconnection between Buronga in NSW and Red Cliffs in Victoria
- Reactive plant, control and protection schemes to maintain network stability.

GHD considers the SSD has adequately defined the technical functional requirements which was originally defined in the PADR and PACR and confirmed that these functional requirements remain the same for the preferred Southern Alternative Route. Consideration as to whether the detailed scope changes within these overarching functional requirements is efficient or not in meeting the investment need is made in section 4.7 of this report.

As TransGrid has adopted the Southern Alterative Route for the CPA, we show the investment scope definition for the Southern Alternative Route compared to the RIT-T PACR project definition in Table 5 below.

While there are some scope changes within the detail of the overall scope, the high level project investment scope as defined in the PACR and the SSD remains unchanged.

Table 5 - NSW Border-Buronga-Darlington Point-Wagga 330 kV – functional requirements[7]

RIT-T PACR project definition	CPA southern alternative route definition
800MW capacity extra high voltage interconnector between Robertstown in SA and Wagga Wagga in NSW	
Three 330KV transmission lines approximately 700 km in total: • 330 kV double circuit twin Mango conductor transmission line between the NSW border with SA and Buronga substation in NSW. • 330 kV double circuit twin Mango conductor transmission line between Buronga and Darlington Point. • 330 kV single circuit twin Mango conductor transmission line between Darlington Point and Wagga.	Three 330KV transmission lines 678 km in total: • 330 kV double circuit twin Mango conductor transmission line between the NSW border with SA and Buronga substation in NSW. • 330 kV double circuit twin Mango conductor transmission line between Buronga and a new Dinawan switchyard. • 330 kV double circuit twin Mango conductor transmission line between Dinawan and Wagga.
330 kV - 3 x 400 MVA new phase shifting transformers on Robertstown – Buronga line at Buronga substation. Rated to ±40° phase shifting and automatic on-load MW control capability.	330 kV - 5 x 200 MVA new phase shifting transformers on Robertstown – Buronga line at Buronga substation. Rated to ±40° phase shifting and automatic on-load MW control capability.
Additional interconnection between Buronga in NSW and Red Cliffs in Victoria	
2 x 330/220 kV transformer with 400 MVA capacity at Buronga substation to interface with the existing 220 kV connections to Broken Hill and Red Cliffs substations	3 x 330/220 kV transformer with 200 MVA capacity at Buronga substation to interface with the existing 220 kV connections to Broken Hill and Red Cliffs substations
One 220 kV double circuit line between Buronga in NSW and Red Cliffs in Victoria of same conductor size as existing line (twin lemon), strung on one side	One 220 kV double circuit twin Paw Paw line between Buronga in NSW and Red Cliffs in Victoria
Reactive plant, control and protection schemes to maintain network stability	
2 x 100 MVAr new synchronous condenser at Buronga 330 kV bus	2 x 100 MVAr new synchronous condenser at Buronga 330 kV bus
2x50 MVAr shunt capacitor banks at Buronga 330 kV bus and 2x50 MVAr 330 kV line shunt reactors	2x50 MVAr shunt capacitor banks at Buronga 330 kV bus and 4x50 MVAr line shunt reactors

[7] SAET – RIT-T Network Technical Assumptions Report – February 2019 - Page 23

RIT-T PACR project definition	CPA southern alternative route definition
2 x 100 MVAr synchronous condenser at Darlington Point 330 kV bus.	2 x 100 MVAr synchronous condenser at Dinawan.
2 x 50 MVAr shunt capacitor banks and 2 x 60 MVAr line shunt reactors at Darlington Point	2 x 50 MVAr shunt capacitor banks and 4 x 50 MVAr line shunt reactors at Dinawan
Special Protection Scheme to detect and manage loss of either interconnector (ElectraNet Scope)	Special Protection Scheme to detect and manage loss of either interconnector (ElectraNet Scope)

GHD considers the SSD has adequately described the PEC project investment scope with the starting point being the scope defined in the RIT-T process and the PACR.

4.3 Asset performance requirements

This section considers whether the performance requirements have been defined for the transmission lines, substations, LSE and reactive plant and represent an efficient approach to meeting the functional requirements for PEC.

The key documents reviewed for this purpose were:

- OFS
- SSD
- SAET RIT-T Network Technical Assumptions Report (developed for the PADR)
- 07.01.01 Phase A RFT (for the Tendered Works (Phase A) and the initial PADR Solution)[8]
- 02.01.01.01 01 Phase A Technical Specification Rev5 PART
- 1.0.01 Phase B RFT (for the Southern alternative route)[9]
- 3.0.05 Phase B Technical Requirements-V8.0 (for the Southern alternative route)

The SSD outlines the initial project specification for the portion of works in NSW, which had been developed for the forecast expenditure included in the PACR economic analysis. The SSD states that for this forecast the initial project specification contained several simplifying assumptions:

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

[8] RFT documents provided to prospective tenderers during the Phase A tender process

[9] RFT documents provided to shortlisted tenderers during the Phase B tender process

- 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 TransGrid 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 manufactures' price lists.

These assumptions were made with consideration to the costing accuracy required for the RIT-T economic analysis.

The OFS defined the capacity rating and conductors for the transmission lines leading to refinements made the Final PACR Solution as follows:

- Each 330kV line is to have 800 MVA[10] (continuous) rating at 330kV per circuit (approximately 1600 MVA in total). This corresponded to Option C.3 in the PACR which was scoped to provide 800 MW of transfer capacity which would increase transfer capacity on the existing Heywood interconnector to 750 MW and provide a combined transfer capacity of 1,300 MW.
- The additional single circuit 330kV line between Darlington Point and Wagga was stated (as per the OFS reviewed) to have a capacity to match the existing transmission line (Feeder 63) of approx. 915 MVA (continuous) but this was inconsistent with the twin Mango conductor stated as the selected conductor size. TransGrid confirmed that, for the Initial PACR Solution, the larger conductor was considered but this option was subsequently discarded as the costs (for twin Mango) of providing a continuous 800MVA capacity was less and that very little benefit existed to match the existing line capacity.
- A new 220 kV double circuit transmission line between Buronga substation in NSW and Red Cliffs substation in Victoria would be built as double-circuit tower structures strung on one side to obtain a line conductor rating of approximately 417 MVA (twin lemon conductor) to match the existing OX1 feeder conductor rating. AEMO studies, detailed in the PACR, indicated future benefits by building this new transmission line with double circuit structures. While it is noted that the requirement for steel towers was changed to a single pole design for the Tendered Works (Phase A) and the Initial PACR Solution, the relevant performance requirement for this single circuit line was to match the existing 417 MVA ratings for the OX1 feeder conductors.

Reactive power support was specified by the capacity required at substation sites:

- At Buronga substation:
  - 2 x 100 MVAr synchronous condensers, with at least two times overloading capability (for at least 10 sec) at Buronga 330 kV bus.
  - 2 x 50 MVAr shunt capacitor banks at Buronga 330 kV bus.
  - 2 x 60 MVAr line shunt reactors, one on each circuit of the Buronga-Darlington Point 330 kV double circuit lines.

[10] The smallest conductor size (Mango) was selected to deliver the required 800 MW for the interconnector

- 2 x 50 MVAr line shunt reactors, one on each circuit of the Buronga-Robertstown Point 330 kV double circuit lines.
- At Darlington Point substation:
  - 2 x 100 MVAr synchronous condensers, with at least two times overloading capability (for at least 10 sec) at Darlington Point 330 kV bus.
  - 2 x 50 MVAr shunt capacitor banks at Darlington Point 330 kV bus.
  - 2 x 60 MVAr line shunt reactors, one on each circuit of the Buronga-Darlington Point 330 kV double circuit lines.
- A special control scheme required to facilitate fast switching (in no more than 1 sec time frame) of line shunt reactors at Darlington Point and Buronga on detection of over voltage conditions at Darlington Point and Buronga 330 kV buses.
- Reactive power controllers at Buronga and Darlington Point required to manage switching of the shunt reactors and capacitors as well as the existing reactive plants on the 220 kV Buronga – Darlington Point section such that Buronga and Darlington Point synchronous condensers output is controlled within a pre-defined MVAr range during normal operation.
- A special control scheme required to facilitate opening of the Buronga 220/330 kV transformers on opening of both of or either of Buronga – Darlington Point, Darlington Point – Wagga 330 lines. This is being implemented by ElectraNet.

Requirements for large transformers were specified by the capacity required at the Buronga substation site:

- Three (3) new 330kV 400MVA phase shifting transformers, noting here that the performance requirement is for 2 x 400 MVA capacity with N-1 redundancy. The phase shift capability was not defined in the OFS.
- Two (2) new 330/220kV 400MVA power transformers to supply the Red Cliffs feeders.

The SSD states that since the issue of the RIT-T PACR, TransGrid has worked to refine the project specification and indicates that this includes the change in the proposed route to bypass Darlington Point in the Southern Alternative Route. Most of the changes though have been required for both the Final PACR Solution (Darlington Point route) and the Southern Alternative Route.

The SSD states that TransGrid used transmission tower designs for the PACR which subsequently required updating to meet a revised AS/NZS 7000 standard for overhead line design. It is noted that this new standard was published in 2016 and superseded AS/NZS 7000:2010. A key change in the standard was the clearance requirements between the structure, conductors and insulators. This meant 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. All of these changes would have impacted on the cost of construction.

The Phase A RFT that was issued for the Initial PACR Solution provided a comprehensive set of asset performance requirements in a number of sections as follows:

- 3.2 Key scope components (Page 12 to 14)
  - This section provides scope requirements for each key component of the project and the purpose for the component. The purpose defined the need in terms of each component's performance requirement.

- 3.3 Interconnector capacity and active power control (Page 15)
  - This section provided the performance requirements of the interconnector capacity and control of power across the existing Heywood interconnector from Victoria to SA and the new interconnector from NSW to SA PEC. The interconnector transfer capacity limits and purpose is defined and the requirements of the phase shift transformers phase shift angle capability of +/-40° was defined and its purpose.
- 3.5 System performance and security considerations (Page 17 to 18)
  - This section defined the power systems and power transfer capability planning criteria for providing secure capability under credible contingency events (N-1) as defined in the NER. In addition, a technical system design objective for the new interconnector is to ensure that for a non-credible (N-2) loss of either of the two double circuit interconnectors (new and Heywood), the remaining interconnector will remain connected and keep the SA system securely connected to the NEM.
  - Performance requirements were defined in detail covering frequency, rate-of-change-of-frequency, voltage envelop, system inertia, system strength, transient stability, oscillatory stability and voltage stability.

In the Phase B RFT[11] for the Southern Alternative Route, details of the asset performance requirements were not specifically defined but referred instead to the following support documents:

- Employer's Requirements – Key Project Functional Requirements[12]
- Employer's Technical Requirements[13]
- Substation Equipment Requirements[14]

The asset performance requirements were defined in the Technical Requirements document covering:

- Geographic locations for the substations and transmission easements provided by TransGrid
- Substation general system requirements; insulation levels, fault levels, current ratings and earthing
- Soecial Control and Protection Schemes; overvoltage protection, backfeed protection, reactive power control current ratings
- Transmission lines system requirements; number of circuits, conductor size, rated voltage and current rating, operating temperature
- Substation plant; transformer firm capacity ratings, circuit and bus configuration reliability requirements, reactive plant ratings.

The Substation Technical Requirements document provided a list of all technical specifications for LSE; synchronous condensors, PSTs, power transformers, shunt capacitors and shunt reactors, and other high voltage plant balance of plant.

[11] Phase B RFT

[12] 3.0.01 Employer's Requirements Key Project Functional Requirements-V8.0

[13] 3.0.05 Technical Requirements-V8.0

[14] 3.0.06 Substation Equipment Requirements-V8.0

The Phase B RFT documents contained performance based requirements and were not specific to transmission structures or substation detailed designs and relevant to asset performance requirements for both the Final PACR Solution and the Southern Alternative Route.

GHD considers that the asset performance requirements were adequately and appropriately defined in documents for both the Phase A and Phase B tender processes, for the scopes matching the tendered works for the Initial PACR Solution and for the Southern Alternative Route respectively.

4.4 Scope refinement and options assessment

In this section GHD considers whether TransGrid has taken the high level performance requirements for the project to inform further optimisation and detailed design for the scope and specifications.

The key documents reviewed for this purpose were:

- OFS
- SSD
- 02.01.01.01.01 Technical Specification Rev5 – (developed for the Phase A RFT)
- 07.01.01 Phase A RFT
- SAET RIT-T Network Technical Assumptions Report – (developed for the PADR)
- Road Transport Study (March 2020)15
- Substation concept design studies – Balance of Plant, LSE and substation configuration and layouts.
- Transmission line concept design studies – Design, access tracks and geological studies
- Beca Transmission Line Project Specific Design Criteria.

TransGrid has continued to refine options through planning and technical studies to determine the minimum requirements to meet the investment need. GHD has identified a list of refinements to the scope and options made by TransGrid to arrive at the two alternate options which were considered the minimum scope necessary to meet technical and other requirements. These are listed under the high level investment scope items below with further details following:

- Extra high voltage interconnector between Robertstown in SA and Wagga Wagga in NSW (NSW scope):
  - Two alternative routes have been identified – the Final PACR Solution and the Southern Alternative Route. The Southern Alternative Route offers several benefits including reducing cost and schedule risks.
  - The transmission line structures required to be compliant to the revised AS/NZS 7000 standard which has increased clearance requirements and impacted on the number of structures required. This applies to both route options.
- 800 MW capacity

[15] 4.0.29 Employer's Road Transport Study March 2020 (Phase B tender documents)

- The original plan defined in the OFS[16], corresponding to the PACR, was to install 3 x 400MVA phase shift transformers at Buronga substation. Due to logistical constraints on local roads, the requirements have needed to be changed to 5 x 200MVA transformers. This applies to both route options.
- Additional interconnection between Buronga in NSW and Red Cliffs in Victoria:
  - The original plan in the OFS for the 220kV transmission lines, and corresponding to the PACR, was to allow for a double circuit single pole line, strung on one side with twin Lemon conductor.
  - AEMO's recommendation was to provide a third 220kV circuit to the existing double circuit line and this new line would have a 415 MVA rating matching the existing circuit ratings.
  - Subsequent site investigations highlighted a constrained corridor which made the establishment of another 50m wide easement for the proposed double circuit line difficult and a significant programme risk to the projects ability to provide first power to SA by November 202217.
  - The transmission line was redesigned to a dual circuit structural tower design, with two circuits strung with twin Paw Paw conductor. This provides a circuit rating of 800MVA with the equivalent N-1 capacity as the previous configuration. The existing line will then be removed. This applies to both route options.
- The original plan in the OFS was to install 2 x 400MVA single phase sets of power transformers at Buronga substation to supply the new 220kV circuits to Red Cliffs. Due to the same logistical constraints on local roads as for the PSTs, the requirements have needed to be changed to 3 x 200MVA transformers. This also applies to both route options
- Reactive plant, control and protection schemes to maintain network stability
- After further technical studies of reactive plant requirements by ElectraNet changes have been required which will apply to both route options. The additional plant required to maintain network stability has needed to be increased by:
  - Adding 2 x 50 MVar line shunt reactors at Buronga
  - A change from 2 x 60MVar to 4 x 50MVar line shunt reactors at Darlington Point at Dinawan for the Southern Alternative Route.

The SSD defines the refined project specification for the Southern Alternative Route to be "just sufficient to meet the need" and also states that this route provides additional benefits compared to the route for the PACR Solution, and overcomes some disadvantages with the original route.

A comparison summary of the route advantages and disadvantages are described below, taken from these above two documents:

- Route options and length

  Both routes minimise capital costs by utilising existing TransGrid's assets in the south west area of NSW. Sections of the route are along existing TransGrid lines where possible considering existing land use and constraints, which may reduce access development costs for those sections. Where possible, new lines will terminate at existing TransGrid substations, which require extensions of existing substations instead of the establishment of new substations, which would cost more.

[16] OFS

[17] Advised by TransGrid in emails and discussions

This is the same for both route options except that along the eastern section a new Dinawan switching station is required in the Southern Alternative Route and for this alternative route the overall line length between Buronga and Wagga Wagga has been reduced by approximately 9 km as advised by TransGrid.

- Risks pertaining to the route options

  The Southern Alternative Route bypasses Darlington Point which has intensive irrigation zones around the township and therefore lowering risks to acquisition costs and project delivery in negotiating suitable easements and access rights.

- Dinawan to Wagga Substation - number of circuits

  A double circuit line is required for the Southern Alternative Route from Dinawan to Wagga Wagga compared to a single circuit line for the Final PACR Solution. Mango is the smallest conductor size required to deliver the required 800 MW. In comparison with the route for the PACR solution, where the single circuit line was rated lower and considered sufficient to match the rating of existing 330kV single circuit line between Darlington Point and Wagga Substation. The cost of a double circuit line is an incremental increase over a single circuit line.

Overall the forecast costs for the interconnector has increased since preparation of the PACR due to a number of technical requirements, higher market based construction costs, route and logistical constraints. GHD has sighted and reviewed the available documentation which confirms that TransGrid has worked to optimise the interconnector design to minimise costs while addressing these factors.

The earlier scope definitions, corresponding to the RIT-T PACR, and that corresponding to the Phase A Estimate evolved into the two route options and their corresponding minimum scope definitions that in our opinion now both meet the project investment scope.

Scope refinements by type of change since the RIT-T PACR

Refinements in the scope that result in material cost increases fall broadly into the following categories and apply to both route options as described:

Compliance to safety and design standards:

- The standard 330 kV tower design used for the PACR capex forecast was not compliant to AS/NZS 7000, and concept designs by the successful EPC contractor were required to meet this standard
- TransGrid's safety in design principles, an example of which is stringing of conductors on towers using helicopters is considered an unacceptable level of safety risk and hence TransGrid's approach is to require contractors to use ground based stringing techniques[18]
- Site conditions and deliverability constraints:
  - Line route deviations – the original structure volumes were s based on a straight line estimate of line length. Revised route distance overall has increased.
  - Earthworks at Buronga substation and Dinawan switching station - normally earthworks are undertaken on a cut and fill basis as this lowers the cost of transporting materials to site. Both of these sites are relatively flat and in flood zones and will require fill to be imported to the sites which has an uplift in costs

[18] SDD, p9

- Loading constraints on roads - TransGrid identified load limits and maximum weights of heavy equipment that can be transported to the Buronga substation site without the need for road and bridge upgrades. This has driven a change to specifying 200MVA transformers away from the larger 400MVA transformers[19]
- Easement restrictions for Red Cliffs corridor - Subsequent site investigations identified a constrained corridor which made the establishment of another 50m wide easement for the proposed double circuit line difficult.

Performance specifications and concept designs

Key elements of the performance requirements and concept designs have been confirmed by specialist consultants and these optimised designs have been market tested with pricing to inform the CPA forecast. This includes desktop geotechnical assessments, access track designs and cost estimates, conductor selection, structure and foundation concept designs.

Many of the above refinements were already included within the scope commensurate with the Phase A RFT which resulted in the RFT Phase A Capex Forecast for the Initial PACR Solution. However, GHD has identified specific further scope changes since which have been needed for the Final PACR Solution. We needed to define these changes to develop our comparative cost estimates in section 4.6 so as to make a direct comparison between the scope and costs for these two final route options.

Scope refinements for each route option compared to the tendered works

The scope changes since the RFT Phase A Capex Forecast were prepared to the Final PACR Solution Route option are:

- The change to 5 x 200MVA PSTs and 3 x 330/220kV 200MVA power transformers at Buronga substation
- The scope changes since the RFT Phase A Capex Forecast were prepared and the Southern Alternative Route option are:
  - The change to 5 x 200MVA phase shift transformers and 3 x 330/220kV 200MVA power transformers at Buronga substation.
  - Construction of Dinawan switching station and the increased earthworks at this site compared with the augmentation of the existing Darlington Point substation in the Final PACR Solution.
  - A double circuit line required from Dinawan to Wagga Wagga compared to a single circuit line for the Final PACR Solution from Darlington Point substation to Wagga Wagga.
  - A change from 2 x 60MVar to 4 x 50MVar line shunt reactors at Darlington Point at Dinawan for the Southern Alternative Route.

Since the scope and costs were prepared for the PACR, TransGrid developed concept designs which underpinned the basis of the Tendered Works (Phase A) and the RFT Phase A Capex Forecast. These concept designs informed the scope and technical requirements as part of the Phase A RFT[20]. In this tender process, applicants were required to base pricing on TransGrid's concept design and quantities which is the basis for forming the capex forecasts for the CPA at that stage.

[19] 4.0.29 Employer's Road Transport Study March 2020

[20] 07.01.01 RFT Phase A

TransGrid then aimed to work with the shortlisted contractors in a process to further develop designs and establish contracts for project delivery. During this time it is evident that TransGrid has developed performance based technical specifications and standards for the Phase B tender which is not prescriptive to any particular detailed design for transmission lines and the substations. This approach is common for large EPC infrastructure projects where concept designs are provided as a guide only allowing a competitive approach to capturing innovation for design and construction optimisation.

Table 6 provides the change in route distance from the RIT-T PACR to the Final PACR Solution. The change of design for structural towers and reduced span lengths has had the most significant impact on costs with respect to transmission line scope.

Section 3.2 in the SSD 29 June 2020 comments with respect to the line route that, "The specification of the new 330kV 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." There was relatively little change with respect to route distance except the 5 km reduction in the line from the SA Border to Buronga.

Table 6 - PACR Solution - change in route lengths since the PACR (km)

Transmission line segment	PACR	Initial PACR solution	Final PACR solution
Border to Buronga	140	135	135
Buronga to Darlington Point	399	401	401
Darlington Point to Wagga Wagga	152	151	151
Total	691	687	687

Source: SSD and Phase A RFT

An allowance for line deviations was added though to the estimated volumes of towers and conductor and adjusted for the new designs to meet the revised AS/NZD 7000 standard. The line length will be longer in some cases due to line deviations, to avoid terrain undulations and sub-optimal location of angle points due to route constraints. About 5% more suspension towers were forecasted. The revised numbers of towers specified in the Tendered Works (Phase A) indicates a ratio of around 90% suspension towers from the NSW border to Darlington Point which is typical for more open and relatively flat terrain. The route from Darlington Point to Wagga indicates a lower ratio of suspension towers which indicates the need for deviations and more angle points along this route as stated.

Table 7 Number of suspension to total towers in phase A tender specifications

Transmission line segment	Suspension to total towers (%)	Medium strain	Heavy strain	Light suspension	Heavy suspension	Total towers
Border to Buronga	88.3	25	9	251	5	290
Buronga to Darlington Point	89.8	60	26	746	10	842

Transmission line segment	Suspension to total towers (%)	Medium strain	Heavy strain	Light suspension	Heavy suspension	Total towers
Darlington Point to Wagga	83.8	26	23	152	102	303
Total		169		1266		1435

Source: Phase A RFT specifications and GHD calculation of suspension tower %

Section 3.3.2.1 in the SSD 29 June 2020 states that the base design does not include additional length from having to detour due to soil conditions, hydrology or community consultation.

The Phase B RFT for the Southern Alternative Route does not specify the design and hence the number of towers required was eventually defined by the successful tenderer. The SSD has provided the route distances shown in Table 8. The SSD provided indicative number of tower structures for the Southern Alternative Route in sections 4.2.1 to 4.2.3 which can be compared to Table 7 for the PACR Route.

Table 8 - Southern alternative route - route lengths (km)

Transmission line segment	Southern alternative route
Border to Buronga	135
Buronga to Dinwawan	383
Dinawan to Wagga Wagga	160
Total	678

Source: SSD

To enable comparative estimates to be developed for the Southern Alternative Route, GHD used the data in Table 9 to prorate the scope requirements for towers over the adjusted length Buronga to Dinawan and for the new proposed Dinawan to Wagga Wagga transmission line.

Table 9 - Suspension and strain towers defined in the SSD for the southern alternative route[21]

Transmission line segment	Suspension to total towers (%)	Strain	Light suspension	Total structures
Border to Buronga	88.5	43	241	284
Buronga to Dinawan	89.6	83	716	799
Dinawan to Wagga	86.8	45	297	342
Total		171	1254	1425

[21] Defined as approximate number of towers in the SSD

Source: SSD and GHD calculation of suspension tower %

GHD notes that the difference in route distance between the Final PACR Solution and the Southern Alternative Route is 9 km which is a 1.27% reduction while the reduction of 10 towers for the concept designs for the two routes represents a lesser amount of 0.70%. This difference has been considered in the in the review of the cost difference in section 5.10 of this report.

Section 3.3.2.3 in the SSD 29 June 2020 provides more detail on the changes in 330kV concept structure designs. A key change in the standard is the clearance requirements between the structure, conductors and insulators. The 330 kV tower must now be 2.4 meters wider than the towers installed in the past. The distance required between the phases is also greater, meaning that the tower is taller. The consequence of this change is be additional steel, the tower weight and footings requirements would increase, and construction costs marginally increase. This design change though also allows an increase in the tower design span from 400 meters to 500 meters which partly would offset the cost increases for each tower. Further refinement of concept designs included heavy and light tower designs which provide wind design spans of 500 and 600 meters respectively.

GHD reviewed studies that TransGrid commissioned to refine the concept designs used for the Tendered Works (Phase A) which included:

- Configuration and layouts to determine substation concept schematics and layouts
- Transmission structures and design spans to determine concept structures and line designs.

The substation concept designs were based on TransGrid's standard breaker and a half bays for 330kV network substations and costs savings through further refinement would be is limited.

The SSD also refers to the following consultant reports involved in developing the concept designs which were available to GHD for review:

- 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 Red Cliffs
- Douglas Partners, July 2019, Report on Preliminary Geotechnical Investigation
- Becca, May 2019, SAET Interconnector - Conductor Selection Study.

Beca previously undertook conductor and structure selection studies for PEC and the outcome of these studies were the basis for the 330 kV structure concept designs. These previous conductor and structure selection reports were:

- Conductor Selection Study: 'AU1-2641658 – SAET Interconnector – Conductor Selection Study Report', dated 28 May 2019
- Structure Selection Study: 'AU1-2670507 –SAET Interconnector – Structure Selection Study Report', dated 28 May 2019

- Conductor and Structure Selection: 'AU1-2705501 – EnergyConnect Concept Design – Buronga to Darlington Point', dated 4 June 2019.

Beca was then commissioned by TransGrid to undertake engineering studies to develop the specific design criteria[22] and structure concept designs[23] in consultation with TransGrid for double circuit towers between the border and Darlington Point. The specific design criteria was developed in accordance with AS/NZS 7000:2016 and the TransGrid's Transmission Line Design Manual (Rev 0.5).

The specific design criteria is comprehensive and GHD considers the criteria is appropriate to the function required and parameters have been selected in accordance with AS/NZS 7000:2016. The concept designs developed by Beca for each specific transmission line was also developed in line with meeting the design criteria at the lowest cost.

Concept designs and consultant reports were provided for information to tenderers in the Phase A tender which forms the basis for the Tendered Works (Phase A Tender).

TransGrid also engaged Douglas Partners to provide preliminary geotechnical design parameters based on assessment of geotechnical data/reports in the area. Geotechnical parameters from these reports were used by Beca to derive three soil strengths considered in the concept designs (good soil, normal soil, and poor soil). The geotechnical data was also provided to tenderers during the current tender process.

GHD considers that the studies that TransGrid has conducted with respect to optimising concept designs for both substations and transmission lines have been appropriate for the scope that defined the Tendered Works (Phase A) and that these concept designs are also included for reference for the shortlisted tenderers in the Phase B tender to refine designs particularly to achieve savings in structure designs and foundations.

GHD notes that the number of structures per km defined in the SSD for the Southern Alternative Route compared to the Initial PACR Solution differs – a 0.7% reduction in towers compared to reduction of 1.27% in route distance (9km). TransGrid has not provided specific information as to whether similar changes would apply to both routes, however it is not a significant difference and both are considered reasonable with respect to the concept designs developed by BECA.

4.5 Scope definition for procurement of work packages (southern alternative route)

In this section, GHD considers whether TransGrid provided the prospective EPC tenderers in the Phase B RFT with sufficient detail on the concept designs and whether the specifications are sufficiently efficient with respect to the costs and performance required from the assets whilst providing opportunities for the tenderers to be able to refine designs and specifications in this regard. This review is commensurate with the scope of work pertaining to the preferred Southern Alternative Route and how this scope has been eventually defined with respect to the BAFO Capex Forecast.

[22] 02.01.02.07 Beca – Transmission Line Project Specific Design Criteria Rev0.0

[23] 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 Red Cliffs

The key documents reviewed generally for this purpose were:

- SSD
- 3.0.05 Technical Requirements Rev 8
- 1.0.01 RFT Phase B

The non-technical scope (not directly related to the asset performance) and more related to project delivery costs and overheads are covered in section 6, 7, and 9. These include:

- Property and easement acquisition costs
- Environmental offset costs
- Corporate and network overheads.

Section 2.3 of Phase B RFT also specified the following key items to be excluded from the contractor's scope:

- Environmental planning approvals
- Environmental offsets costs
- Acquisition of land and easements
- Community and Stakeholder Management
- Commissioning
- Operations and Maintenance (after Final Completion)
- Property owner compensation costs.

GHD's review of the procurement documentation contained within the current tender documents covered:

- Generally the scope and specifications contained within the Phase B RFT
- The transmission line scope and specifications
- The substation scope and specifications
- General substation equipment specifications
- The LSE specifications.

The RFT for the Southern Alternative Route was divided into the following nine separable portions:

Separable portion	Scope of work
L1	Approximately 135 km of 330 kV double circuit twin Mango conductor transmission line from the SA/NSW border to Buronga substation.
L2	Approximately 383 km of 330 kV double circuit twin Mango conductor transmission line between Buronga to a new Dinawan switching station.

Separable portion	Scope of work
L3	Approximately 160 km of 330 kV double circuit twin Mango conductor line from the new Dinawan switching station and Wagga 330 Substation.
L4	Reconstruction of the existing approximately 24km 220 kV single circuit line from Boronga Substation to the Red Cliffs Substation as 220 kV double circuit.
S1	Construction of a new Buronga 330 kV substation consisting of: • 330 kV 5 x 200 MVA new phase shifting transformers at Buronga substation. Rated to ±40° phase shifting and automatic on-load MW control capability. • 330 kV and augmentation of the existing 220 kV switchyard at Buronga substation • 2 x 330/220 kV transformers each with 400 MVA capacity at Buronga substation to interface with the existing 220 kV connections to Broken Hill and Red Cliffs substations. • 2 x 100 MVAr new synchronous condensers at Buronga 330 kV bus. • Shunt capacitor banks 2x50 MVAr at Buronga 330 kV bus and 2x50 MVAr 330 kV reactors
S2	Construction of a new 330 kV Dinawan switching station consisting of: • 330 kV bays to terminate and switch the new incoming and outgoing transmission lines • 2 x 100 MVAr synchronous condenser at Darlington Point 330 kV bus • Capacitor Banks 2 x 50 MVAr at Dinawan 330 kV bus and 4 x 50 MVAr shunt reactors
S3	Augmentation of the existing 330 kV Wagga 330 substation to connect the new double circuit transmission lines.
S4	Augmentation of Red Cliffs 220kV Substation for the new dual circuit transmission line.
SPC	Special Protection Scheme to detect and manage the loss of either interconnector.

General findings

GHD's review of the concept designs contained in the procurement packages provided a means to consider whether these designs are efficient towards meeting the asset performance requirements.

The specifications in the tender documents were provided with fundamental design information with a reasonable level of specific details and requirements for the project.

TransGrid's electrical substations and transmission lines have been designed to provide very long term reliable operational service and high availability. Hence capital construction costs may not be the lowest costs possible however the designs and specifications have aimed to minimise costs over the lifetime of the assets.

The specifications were also prepared generally consistent with other TransGrid substation and transmission line projects. GHD considers these specifications are in line with good electricity industry practice. The specifications consider long term operating and maintenance efficiencies having standard plant and equipment across the network, and having consistent, safe and efficient operating protocols.

There were some discrepancies between drawings and technical requirement documents in relation to the sizing of reactive plant (with the Buronga and Dinawan general arrangement drawings showing 60 MVAr reactors on two lines whilst the specification refer to 50 MVAr reactors).

Transmission lines, access tracks and geotechnical

The following concept designs and specification for transmission structures and lines were reviewed:

- 4.0.01.02 Portion L1 The Employer’s Concept Design
- 4.0.01.03 Structure Concept Design Report - 330 kV Double Circuit
- 4.0.02.02 Portion L2 The Employer’s Concept Design
- 4.0.02.03 Structure Concept Design Report - 330 kV Double Circuit
- 4.0.03.02 Portion L3 The Employer’s Concept Design
- 4.0.03.03 Structure Concept Design Report - 330 kV Double Circuit
- 4.0.04.02 Portion L4 The Employer’s Concept Design
- 4.0.04.03 Structure Concept Design Report - 220 kV Double Circuit
- 4.0.32.01 Transmission Line Design Manual Rev 1.0
- 4.0.28 Employer’s Concept Design Temporary Access Tracks

GHD found the concept designs for transmission structures and foundations typical of electricity industry practice and that tenderers will be able to develop alternative concept designs to optimise delivered costs and price accordingly. There was some geotechnical data available, although limited, and GHD has some concerns that there is scope risks at this point due to the limited knowledge of geotechnical factors which will need to be addressed in risk assessment by the tenderers.

Substations

The following substation concept designs were reviewed;

- 4.0.07.01 Portion S1 The Employer’s Concept Design Information
- 4.0.07.12 BRG-PYD-SKT-100001 (Buronga Initial SLD)
- 4.0.07.13 BRG-PYD-SKT-100002 (Buronga Final SLD)
- 4.0.07.25 BRG-PYD-SKT-100101 (Buronga Initial GA)
- 4.0.07.26 BRG-PYD-SKT-100102 (Buronga Future GA)
- 4.0.08.01 Portion S2 The Employer’s Concept Design Information
- 4.0.08.07 BRG-PYD-SKT-100001 (Dinawan 330 kV Initial SLD)
- 4.0.08.08 BRG-PYD-SKT-100002 (Dinawan 330 kV Final SLD)
- 4.0.08.10 BRG-PYD-SKT-100101 (Dinawan 330 kV Initial GA)
- 4.0.08.11 BRG-PYD-SKT-100102 (Dinawan 330 kV Future GA)

- 4.0.09.01 Portion S3 The Employer's Concept Design Information
- 4.0.09.02 BRG-PYD-SKT-100001 (Wagga Wagga 330 kV SLD)
- 4.0.09.05 BRG-PYD-SKT-100101 (Wagga Wagga 330 kV GA)
- 4.0.10.01 Portion S4 The Employer's Concept Design Information
- 4.0.10.02 2580421-UP-K001 (Red Cliffs 220 kV SLD)
- 4.0.10.03 2580421-UP-K002 (Red Cliffs 220 kV GA)

A review of the documents within the substation concept design package shows alignment to industry standards for substations layout, configuration, and plant requirements for major 330 kV and 220 kV transmission network substations.

The procurement documentation was found to comply and align with the scope definition in the SSD Rev D.

GHD found the concept configurations and layouts for the substation and the substation standards manuals is typical of electricity industry practice and that tenderers will be able to develop optimised designs and price accordingly based on the information provided.

Substation product type equipment

Substation Product Type Equipment includes[24]:

- Circuit Breakers (LTCB & DTCB)
- Current Transformers (CT)
- Current Voltage Transformers (CVT)
- Inductive Voltage Transformers (IVT)
- Disconnector (DS)
- Earth Switch (ES)
- Surge Arrestor (SA)
- Line Trap (LT)
- Post Insulator (PI)
- Auxiliary transformer dry type (Aux-Tx)

The following documents were reviewed;

- 3.0.06 Substation Equipment Requirements - V8.0
- 3.0.06.06.01 ES No.6 PTE - Technical Specification V1.1
- 3.0.06.06.02-08 ES No.6 PTE - Returnable Schedules

These documents were found to be in accordance with expected utility practise for specifying these types of equipment.

[24] 3.0.06 Substation Equipment Requirements - V8.0

Large specialist equipment

LSE includes[25]:

- Synchronous Condensers (SC)
- Phase Shift Transformers (PST)
- Power Transformers (PT)
- Shunt Capacitor Banks (SCB)
- Shunt Reactors (SR)

The following equipment specifications were reviewed:

- 3.0.06.01.01-06 ES No.1 Synchronous Equipment Specification Part A - F
- 3.0.06.01.07 ES No.1 SC - Returnable Technical Schedules V1.0
- 3.0.06.02.01 ES No2 Phase Shift Transformer Equipment Specification V3.0
- 3.0.06.02.02-03 ES No2 PST - Returnable Technical Schedules
- 3.0.06.03.01 ES No.3 Shunt Reactor Equipment Specification V6.0
- 3.0.06.03.02-03 ES No.3 Shunt Reactor - Returnable Technical Schedules
- 3.0.06.04.02-03 ES No.4 Power Transformer - Returnable Technical Schedules
- 3.0.06.05.01 ES No.5 Shunt Capacitor Bank Equipment Specification V3.0
- 3.0.06.05.01 ES No.5 SCB - Returnable Technical Schedules

LSE forms a significant part of the overall project cost, in particular PSTs and synchronous condensers.

Review of the PST, shunt reactors and capacitor bank equipment specifications shows some accord to good engineering practise. The ratings of this equipment is aligned with the highest end of the electrical ratings possible, and specifying industrially recognised branded equipment for sub-assemblies. The overall specification when read as a datasheet is clear but not complete in regard to the electrical, key subcomponent and physical requirements of the equipment, while allowing tenders freedom in the final specification of ancillary items.

The capacitor technical requirements document[26] state that capacitor bank ratings are still preliminary and are subject to further studies. Hence there remains some degree of uncertainty in the scope at the time of the RFT. GHD does not consider the potential change would be material in terms of costs.

The LSE documents are performance based and allow in some situations for tenderer innovation. An example of this is that the Substation Technical Requirement document which specifies a firm capacity of 800 MVA from the PSTs at the Buronga 330 kV substation. This allows for the tenderer to propose an alternative to the concept design (5 x 200 MVA PSTs) or 3 x 400 MVA subject to the feasibility of transporting larger PSTs. The Tendered Works (Phase A) in the Phase A RFT included the transformers as

[25] 3.0.06 Substation Equipment Requirements - V8.0

[26] 3.0.05 Technical Requirements V8.0

based on the 3 x 400 MVA (9 single phase units) arrangement and the BSFO Capex Forecast includes the concept design in the Phase B RFT. Any variance is detailed in section 5.8.

The LSE RFT documents for the synchronous condensers[27] were reviewed, with the requirements document appearing to be a full specification and the functional specification, a supporting datasheet. The requirements document appears to be a comprehensive technical specification, covering all expected items. The equipment specification appears to be generally in accordance with good engineering practice, and allows for the units including surrounding buildings to be delivered whole, with clear demarcation points. The ratings of this equipment are also aligned with the highest end of the electrical ratings possible, and specifying industrially recognised branded equipment for sub-assemblies. As per the other LSE specifications there is allowance for innovation: the specification states that each of the two synchronous condensors at Buronga and at Dinawin Substations are to be housed separately however the tenderer may provide an alternative were the two units are housed together at each substation.

Summary

GHD has reviewed the specification of key scope items for the project which were included in the current tender process (Phase B RFT). The review considered:

- Transmission specifications – structures, route, soil and ground conditions
- Substation specifications – balance of plant specs, ground conditions etc
- LSE specifications.
- The review also considered the aim of the procurement process:
- To obtain market based and binding prices for scope of work for the Southern Alternative Route, being the majority of the project costs
- To select the EPC contract to deliver the project based on a firm performance scope and risk allocation
- To update the AER with the final costs for the preferred solution.

GHD's review found:

- The specifications represent standards expected for transmission infrastructure and good electricity industry practice
- The specifications consider the need to operate reliability over the life expectancy of the transmission interconnector
- Certain gaps in the specifications were identified where uncertainty may impact the timing to arrive at a final scope and pricing by tenderers. These include agreement on risk allocation and the final configuration of the PST and power transformer units (three vs five sets) which also will impact the amount of HV equipment and civil footprint required for the new 330kV Buronga switchyard[28]
- The specifications and concept designs are performance based allowing and encouraging innovation from tenderers.

[27] 3.0.06.01.01-06 ES No.1 Synchronous Equipment Specification Part A - F

[28] A change of scope and costs at Buronga 330kV substation would also apply to the *final PACR Solution*.

4.6 Comparison of alternative route work scopes

The specified work packages within respective Phase A and Phase B RFTs have been compared in the following table to verify the scope changes that reflect in the expenditure adjustments to derive the RFT Phase B Capex Forecast for the Southern Alternative Route compared to the RFT Phase A Capex Forecast developed for the Initial PACR Solution.

Table 10 - Scope of work comparison

Phase A RFT – tendered works for the PACR solution	Phase B RFT Scope of work – southern alternative route	Identified changes in scope
135 km of 330 kV double circuit twin Mango conductor transmission line from the SA/NSW border to Buronga substation in NSW.	L1 - 135 km of 330 kV double circuit twin Mango conductor transmission line from the SA/NSW border to Buronga substation in NSW.	Scope and asset performance requirements unchanged
401 km of 330 kV double circuit twin Mango conductor transmission line between Buronga and Darlington Point substations.	L2 - 383 km of 330 kV double circuit twin Mango conductor line Buronga to a new Dinawan switching station	18 less kms of 330 kV double circuit twin Mango conductor transmission line.
151 km of 330 kV single circuit twin Mango conductor transmission line between Darlington Point and Wagga substations.	L3 - Approximately 160 km of 330 kV double circuit twin Mango conductor line a new Dinawan switching station and Wagga Substation in NSW.	• 9 additional kms • A double circuit twin Mango conductor transmission line instead of single circuit
24 km of 220 kV double circuit line between Buronga in NSW and Red Cliffs in Victoria of same conductor size as existing line (twin lemon), strung on one side steel pole structures	L4 - 24 km of 220 kV double circuit line between Buronga in NSW and Red Cliffs in Victoria of twin Paw Paw conductor strung on both sides of a structural steel transmission line	Replacement of existing conductor and line with double cct twin Paw Paw (24 kms) instead of single circuit twin lemon (24 kms)
Construction of a new Buronga 330 kV substation consisting of: • 330 kV 3 x 400 MVA new phase shifting transformers. Rated to ±40° phase shifting and automatic on-load MW control capability. • 330 kV and augmentation of the existing 220 kV switchyard at Buronga substation • 2 x 330/220 kV transformers each with 400 MVA capacity at Buronga substation to interface with the existing 220 kV	S1 Construction of a new Buronga 330 kV substation consisting of: • 330 kV 5 x 200 MVA new phase shifting transformers. Rated to ±40° phase shifting and automatic on-load MW control capability. • 330 kV and augmentation of the existing 220 kV switchyard at Buronga substation • 3 x 330/220 kV transformers each with 200 MVA capacity at Buronga substation to interface with the existing 220 kV connections to	• Two additional PSTs 3 ph sets - 5 x 200 MVA compared with 330 kV 3 x 400 MVA. • 2 additional PST bays. • Additional 330/220 kV transformer & associated 330kV and 220 kV transformer bays

Phase A RFT – tendered works for the PACR solution	Phase B RFT Scope of work – southern alternative route	Identified changes in scope
connections to Broken Hill and Red Cliffs substations. • 2 x 100 MVAr new synchronous condensers at Buronga 330 kV bus. • Shunt capacitor banks 2x50 MVAr at Buronga 330 kV bus and 2x50 MVAr 330 kV reactors	Broken Hill and Red Cliffs substations. • 2 x 100 MVAr new synchronous condensers at Buronga 330 kV bus. • Shunt capacitor banks 2x50 MVAr at Buronga 330 kV bus and 2x50 MVAr 330 kV reactors	
Construction of a new 330 kV Darlington Point substation consisting of: • 330 kV bays to terminate and switch the new incoming and outgoing transmission lines • 2 x 100 MVAr synchronous condenser at Darlington Point 330 kV bus • Capacitor Banks 2 x 50 MVAr at Darlington Point 330 kV bus and 2 x 60 MVAr shunt reactors	S2 Construction of a new 330 kV Dinawan switching station consisting of: • 330 kV bays to terminate and switch the new incoming and outgoing transmission lines • 2 x 100 MVAr synchronous condenser at Dinawan 330 kV bus • Capacitor Banks 2 x 50 MVAr at Dinawan 330 kV bus and 4 x 50 MVAr shunt reactors	Additional 2 x 50 MVAr shunt reactors at Dinawan switching station
Augmentation of the existing 330 kV Wagga substation to connect the new single circuit transmission lines.	S3 Augmentation of the existing 330 kV Wagga substation to connect the new double circuit transmission lines.	Additional circuit bay and associated switchgear
Augmentation of Red Cliffs 220kV Substation for the new dual circuit transmission line (one circuit added)	S4 Augmentation of Red Cliffs 220kV Substation for the new replacement dual circuit transmission line	Augmentation of existing double circuit bays instead of adding an additional line bay
Special Protection Scheme to detect and manage loss of either interconnector	Special Protection Scheme to detect and manage loss of either interconnector	Unchanged

GHD considers that the scope of work for both the Final PACR Solution and the Southern Alternative Route scope of work are necessary to meet the asset performance and investment need.

4.7 BAFO outcome Scope

This section considers whether the successful BAFO tender submission has met the specification requirements for the Southern Alternative Route and is efficient in design. In addition GHD reviews whether the BAFO submission has optimised the concept designs for their complying offer.

4.7.1 Review of BAFO submission concept designs

Transmission Lines

A conforming 330 kV transmission line offer was based on double circuit freestanding lattice steel towers with twin Mango ACSR/Gz complying with TransGrid's preference for conductor size and the thermal rating of each circuit. The proposal used very similar tower arrangements as per TransGrid specified concept towers designs with the exception of not including the heavy suspension tower and instead utilising the light angle strain tower for the limited locations where they are needed. In addition some special structure types were proposed to accommodate heavier earthwire and OPGW near the substations.

The bidder has proposed single vertical pile foundations at each tower leg.

The 220kV double circuits offered were a steel pole design with an additional bypass line created to address limited outage opportunities on the line. The foundations are proposed to be a pile cap arrangement.

This complying design shows a slight increase in the number of towers by approximately 3% compared to TransGrid's design. Table 11 shows a breakdown of the number of towers compared to the TransGrid Phase B concept design.

Table 11 – Number of towers in the BAFO submission compared to the TransGrid concept design

	TransGrid Phase B tender design			BAFO concept design			
Transmission line segment	**Strain**	**Light suspension**	**Total structures**	**Strain**	**Light suspension**	**Total structures**	**% Increase in total structures**
Border to Buronga	43	241	284	41	254	295	16%
Buronga to Dinawan	83	716	799	84	726	810	1%
Dinawan to Wagga Wagga	45	297	342	52	308	360	5%
Total	171	1254	1425	177	1,288	1,465	3%

The bidder also proposed a guyed tower arrangement to replace the majority of the suspension towers. The option is to replace light suspension towers with the guyed tower solution ((saving of $55 million) and use of foundations to CIGRE design (saving of $5 million). The guyed towers design offers the following advantages:

- Reduction in tower weight as well as the foundation size (which reduces the capital cost of the towers)
- The towers can be pre-assembled and installed with only one crane reduced installation costs and time.
- Reduction in the potential of cascade tower failure due to greater stiffness compared to suspension towers.[29]

[29] Bidder 2 Data Room: 1.29RS 16 Options & Alternatives.pdf, page 6.

TransGrid have accepted the option of guyed towers with the offered cost reductions included in the BAFO Capex Forecast. The successful bidder has identified L1 and L2 are suitable for replacement of the majority of suspension towers based on consideration of lower land use constraints:

- L1 Border to Buronga 330kV - 82% of suspension towers are able to be replaced by guyed towers.
- L2 Buronga to Dinawan 330kV - 94% of suspension towers are able to be replaced by guyed towers.[30]

TransGrid did not accept the use of guyed towers for the line between Dinawan and Wagga 330kV considering the visual impact and land use along this route. GHD considers this decision reasonable. Guyed towers are typically not used internationally in agricultural or in other higher density land use regions.

Accepting the concept design option for guyed towers increases the costs for the Safety in Design review process and also increases maintenance costs. These additional costs are included in other construction costs and the maintenance costs considered in the review of tenders.

Substations

Buronga 330 kV Substation

The bidder has adopted a similar substation layout and arrangement to the Adjusted Phase B RFT with a few changes (such as the incoming 330kV Bundey 6C connecting to a different bay) to allows staging works to meet the energisation required milestone dates. Optimisation of the site included removal of PST firewalls, removal of an existing bypass disconnector and no longer requiring the access road on the eastern side.

Dinawan 330kV Substation

The bidder has adopted a similar substation layout and arrangement to the Adjusted Phase B RFT with a few changes (such as the position of the transmission line cut in and the main road as well as the use of phase duct in lieu of underground cable connections). Optimisation of the site included removal of duplication of disconnectors on the synchronous condenser bay and changes to the location of the capacitor bank and synchronous condenser.

Augmentation of Wagga Wagga Substation

The bidder has adopted a similar substation layout and arrangement to the Adjusted Phase B RFT with a few changes (such as converting the existing Bay 1L into a double CB switchbay by utilising a dead tank cb). The design of the augmented site has been optimised by changing the location of the capacitor bank.

Augmentation of Red Cliffs 220kV Substation

The bidder's concept is broadly in line with TransGrid's design.

Special Protection and Communications

The bidder has proposed the same design as TransGrid.

Large Specialist Equipment

Prior to the BAFO the bidder had not finalised the suppliers for the LSE such as PSTs, power transformers, line shunt reactors and capacitor banks. The scope and specification did not change for the BAFO.

[30] Bidder 2 Data Room: 1.29RS 16 Options & Alternatives.pdf, page 6.

4.7.2 Update to the Specification and Scope Description Document (SSD)

The previous version of the SSD was submitted on June 29 2020 as part of the CPA which was based on:

- A TransGrid concept design prepared based on independent expert reports
- The outcomes from the RFT A responses from November 11 2019
- Quotations from suppliers for the large specialised equipment[31]

The SSD has been updated to document the revised scope and specification since the RIT-T submission and to incorporate the designed prepared by the two BAFO bidders in response to the adjusted Phase B tender design for the southern alternative route.

The following table outlines the key changes in to the SSD since the RIT-T:

Table 12 Changes to the SSD since the 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 avoids negotiating suitable easements and access rights through the intensive irrigation zones around Darlington Point township.
Redesigned 330 KV transmission towers	Modifications to 330 kV tower design primarily to meet AS:7000 standards which increases tower steel and foundations. Each of the short-listed tenderers has specified towers that are compliant with the revised AS7000 standard. In addition Bidder 2 has proposed a guyed tower arrangement to replace the majority of suspension towers which TransGrid has accepted.
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 PST specification changed from three 400 MVA 3-phase units to five 200 MVA 3-phase units, due to road transport weight limitations
Shunt reactors	Originally 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. Tenderers have proposed to use either the same 330 kV towers as for the 330 kV line segments or a double circuit steel pole.
Change in 220 kV scope	Originally 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.

[31] Specification and Scope Description, page 1.

Item	Comment
	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.

The updated SSD demonstrates that TransGrid have further optimised the design with the tenderers since the RIT-T through the market testing and validation from the RFT B process.

Since the submission of the SSD and during the completion of the BAFO stage, TransGrid has included a provisional sum ($32.6 million) allowing for alignment to the Dinawan to Wagga 330kV transmission line due to feedback from environmental impact assessments and stakeholder engagements. The allowance is for 20km of additional distance for this transmission line. GHD was not able to verifiy the justification for this change of scope except that it is consistent with TransGrid's experience in developing the route in the initial PACR solution near Darlington Point.

4.8 CPA PEC scope definition

This section considers the final scope defined for the CPA. The assessment is with regard to whether the final scope definition adequately defines the scope in line with the optimally planned solution and that the scope accurately aligns with the final estimate of costs submitted for the CPA. This then leads to verifying whether the scope is efficient in meeting the investment need.

The Phase B RFT scope definition was discussed in section 4.7. The associated tender documents and the SSD have adequately defined the scope in line with the planned solution which GHD considers an optimum performance based scope definition and specification that would have enabled further efficiencies in design.

The BAFO outcome includes the adoption of some significant design options which have been accepted by TransGrid providing cost efficiencies compared to the original TransGrid concept designs. These were detailed in section 4.7.

The BAFO scope definition was provided to the final two BAFO tenderers within TransGrid's document titled "Employer's Requirements Key Project Functional Requirements Exhibit B Dated 7 August 2020 V9.1". This included refinement of route distances providing a slightly reduced route distance overall.

Within the BAFO outcome TransGrid includes provisional sums which were required to be priced in the BAFO process. Some related to commercial risk items transferred to the contractor. The majority of the costs however relate to the provision for the additional 20km of line route ($32.6 million) which was not specified in the original Employer's Requirements for the BAFO.

As indicated above, GHD was not able to verifiy the justification for this change of scope except that it is consistent with TransGrid's experience in developing the route in the initial PACR solution near Darlington Point.

GHD considers the SSD document adequately defines the project investment scope with respect to the preferred Southern Alternative Route and details all of the refinements that have been made since the project scope was originally defined in the RIT-T PACR, except for the additional 20km route distance provision. The defined CPA investment scope is consistent with the investment need defined in the PADR and PACR.

GHD's verification process was also conducted in parallel with TransGrid's earlier consideration of whether a change to a southern route for the Buronga to Wagga 330 transmission line should be preferred compared to the route north through Darlington Point substation as defined in the PACR. GHD identified the scope changes since the Tendered Works (Phase A) that would also had a cost impact to both route options.

GHD has assessed the scope of work defined for both route options, the Final PACR Solution and the Southern Alternative Route and considers that both options meet the asset performance and the investment need. We later compare the cost efficiency of both of these options in section 5 to consider TransGrid's finding that the Southern Alternative Route is likely to the most efficient solution for the project. While the provisional sum for an additional 20 km of line from Dinawan to Wagga would increase the cost of the Southern Route compared to a Final PACR Solution, a similar provision however would likely be needed for the PACR Solution route.

4.9 Summary of the scope review

Table 13 provides the summary of GHD findings related to the review of the TransGrid's PEC scope.

Table 13 PEC scope – findings, qualifications and verification

Findings	
1	The SSD and the Supplementary Capex Forecast Methodology - BAFO documents adequately track the changes and refinement of scope from the PACR through to the scope which is commensurate with the CPA. The scope detailed is applicable to the preferred Southern Alternative Route.
2	TransGrid did not provide documentation that showed the changes and refinement of scope from the PACR through to what would have been the Final PACR Solution.
4	GHD was able to identify some scope changes in the TransGrid's documentation for the CPA which should also apply to Final PACR Solution, but these were not included in the Tendered Works (Phase A). We developed comparative estimates for the total scope for both route options by revising the RFT Phase A Capex Forecast to include the scope changes applicable to both options.
5	The Phase B RFT documents best describe the asset performance requirements for PEC covering details on the required transmission line, substation and large specialist plant ratings and performance specifications. These specifications allow the tenderers to provide their own optimised technical solutions to meet the performance specifications. The performance specification can be applied to both route options.
6	The transmission line design criteria is comprehensive and GHD considers the parameters have been selected in accordance with AS/NZS 7000:2016. The concept designs developed by consultants for each specific transmission line have also been developed in line with meeting the design criteria at the lowest cost. Pricing by tenderers in the first Phase A RFT was required to be based on the concept designs. In the Phase B RFT the concept designs are provided to the shortlisted tenderers to assist in developing their own designs which is a consistent approach for large infrastructure projects.

Findings	
7	The specifications in both the tenders represent standards expected for transmission infrastructure and good electricity industry practice.
8	The BAFO submissions has complied with the tender specifications in addition to optimising TransGrid's design by use of guyed tower designs, the layout of substations and simplifying the staging of works. Deviations from the TransGrid design have been justified and the bidder has indicated that their optimised design complies with the appropriate Australian and TransGrid standards.
9	The updated SSD demonstrates that TransGrid have further optimised the design since the RIT-T through the market testing and validation from the RFT B process.
10	Since the issue of the BAFO Employer Requirements, a provisional sum ($32.6 million) has been included allowing for alignment changes for the Dinawan to Wagga 330kV transmission line due to feedback from environmental impact assessments and stakeholder engagements. The allowance is for 20km of additional distance for this transmission line.

Qualifications	
1	GHD has used the Success BOE 5.0 estimate and the Phase A RFT procurement documentation to identify the scope defined for the Tendered Works (Phase A).
2	Scope changes since the Tendered Works (Phase A) based on our findings, were identified in the SSD and Supplemental Capex Forecast Methodology - BAFO documents for the common changes that should apply to both routes.
4	The review of the Adjusted RFT Phase B BAFO tender's design only considered the elements that are part of the base design.
5	GHD was not able to verifiy the justification for this change of scope except that it is consistent with TransGrid's experience in developing the route in the initial PACR solution near Darlington Point.

Verification	
Project investment scope	The SSD document adequately defines the project investment scope originally defined in the PACR.
Asset performance requirements	The asset performance requirements were adequately defined for the Phase A RFT and specifically defined in the Phase B RFT through performance based specifications. GHD considers the defined asset performance requirements are the minimum required to meet the investment needs. TransGrid and ElectraNet have conducted relevant studies to confirm the active and reactive plant requirements to meet asset performance requirements for PEC.

Verification	
Planning and options assessment	GHD considers that the planning studies and refinements that TransGrid has conducted to reach the final scopes of work for both route options have resulted in the minimum scopes required to meet the investment need.
Scope definition for the CPA estimates	The scope definition in the SSD and Supplemental Capex Forecast Methodology - BAFO documents are adequately defined for the Southern Alternative Route except for the allowance made for the additional 20km of route realignment along the DInawan to Wagga 330kV transmission line.
Scope definition for procurement of work packages	The key plant scope and specifications have been adequately defined in both the Phase A RFT and Phase B RFT.
CPA Scope Definition	The PEC scope has been refined since the PACR and is considered prudent and efficient towards minimising costs for each route option to meet the defined investment need for the project and is consistent with the investment need defined in the PADR and PACR.
Submissions to Tendered Works Phase B	The submissions to the Tenders Works Phase B by the BAFO bidder has adequately addressed TransGrid requirements and specifications and are considered prudent. The BAFO bidder has optimised the design whilst still complying with performance requirements.

5. Capex forecast review

The cost review focuses on the BAFO outcome which relates to the Southern Alternative Route and also provides an assessment of costs difference relevant to the Final PACR Solution in comparison to the Southern Alternative Route.

Property and biodiversity costs, indirect costs and risk allowance are reviewed in other sections of this report.

Table 14 - Capex build categories and GHD's comparative review

TransGrid key capex categories	GHD's review categories	GHD report sections
BAFO outcome[6]	Review of Southern Alternative Route GHD Comparative Cost Estimate	• In section 5 GHD provides comparative estimates which were based on the RFT Phase B concept designs for the Southern Alternative Route and cost difference between the two alternative routes after adjusting for changes applicable to both routes[32] • Other construction costs are considered in section 5.7 • In section 5.10 we compare the efficiency of each route option
Property costs	Property/Biodiversity capex review	• Property and biodiversity costs estimates are reviewed in section 6 and 7.
Indirect costs	Indirect capex review	• Indirect costs are reviewed in section 8.
Risk event costs	Risk event capex review	• Biodiversity risk allowances are reviewed in section 9.

Source: Figure 4.3 PEC capex building blocks and GHD related review sections[33]

[32] To compare the *Final PACR solution* to the *Southern Alternative Route* adjustments to the *Phase A Estimate* have been necessary including TransGrid's defined "Other construction costs" reference Capex FM Table 2.2 pp. 7-8

[33] Capex Forecasting Methodology 29 June 2020

5.1 PEC capex forecast

Table 15 shows a summary of the capex forecast for the project.

Table 15 PEC capex forecast

Cost element	Description / section reference	BAFO forecast (2017/18 $ million)
Substations and transmission lines, including access tracks.	Refer section 5.3	1,270.2
Large specialist equipment	Refer section 5.3	140.2
Other construction costs	Refer section 5.7	58.2
BAFO outcome		***1,468.6***
TransGrid direct costs	Property and easement acquisition and costs considered in section 6.	121.5
	Biodiversity ‘offset’ costs considered in section 7.	127.4
TransGrid indirect costs	Corporate and Network overheads, including property portfolio considered in section 8.	135.8
Biodiversity risk costs	Biodiversity risk allowances considered in section 9.	38.2
Real input escalators	Detailed in section 10.	3.2
Total Capex		**1,894.6**

5.2 Assessment approach

5.2.1 Variance range

Full details of the methodology and assumptions used in the preparation of comparative estimates are provided in Appendix C. In short, our reference comparative estimates for similar projects is used as a test for reasonableness. The comparative estimates are based on inputs from completed projects throughout Australia for similar types of 330 kV substation and transmission projects, older projects escalated and weighted against new project data being entered.

We have determined the variances respectively between the BAFO submission and the GHD comparative estimates for each work package. Where the variation to the comparative estimate is less than ±20%, GHD considers the tender estimate to be reasonable and no further detailed assessment is undertaken.

For those tender estimates where the variation is outside the nominal range, GHD has reviewed any known project specific issues to identify the potential reasons. If the variation is within our nominal ±20% range, we will consider the TransGrid assessment of the impacts to be reasonable. If this variance is outside the nominal range, we have reviewed any factors that may have the result.

5.2.2 Estimate comparisons

We have assessed the forecast costs for PEC over a number of phases:

1. Our initial review considered the scope of works as defined with the TransGrid Success version 4.1 estimate, and our comparative estimates were based on the appropriate building blocks for supply and construction of the specified transmission line and substation assets.
2. Subsequently, we refined our comparative estimates based on the revised scope of works underpinning the TransGrid 5.0 Final estimate and assessed the reasonableness of the 5.0 Final estimate values using our ±20% check (refer Appendix C). We verified the scope of works supporting the 5.0 Final estimate against the tender specification scope (the Tendered Works (Phase A) – refer Appendix A).
3. For the Phase A tender prices received, average adjusted prices were determined by TransGrid for each of the activities within each work package, and at the aggregate work package level. This was the price deemed to represent the average market value for the works. GHD assessed the average market price for each work package at the aggregate or bottom-line level, and where appropriate, highlighted any factors that are contributing to any variance outside of our nominal ±20% range.
4. For the Southern Alternative Route (the preferred route option), we refined our comparative estimates based on the revised scope, with an overall shorter transmission line between Buronga and Wagga, and the establishment of a new Dinawan Substation. GHD's comparative estimate is based on TransGrid's concept designs for the Southern Alternative Route hence scope refinements made by the bidders during Phase B, and cost benefits (or otherwise) will be reviewed and discussed in this section with respect to variations.
5. For the Final PACR Solution, we also refined our comparative estimates based on the common scope changes that were identified for the Southern Alternative Route that will also have to apply to the Final PACR Solution. GHD's comparative estimates have also been based on TransGrid's concept designs and used for a review of the difference in costs between these alternate routes.
6. We have reviewed cost data provided by TransGrid for the respective transmission line and substation scope elements, the project management and design costs, and provisional sums included in the BAFO submission. TransGrid has applied an allocation methodology for project overheads and provisional sums to derive overall costs for the transmission line works and the substation works within the capex forecast. GHD separately reviewed the individual line items, including the provisional sums, and allocated these costs to either transmission lines, or substations, and in one case specifically to the 330kV transmission line from Dinawan to Wagga 330kV. This was needed to provide a like for like comparison of variations to GHD's comparative estimates.

5.3 Adjusted BAFO costs

Summary

In this final phase of the GHD review we have focussed on a comparison of the BAFO submission documentation and costs with GHD's comparative estimates.

Table 16 provides the high level BAFO costs presented by TransGrid in the capex forecasts compared with GHD's independent review of the breakdown of costs. TransGrid's breakdown into the high level work scope elements was based on an approach to the allocation of project management, design costs and provisional sums which we were not able to review or validate. These costs in total were separated out by TransGrid from direct costs for the successful BAFO submission of costs.

To ensure valid comparison with GHD's estimates of costs, we applied the same method of allocating project management and provisional costs as used in our building block comparative estimates. The method which is described in the subsections below results in different costs to TransGrid's totals for transmission lines and substations as shown in Table 16 below.

Table 16 BAFO costs by scope element ($M, 2017-18)

Description	TransGrid's BAFO Costs (2017/18 $ million)	GHD's Comparative BAFO Breakdown[34]
Transmission lines, including access tracks	969.7	907.6
Substations (not including LSE)	297.9	360.0
Large specialist equipment (LSE)	140.2	140.2
Special protection, Communication and Balance of Works	2.6	2.6
Subtotal	**1,410.4**	**1,410.4**
Other construction costs	58.2	58.2
BAFO outcome	**1,468.6**	**1,468.6**

Provisional Sums

During the BAFO procurement phase, TransGrid have been able to transfer previously identified "other construction costs" to the EPC contractor.

The items include commissioning support, independent environmental oversight, geotechnical risk, additional noise control and risks of soil contamination. These sums were explicitly priced with overheads and margin by the contractor. GHD has assessed these requirements as necessary scope which were competitively priced during the BAFO stage.

GHD noted a sum allocated for the addition of 20 kms to the Dinawan to Wagga 330kV transmission line route due to alignment changes identified in detailed design work and from stakeholder feedback. We were unable to make an assessment of the need for this additional scope.

GHD also identified that TransGrid have included the provisional sum in the BAFO costs corresponding to costs for a 500kV line and not the costs for a 330kV line.

TransGrid advised that the BAFO submission included the assumption of guyed structures for this provisional sum, and that TransGrid concluded that the assumptions for their 330kV pricing were not relevant for inclusion as a provisional sum and so retained the figures for the 500kV line. TransGrid does not believe guyed towers would be suitable or accepted by stakeholders which we support.

On this basis, TransGrid retained the provisional sums currently reflected in the capex forecast.

[34] Refer Table 19

GHD acknowledges that the same savings priced in the BAFO submission is not directly applicable, however we consider that the cost of an additional 20 km of 330kV line should still be less than the cost for a 500kV line using conventional towers.

GHD considers that the costs for a conventional 330kV tower line should still have been determined for this additional section of line and not the costs for a 500kV line. GHD estimates the difference in cost to be around $10 million ($0.5 million difference per km). This is based on the difference in relative per km costs for 330kV compared to 500kV adjusted down by 25% considering the costs for the additional line to be incremental.

GHD has separately reviewed the provisional sums and allocated costs to the respective transmission lines and substations. We have commented further on the cost variation for the Dinawan to Wagga 330kV line in section 5.4.

BAFO costs and GHD comparative estimates

GHD reviewed the allocation of project management, design and provision sums starting with the project management allocations by the successful bidder in the RFT Phase B tender submissions before allocation of the provisional sums, and before allocation of TransGrid's other construction costs.

GHD used the following allocation method to develop total costs for each work package and cost element:

- Some minor re-allocation of the successful bidder's project management and other overheads to align with the methodology applied by GHD in developing its comparative estimates at a work scope level. These were applied first before allocation of TransGrid's other construction costs and allocation of the provisional sums in the BAFO submission.
- The provisional sum line items were separated into three categories – transmission lines, substations and in one case the specific transmission line from Dinawan to Wagga. The provisional sum for this transmission line sector was the allowance for the additional 20km due to the route realignment identified through stakeholder engagement. These costs were then weighted across all transmission line and substation elements respectively or added directly to the Dinawan to Wagga transmission line, in that one case. The provisional sum amounts included allowances for additional project management and margins, hence GHD considers these costs should not be added to direct costs for each scope element, but instead after other project management costs have been allocated.
- TransGrid's other construction costs were allocated to transmission lines and substations according to the approach taken in TransGrid's A6 Capex Forecast Model (A.6 - Transgrid - PEC - Capex Forecast Model).

The cost build ups are shown in Table 17 and Table 18 below after allocation of the provisional sums. The substation costs for Buronga and Dinawan include the respective LSE plant costs.

Table 17 Adjusted BAFO costs by work packages prior to allocation of "other construction costs"

Description	BAFO Costs (2017/18 $ million)
330 kV Double Circuit OHL SA/NSW Border to Buronga Substation	172.2

Description	BAFO Costs (2017/18 $ million)
330 kV Double Circuit OHL - Buronga to Dinawon	446.9
330 kV Single Circuit OHL - Dinawon to Wagga 330	241.4
220 kV Double Circuit OHL - Buronga to Red Cliffs	46.1
Total Transmission Lines	**906.7**
Buronga Substation	292.2
Dinawan Substation	162.9
Wagga 330 Substation	42.4
Red Cliffs Substation	3.5
Total Substations	**501.1**
Special protection, Communication and Balance of Works	2.6
Subtotal	**1,410.4**
Other construction costs	58.2
BAFO outcome	**1,468.6**

Table 18 represents the tender submission by cost element prior to the re-allocation of overheads.

Table 18 Adjusted BAFO cost elements prior to allocation of "other construction costs"

Cost element	Description	BAFO cost estimates (2017/18 $ million)
Civil works	Substations and transmission lines, including access tracks	241.4
Electrical & Structural Works	Structures, stringing and substation electrical works	376.8
Large specialised equipment	LSE - synchronous condensers, phase-shift transformers including supply and installation	140.2
Project Management, contingency and other overheads	Direct and indirect project management costs	578.8
Design, test and commissioning	Direct and indirect design, test and commissioning costs	70.6

Cost element	Description	BAFO cost estimates (2017/18 $ million)
SPC	Special protection, Communication and Balance of Works	2.6
Subtotal		**1,410.4**
Other construction costs		58.2
BAFO outcome		**1,468.6**

Table 19 shows a summary of the costs by work scope packages after including allocation of TransGrid's other construction costs.

Table 19 Adjusted BAFO costs by work packages after allocation of "other construction costs

Description	BAFO[35] cost estimates (2017/18 $ million)
330 kV Double Circuit OHL SA/NSW Border to Buronga Substation	181.2
330 kV Double Circuit OHL - Buronga to Dinawon	470.2
330 kV Single Circuit OHL - Dinawon to Wagga 330	254.0
220 kV Single Circuit OHL - Buronga to Red Cliffs	48.5
Total Transmission Lines (GHD allocation method)	**953.8**
Buronga Substation	298.7
Dinawan Substation	166.5
Wagga 330 Substation	43.4
Red Cliffs Substation	3.5
Total Substations (GHD allocation method)	**512.2**
Special protection, Communication and Balance of Works	2.6
BAFO outcome	**1,468.6**

The unit price build up in the RFT Phase B and BAFO submissions are more detailed than GHD's comparative estimate building blocks. GHD has relied upon a review of the variances at both the work package and the cost element level to assess if the comparative estimates are within ±20% of the adjusted BAFO costs. Where feasible, any contributory factors have been assessed for the variances outside ±20%.

[35] Totals for transmission lines and substation work scope items will differ to TransGrid's totals due to different allocation methods

Company overheads and margin

GHD has allowed 11% project overheads in the comparative estimates to represent overheads and margins that an EPC contractor would apply for large infrastructure projects to oversee their own separate work packages (either directly delivered or through subcontract).

5.4 Transmission line cost comparisons

5.4.1 Transmission line comparison by scope and cost elements

Table 20 is a summary of the comparison by cost elements between the adjusted BAFO costs and the comparative GHD estimates.

Table 20 Transmission line comparative estimates by cost element

Elements	Adjusted BAFO ($ million 2017/18)	GHD ($ million 2017/18)	Variance GHD to BAFO (%)
Civil works	200.2	226.4	13%
Electrical & Structural Works	296.6	359.3	27%
Project Management, contingency and other overheads	410.6	375.3	-9%
Design, testing and commissioning	46.4	34.5	-64%
TOTAL	**953.8**	**995.5**	4%

The variations of adjusted BAFO costs by cost element to GHD's comparative estimates are within our nominal ±20% range for acceptance except for electrical & structural works and for design, testing and commissioning works. Design and testing costs for guyed towers is expected to be higher compared with conventional self-supporting transmission towers but significantly lower for civil and structural construction cost. GHD is satisfied based on a review of the cost elements that TransGrid has achieved an efficient range for the capex costs for the transmission line scope of work.

Table 21 is a summary of the comparison for each transmission line scope of work between the adjusted BAFO costs and the comparative GHD estimates.

Table 21 Transmission line comparative estimate by work package

Transmission Line	Adjusted BAFO ($ million 2017/18)	GHD ($ million 2017/18)	Variance GHD to BAFO (%)
330 kV DCST SA border – Buronga	181.2	200.0	10%
330 kV DCST Buronga - Dinawan	470.2	586.4	25%
330 kV DCST Dinawan - Wagga 330	254.0	179.8	-29%
220 kV SCSP Buronga - Red Cliffs	48.5	29.4	-39%

Total	**953.8**	**995.5**	4%

The following summarises a review of the prices from the successful EPC contractor compared to the GHD estimates for the four transmission line construction works while considering scope changes since the development of GHD's estimates.

5.4.2 330 kV Double Circuit OHL - SA/NSW Border to Buronga substation

GHD's comparative estimate was based on 135 km length with a Double Circuit Steel Tower configuration with 256 suspension and 34 strain towers and 3 monopole structures, and an average span of 464 metres. The conductor is Twin Mango ACSR/GZ 54/7/3.00 3-core 431 mm^2.

The key project functional requirements[36] updated for the BAFO submission confirmed the route distance of 135 km.

The variance in Table 21 for this transmission line is 10% which is within our nominal ±20% range before requiring further assessment. The contractor's adoption of guyed towers for this transmission line will have contributed to the lower cost. Section 4.8.1 shows that the total number of towers though increased by 9% compared to the conventional concept design which would offset against the lower construction costs per tower. The benefit of these structures is provided through lower construction costs for foundations and erection of the structures.

GHD is satisfied that TransGrid's procurement process has achieved efficient market tested capex costs for this transmission line.

5.4.3 330 kV Double Circuit OHL - Buronga to Dinawan

GHD's comparative estimate was based on 401 km length with a Double Circuit Steel Tower configuration with 756 suspension and 88 strain towers, and an average span of 476 metres. The conductor is Twin Mango ACSR/GZ 54/7/3.00 3-core 431 mm^2.

The variance is 25% which is outside the nominal ±20% variation range. The market based price is lower compared to GHD's estimate.

The key project functional requirements for BAFO submissions identified the route distance to be 376 km which is 9.4% less than the route distance used for GHD's comparative estimate.

After comparing the adjusted BAFO costs and GHD estimates at a lower granular level, GHD was able to identify that civil and structural costs were much lower compared to GHD's estimate. Section 4.8.1 shows the total number of towers increased by 1% compared to the conventional concept design, however the shorter route distance explains the greater variation for this transmission line compared to the Border to Buronga transmission line.

Other factors are the relative more detailed knowledge of ground conditions and the number of road and river crossings not considered specifically for each route in the GHD comparative estimates.

GHD is satisfied that TransGrid's has achieved efficient market tested capex costs for this transmission line.

[36] Employer's Requirements – Key Project Functional Requirements – Exhibit B, dated 7 August 2020

5.4.4 330 kV Single Circuit OHL – Dinawan to Wagga

GHD's comparative estimate was based on 151 km length with a Double Circuit Steel Tower configuration with 257 suspension and 49 strain towers, and an average span of 493 metres. The conductor is Twin Mango ACSR/GZ 54/7/3.00 3 core 431 mm^2.

The key project functional requirements for the BAFO submissions identified the route distance to be 157 km which was 4% higher than the route distance used for GHD's comparative estimate. GHD identified a provisional sum in the BAFO costs for an additional 20km of route which would then total 177km, an increase of 17% over the route distance in GHD's estimate.

The variance shown in Figure 21 is 29% over GHD's comparative estimate which would be mainly explained by the revised and longer route distance, and which would bring the variation within ±20% of GHD's comparative estimate. Conventional tower designs are proposed to be used for this line as guyed towers are not suitable due to land use constraints.

GHD identified that TransGrid has used to pricing for a 500kV transmission line in the provisional sum for the additional 20km route distance. Our assessment is that TransGrid should have explicitly calculated the provisional sum based on a conventional 330kV transmission line structures.

The EPC contractor had provided costs for 330kV guyed towers for this section, a design not accepted by TransGrid for this route. GHD considers that the costs for a conventional 330kV tower line should still have been determined for this additional section of line and not the costs for a 500kV line. GHD estimates the difference in cost to be around $10 million ($0.5 million per km).

Section 4.8.1 shows that the total number of towers for this line increased by 5% compared to the conventional concept design would have increasing effect on the BAFO costs compared GHD's estimate.

The following summary of these factors explains the majority of the variance of 29%:

1. The revised original route distance is higher by 4%
2. A further additional 20km realignment higher increasing costs by 13%
3. Cost higher due to 500kV pricing for the realignment of around 3%
4. Additional tower structures offsetting the reduction in costs (-5%)

GHD is satisfied that TransGrid has achieved efficient market tested capex costs for this transmission line but consider an adjustment should be made for the costs in the provisional sum for the additional 20km 330kV transmission line.

5.4.5 220 kV Single Circuit OHL - Buronga to Red Cliffs

GHD's comparative estimate was based on the 24 km length of line with a double circuit steel monopole configuration (strung both sides) with 49 suspension and 11 strain poles, and an average span of approximately 400 metres.

The EPC contractor adopted a monopole steel pole design achieving an average span length of 387 metres. A challenge for the 220kV line design is the existing transmission line which has very limited outage availability. In order to solve that, the EPC contractor will construct an additional bypass line to provide enough space between the old and new lines for the work to be carried out with the existing lines energised. A total of 60 new bypass poles and associated conductor movements will be required for this purpose. The existing line will then also need to be dismantled.

GHD did not allow for this additional work scope in the comparative estimates. The variance to the adjusted BAFO costs is 39% lower which is outside the nominal ±20% range and required additional consideration.

GHD reviewed the cost elements for this 220kV line and identified the key reasons for GHD's lower estimate for Red Cliffs line as follows:

- The size and therefore cost of supply and installation of the mono poles were underestimated by GHD. This reflected in the civil, structural and electrical components of the work being under-estimated.
- The number of steel poles included in GHD's building block estimate was 50 compared to the BAFO design which required 62 poles
- Brownfield uplift costs were not included, particularly the need for the 60 additional temporary poles and construction of the bypass line
- Allowance for dismantling the existing line was not included

After reviewing and adjusting the building block costs for the steel poles and associated installation costs, GHD estimated costs increased to within a variation of 8% lower. The other factors would explain the remaining difference. GHD is therefore satisfied that TransGrid has achieved efficient market tested capex costs for this transmission line.

5.4.6 Transmission line cost summary

From this analysis, GHD has found:

- The variance for the 401km 330 kV double circuit OHL between Buronga and Dinawan was 25% higher compared to the adjusted BAFO costs and this is mainly due to cost savings in the construction of guyed towers compared with conventional free standing structures. The route distance identified in the BAFO was 376 km which is 9.4% less than the route distance used for GHD's comparative estimate. After comparing the adjusted BAFO costs and GHD estimates at a lower granular level, GHD was able to identify that civil and structural costs were much lower compared to GHD's estimate.
- A variance for the 151km double circuit OHL between Dinawan and Wagga was 29% lower compared to the adjusted BAFO costs and this predominately was due to TransGrid's need to add a provisional sum for 20km of additional transmission line.
- TransGrid used the pricing offered for 500kV for this 20km additional section whereas GHD considers that the costs for a conventional 330kV tower line should still have been determined. GHD estimates the difference in cost to be around $10 million ($0.5 million per km).
- After adjustments for scope and costs, the variance of GHD's comparative estimate for the Dinawan to Wagga 330kV line would reduced to 12%.
- A relatively large variation (39% higher) to the adjusted BAFO costs for the 24km 220 kV Buronga to Red Cliffs line was primarily due to GHD not allowing for larger steel poles and associated installation costs required for the conductor design wind loading. GHD had also not included costs allowing for the brownfield construction environment and not included costs for the removal of the existing tower line. Allowing for larger steel poles and installation costs would have reduced the variance to within 8%.

- Overall the adjusted BAFO costs for transmission lines have a variation with GHD's estimates of 4%. This variance would increase to 9% when the identified scope changes are added to the original GHD's estimate for the Dinawan to Wagga 330kV line and for the Red Cliffs 220kV line.
- There was general alignment between the adjusted BAFO costs and GHD's estimates across the cost elements analysed – civil works; electrical and structural works; project management; contingency and other overheads; and design, testing and commissioning. Design and testing costs for guyed towers can be expected to be higher compared with conventional self-supporting transmission towers but significantly lower for civil and structural construction cost which is reflected in the variances to GHD's comparative estimates.

The variance in total for the four transmission lines is within the nominal range of ±20%, and lower than GHD's comparative estimate which is based on building block unit rates from historic projects and market data. GHD considers that TransGrid has achieved efficient pricing for the transmission line work scope through the procurement process undertaken.

5.5 Tendered substation cost comparisons

5.5.1 Substation comparison by scope and cost elements

Table 22 is a summary of the comparison by cost elements between the adjusted BAFO costs and the comparative GHD estimates.

Table 22 Substation costs element summary

Elements	Adjusted BAFO ($ million 2017/18)	GHD ($ million 2017/18)	Variance GHD to BAFO (%)
Civil works	41.1	103.0	150%
Electrical & Structural Works	80.2	73.9	-8%
Large Specialist Equipment	140.2	223.3	73%
Project Management, contingency and other overheads	169.8	127.6	-29%
Design, testing and commissioning	80.8	8.4	-90%
TOTAL	**512.2**	**536.2**	**5%**

The variations of the adjusted BAFO costs and GHD's comparative estimates cost elements show large variations outside our nominal ±20% range. We have made the following observations to identify likely causes of the variations at a cost element level:

- Overall the civil costs included by GHD appear to be well above that of prices from bidders in RFT Phase B submissions.
- GHD's estimates for the LSE scope also included allowances for civil, design, electrical and structural components of the work rather than separated out. Hence the inclusion of these cost

elements could account of the higher LSE costs, and for the much lower design, testing and commissioning costs elements.

- The reduced substation footprints in the BAFO, for example at Dinawan Substation, will have also significantly contributed to lower civil costs.
- GHD's project management costs for substation are lower than the adjusted BAFO costs by 29%.
- GHD considers if the costs were re-allocated using a common cost element approach that all elements would be within the nominal ±20% range based on the variations at the total substation level (5% above the adjusted BAFO costs).

GHD is satisfied based on a review of the cost elements that TransGrid has achieved efficient capex costs for the substation scope of work. This is supported by the following analysis for each substation scope of work and costs with the exception of the Wagga 330kV Substation where GHD's costs are significantly lower than the adjusted BAFO costs.

The Wagga 330kV substation has less scope requirements compared to Buronga and Dinawan substations, and if the difference of $37 million is added to GHD's comparative estimates respectively as shown in Table 23, the total substation cost variation would increase to 11% above the adjusted BAFO costs. Hence still within a ±20% range and below GHD's estimates.

Table 23 is a summary of the comparison for each substation scope of work between the adjusted BAFO costs and the comparative GHD estimates.

Table 23 Substation work scope summary

Elements	Adjusted BAFO ($ million 2017/18)	GHD ($ million 2017/18)	Variance GHD to BAFO (%)
Buronga Substation	298.7	355.1	19%
Dinawan Substation	166.5	171.8	3%
Wagga 330 Substation	43.4	6.4	-85%
Red Cliffs Substation	3.5	3.0	-16%
TOTAL	**512.2**	**536.2**	5%
TOTAL (Wagga 330kV estimated cost increased)		**573.2**	11%

The following summarises a review of the market prices from the tender submissions and the GHD's comparative estimates for the four scope of works for the individual substations.

5.5.2 Buronga Substation

GHD's estimates were based on TransGrid's concept designs and the scope of work at Buronga Substation included:

- Extension to existing Buronga Substation switchyard
- Addition of 330 kV switchyard bus sections and additional 1.5 CB layout bays
- Two additional 330/220 kV 400 MVA transformers and auxiliary transformers and associated switchbays
- Additional 330 kV PSTs and associated switchbays
- Two 330 kV 100 MVAr synchronous condensers and associated switchbay
- Two 330 kV 50 MVAr capacitor banks and associated switchbays
- Four 330 kV shunt reactors and associated switchbays
- Additional 220 kV line bay for new Buronga - Red Cliffs transmission line.

GHD is satisfied that TransGrid's procurement process has achieved efficient market tested capex costs for the Buronga substation. The variance is 19% higher than the adjusted BAFO costs as shown in Table 23 but within our nominal ±20% range for further costs assessment.

From the analysis, our findings are:

- GHD's comparative estimates for substation the civil works are much higher in general in comparison to civil costs identified in the adjusted BAFO costs (refer Table 22) and this would be reflected in the higher civil costs for this substation in GHD's comparative estimate.
- The contribution of the new switchbays and the LSE (PSTs and synchronous condensers) is approximately 33% of the total Buronga substation project costs; consequently, the final estimated cost for this substation augmentation work was highly contingent on the final costs tendered for this equipment. GHD included a provisional sum for the synchronous condensers and PSTs from TransGrid's previous estimates.
- The prices achieved by the bidders for the LSE indicates that competitive negotiations by bidders with the equipment manufacturers has achieved benefits with TransGrid's overall owner risks (hence consumers) being reduced compared to the alternative approach to free issue the LSE to the successful contractor.
- GHD included a nominal 7.5% contingency margin which contributes to the variations of GHD's estimates above that of the bidders.

5.5.3 Dinawan Substation

GHD's estimates, was prepared in accordance with TransGrid's concept designs for the proposed Dinawan Substation, and allowed for the following:

- The construction of a new greenfield 330kV switching station at Dinawan.
- Two incoming and two outgoing 330 kV 1.5 CB layout bays to terminate and switch the new transmission lines from Buronga and to Wagga 330kV substations
- Two 330 kV 100 MVAr synchronous condensers and associated switchbays
- Two 330 kV 50 MVAr capacitor banks and associated switchbays
- Four 50 MVAr shunt reactors and associated switchgear connected one to each of the four feeders

GHD included civil work costs based on a 93,000 m^2 new switchyard as per the TransGrid concept design. The BAFO costs are based on a 73,000 $m^{2\ \text{footprint}}$.

The variances of GHD's estimate shown in Table 23 is only 3% higher compared to the adjusted BAFO costs which is within the nominal ±20% range. GHD is satisfied that TransGrid's has achieved efficient market tested capex costs for the Dinawan switching station.

From this analysis, our findings are:

- The GHD comparative estimate for the civil works required to extend the switchyard are also higher in comparison with the bidders costs similar to the findings for Buronga Substation and as discussed in the previous section relating to civil costs and the footprint reductions achieved in the BAFO outcome.
- The contribution of the new switchbays and the LSE (synchronous condensers) is also approximately 33% of the total Dinawan switchyard project costs; consequently, the final estimated cost for this work was highly contingent on the final costs tendered for this equipment. GHD included a provisional sum for the synchronous condensers and PST from TransGrid's previous estimates.
- GHD included a nominal 7.5% contingency margin which contributes to the variations of GHD's estimates above that of the bidders.

5.5.4 Wagga 330 Substation

The original TransGrid estimate[37] specified limited information for what was originally to be a single feeder (1 330kV line bay. GHD also assumed that the existing Wagga 330 Substation would have sufficient spare space in the switchyard for this additional switchbay. The requirements for the substation were augmented for the Southern Alternative Route to accommodate two additional 330kV feeders. GHD's estimate allowed for the electrical, structural and civil works associated with the two incoming feeders within a 330 kV 1.5 CB layout bay however in reviewing the estimates an allocation of project management and design costs were overlooked and not included.

From this analysis, our findings are:

- GHD used a reference switchbay configuration for a 1.5 CB bay (including structure civil works), resulting in the comparative estimate of $5.9 million, which was approximately half of the comparable scope of works priced for the BAFO. Both the electrical and civil works were higher indicating a combination of the additional work scope to extend the yard and configure the new bay and the brownfield construction environment would explain the increased costs compared to GHD estimates.
- GHD estimates should have also included the allocated project management, design and other overheads commensurate with this substation work. These costs would be expected to be higher as a percentage of the total with a lower component of plant and equipment costs compared with larger two substations.
- Considering the above difference in direct scope and cost allowances, GHD's estimate would otherwise have been higher over $10 million for the direct substation works and a further $15 million for the allocated project management, design, overheads and contingency allowances – totalling over an additional $25 million.

[37] Success Version 4.1

As the variance is outside our nominal ±20% range, we have investigated the reasons. We found that the GHD estimate was insufficient and that the scope of work was more accurately established and understood by the bidders during the Phase B tender process. After adjusting for the omissions, the percentage variance to the adjusted BAFO costs would still be outside the ±20% range.

In reviewing the more detailed cost elements for this substation it appears that the adjusted BAFO costs has a relatively high component for site management, site running costs, and other overheads and contingencies allocated to the Wagga 330kV substation project compared to the other larger substation projects.

If GHD adopted the adjusted BAFO costs of $43.4 million, GHD's comparative estimates across all four substations would increase to $573.2 million which is still only 12% above the total adjusted BAFO costs. Considering the total substation costs across the four substation projects balance out compared to GHD's comparative estimates, GHD considers the differences can be explained by the fact that GHD did not allow for sufficient scope of work and contingencies at the time of preparing the estimates and allocation of project overheads specifically for this substation.

5.5.5 Red Cliffs Substation

The original TransGrid estimate[38] specified the following scope of works:

- 2 off 220 kV line bays
- 2 off 220 kV busbar bays

GHD assumed that the existing Red Cliffs Substation had insufficient spare space in the switchyard for these additional switchbays. We included provisions for additional fencing, roads, drainage, and cable trenching so as to extend the existing Red Cliffs substation by a nominal 1,760 m^2.

Table 23 provides a comparison between the adjusted BAFO costs and the GHD comparative estimate. The variance of 16% under the adjusted BAFO costs is within the ±20% range and does not warrant further assessment. GHD is satisfied that TransGrid's has achieved efficient market tested capex costs for the Red Cliffs Substation scope of work.

5.5.6 Substation cost summary

From this analysis, GHD has found:

- The substation costs for the Buronga Substation and Dinawan Switchyard were within our nominal ±20% range of costs for the scope of work. The variations were 19% and 3% respectively. These projects represent over 90% of the total substation project costs associated with PEC.
- The variance for the Wagga 330kV Substation was outside our nominal ±20% range, however GHD found that our estimates were insufficient in covering the scope and allocation of project management costs. After adjusting for the omissions, the percentage variance to the adjusted BAFO costs would still be outside our nominal ±20% range, however we consider that this is due to the allocation of a relatively large component of other overheads and contingencies to the Wagga 330kV substation by the EPC contractor in its pricing.

[38] Success Version 4.1

- The smaller Red Cliff's substation was within our nominal ±20% range of costs for this scope of work.
- The variations by cost element between to GHD's comparative estimates and the adjusted BAFO costs (refer Table 22) shows some large variations outside our nominal ±20% range. We consider that the allocation of non-direct project costs (design, testing and commissioning; project management, other overheads and contingencies) are predominantly the reason for the variances making it difficult to make comparisons at a cost element level for the substation works. GHD considers if the costs were re-allocated using a common cost element approach that all elements would be within the nominal ±20% range based on the variations at the total substation level (4% higher before the Wagga 330kV adjustments or 11% higher after adjustments).
- The overall variance of GHD estimates in the aggregate substation cost estimate were:
  - Before adjustments for Wagga 330kV substation - $24.1 million higher than the adjusted BAFO costs (4%)
  - After adjustments for Wagga 330kV substation - $61.0 million higher than the adjusted BAFO costs (11%)

The variance in total for the four substation projects is within the nominal range of ±20%, and lower than GHD's comparative estimate which is based on building block unit rates from historic projects and market data. GHD considers that TransGrid has achieved efficient pricing for the substation work scope through the procurement process undertaken.

5.6 Summary of BAFO costs

Table 24 shows a summary of the adjusted BAFO costs for the transmission line and substation project scopes and the comparative GHD estimates (including project allocations for project-specific overheads and on-costs, provisional sums and TransGrid's other costs).

These estimates exclude consideration of land acquisition, property portfolio and environmental offsets. The scope of work for special protection, communication and balance of works are relatively lower in costs and have not been reviewed with comparative estimates.

Table 24 Adjusted BAFO costs compared to GHD estimates

Elements	Adjusted BAFO ($ million 2017/18)	GHD ($ million 2017/18)	Variance GHD to BAFO (%)
Total Transmission Lines	**953.8**	**995.5**	**-4%**
Substations (LSE separated)	372.0	313.0	19%
Large Specialist Equipment (LSE)	140.2	223.3[39]	-37%
Total Substations	**512.2**	**536.3**	**4%**
Special Protection, Communication and Balance of Works (SPC)	2.6	2.5	4%

[39] GHD LSE estimates included installation and project management costs

TOTAL	**1,468.6**	**1,534.3**	**4%**

Based on the GHD comparative estimates and the adjusted BAFO costs the following variances were found:

- The overall variance was 4% over ($65.7 million) for the GHD comparative estimate ($1,534.3 million) compared with the adjusted BAFO costs ($1,468.6 million).
- The variation was 4% over ($41.7 million) for the transmission line scope of work between the GHD comparative estimate ($995.5 million) and the adjusted BAFO costs ($953.8 million).
- The variation was 4% over ($24.1 million) for the substation scope of work between the GHD comparative estimate ($536.3 million) and the adjusted BAFO costs ($512.2 million).

Table 25 shows a summary of the adjusted BAFO costs and GHD's comparative estimates after further adjustments based on the findings related to the additional route distance for the Dinawan to Wagga 330kV line and other relevant scope and costs adjustments in GHD's comparative estimates. This provides a better reflection of the cost reductions achieved through TransGrid's competitive procurement process. This is qualified by the relative accuracy of GHD's comparative estimates and hence indicative only of the cost reductions achieved.

Table 25 Comparisons after further adjustments for scope, costs and omissions

Elements	Adjusted BAFO ($ million 2017/18)	Adjusted GHD ($ million 2017/18)	Variance GHD to BAFO (%)
Total Transmission Lines	**953.8**	**1052.9**	**9%**
Substations (LSE separated)	372.0	349.9	-6%
Large Specialist Equipment (LSE)	140.2	223.3[40]	37%
Total Substations	**512.2**	**573.2**	**11%**
Special Protection, Communication and Balance of Works (SPC)	2.6	2.5	-4%
TOTAL	**1,468.6**	**1628.6**	**10%**

From this analysis, GHD found:

- The overall variance is 10% higher ($160.0 million) for the adjusted GHD comparative estimate ($1,628.6 million) compared with the adjusted BAFO costs ($1,468.6 million).
- The variation is 9% higher ($99.1 million) for the transmission line scope of work between the adjusted GHD comparative estimate ($1052.9 million) and the adjusted BAFO costs ($953.8 million).
- The variation is 11% over ($61.0 million) for the substation scope of work between the adjusted GHD comparative estimate ($573.2 million) and the adjusted BAFO costs ($512.2 million).

[40] GHD LSE estimates included installation and project management costs

- TransGrid's procurement process which progressed from in-house project cost estimates, to prices from the initial Phase A Tender based on concept designs pricing and then the bidder pricing following the Phase B Tender has served to optimise the scope of work and achieve project costs tested and reasonable in today's current market.
- That the scope of work has become clearer and an understanding has been developed by the bidders over the duration of two tender phases to enable scope optimisation and to reach the point of a commercial binding offer for the BAFO.

With respect to variances at lower levels of scope and costs, GHD found:

- For transmission line costs compared to GHD's comparative estimates
  - The variance for the 401 km 330 kV double circuit OHL between Buronga and Dinawan was 25% higher compared to the adjusted BAFO costs and this is mainly due to cost savings in the construction of guyed towers compared with conventional free standing structures. The route distance identified in the BAFO was 376 km which is 9.4% less than the route distance used for GHD's comparative estimate.
  - A variance for the 151km double circuit OHL between Dinawan and Wagga was 29% lower compared to the adjusted BAFO costs and the variance outside of our nominal ±20% range is predominately due to TransGrid's need to add a provisional sum for 20km of additional 330kV transmission line which was not included in GHD's estimate.
  - GHD's review also identified that TransGrid included corresponding costs for a 500kV line and not specifically the costs for a 330kV line for this additional 20km section of line. The EPC contractor had provided costs for 330kV guyed towers for this section, a design not accepted by TransGrid for this route. GHD considers that the costs for a conventional 330kV tower line should still have been determined for this additional section of line and not the costs for a 500kV line. GHD estimates the difference in cost to be around $10 million ($0.5 million per km).
  - A relatively large variation (39% lower) to the adjusted BAFO costs for the smaller (24km) 220 kV Buronga to Red Cliffs line was primarily due to GHD not allowing for larger steel poles needed and associated installation costs required for this double circuit line and the conductor design wind loading. GHD had also not included costs allowing for the brownfield construction environment and not included costs for the removal of the existing tower line. Allowing for larger steel poles and installation costs would have reduced the variance to within 8%.
- For substation costs compared to GHD's comparative estimates
  - The substation costs for the Buronga Substation and Dinawan Switchyard were within our nominal ±20% range of costs for the scope of work. The variations ranged between 3% and 19%. These projects represent over 90% of the total substation project costs associated with Project EnergyConnect.
  - The variance for the Wagga 330kV Substation was outside our nominal ±20% range, however GHD found that our estimates were insufficient in covering the scope and allocation of required project management costs. After adjusting for the omissions, the percentage variance to the adjusted BAFO costs would still be outside our nominal ±20% range, however we consider that this is due to the allocation of a relatively large component of other

overheads and contingencies to the Wagga 330kV substation by the EPC contractor in its pricing.

- The smaller Red Cliff's substation was within our nominal ±20% range of costs for this scope of work.

5.7 Other construction costs

Table 26 details other construction costs allowances made by TransGrid. The total of $58.2 million represents 4.0% of the BAFO outcome. The commissioning and safety assurance program are specific costs while the other components can be considered allowances for risk. These more risk based items amount to $41.6 million and 2.8% of the BAFO outcome. The items are typical for construction projects except COVID-19 being the exception. GHD considers an allocation of 2.8% construction risk allowance for these items is reasonable and typical items associated with linear construction projects. The commissioning and safety audit program is discussed below.

Table 26 Other construction costs

Other construction costs	Description	($ million)
Commissioning	The Supplemental Capex Forecasting Methodology outlines the commissioning includes services to safely energise the line and equipment, then undertake a series of tests to ensure that the line and equipment performs as expected and that there are no adverse impacts on the wider electricity network. The Supplemental Capex Forecasting Methodology detailed that the forecast is based on advice from AEMO and the SISC, as well as our experience of commissioning other new transmission line and substation assets and excludes out-of-market generation costs. GHD staff have had experience in commissioning tests required to connect the original QNI interconnector – these tests to ensure stability could be maintained across the now much longer National Electricity Grid. These costs are consistent with their previous experience for QNI.	11.9
Safety & quality assurance program	The Supplemental Capex Forecasting Methodology indicates that independent safety and quality assurance will be required to meet Board and stakeholder expectations for the execution of the project works. This is a consequence of the scale and remote location of the construction works. GHD advises that this is usual practice for large infrastructure projects, required to support Board responsibilities.	4.7
Planning approval delay	The Supplemental Capex Forecasting Methodology indicates that there remains a risk that State and Federal Environmental Impact Statement (EIS) approvals could take longer than expected, particularly given the scale of PEC and the greenfield nature of the project resulting in delay	11.9

Other construction costs	Description	($ million)
	costs from the contractor. These costs will be impacted by the condition of the site. The Supplemental Capex Forecasting Methodology indicates that the allowance is based upon costs provided by the contractor for each additional month of delay up to 6 months. GHD considers it prudent to create an allowance for EIS approval delay. Given that these costs are based on the contractor's responses, they have been market tested and are therefore prudent and efficient.	
Unforeseen planning approval requirements	The Supplemental Capex Forecasting Methodology indicates the BAFO tender price assumes a set of baseline planning approval conditions based on advice from our environmental advisors WSP. TransGrid indicates that the baseline planning approval conditions were based on an assessment of the reasonable requirements that are likely to be imposed, with the understanding that there were likely to be a limited number of areas where more onerous requirements are imposed. TransGrid have assessed that including a comprehensive set of baseline planning approval conditions that covered every possibility was unlikely to result in efficient pricing from the contractor, as the contractor would be pricing a worst case scenario across the whole project. TransGrid have estimated these costs based on the most likely outcome of a 10% reduction in productivity for 25% of the workforce. The base labour costs were sourced from the contractor's bid submissions and then adjusted to reflect the most likely reduction in productivity. GHD considers an allowance for unforeseen planning approval requirements prudent given the uncertainty.	8.1
COVID-19	The BAFO tender price assumes current baseline of COVID-19 restrictions and a continuation of international travel quarantine restrictions until 31 December 2021. The Supplemental Capex Forecasting Methodology indicates that TransGrid are responsible for the consequence of incremental Government action in Australia or in nominated locations for LSE manufacture. TransGrid expect some delay and have estimated the cost based on a most likely outcome of a 5 day delay to LSE supply chain. Given that the COVID-19 situation remains fluid, GHD considered it prudent to create an allowance for other project impacts not already provided for in the BAFO tender price.	8.0
Extreme weather	The Supplemental Capex Forecasting Methodology indicates extreme weather events, principally 1-in-100 year flood events will significantly	10.7

Other construction costs	Description	($ million)
	affect the works. Due to the extreme length/size of the project, the probability of an event occurring across the project is increased. TransGrid have included in our cost an estimate of the most likely impact on the project of a delay for one of our 9 separable portions by 6 weeks (for example an extreme flood, which in many of the regions EnergyConnect passes through would render roads inaccessible for an extended period of time). This has been calculated from the daily delay rate (provided by contractor), multiplied by 42 days (6 weeks), then multiplied by 9/100 (as there is a 1-in-100 year probability for each separable portion, and 9 separable portions). GHD considers an allowance for extreme weather events prudent.	
Total		**58.2**

5.8 The final PACR solution

Table 27 summarises the incremental cost impact on what would have been the Final PACR Solution based on GHD comparative estimates for the Initial PACR Solution. This comparison considers the difference in scope and used Phase A pricing to determine the cost impact.

Given lower overall Phase B pricing compared to Phase A pricing the cost increases should be marginally lower in theory however GHD's comparative estimates will still provide a reasonable estimate of the costs for this common additional scope of work.

The key points of difference since the Phase A RFT are:

- The change in design of the 220 kV Buronga - Red Cliffs line from Double Circuit Twin Lemon on steel monopoles (strung one side) to Double Circuit Twin Paw Paw on steel monopoles to meet required transfer capacity, and construction within existing easements
- Buronga substation configuration changed from 3 * 400 MVA PSTs to 5 * 200 MVA PSTs, and 2 * 400 MVA power transformers - changed to 3 * 200 MVA power transformers

Table 27 Variances for the final PACR solution

Component impacted	TransGrid description of incremental changes that also impact the final PACR solution	Incremental impact to GHD comparative estimates used for tendered costs review
Transmission line construction	Change in tower configuration of SA border - Buronga line	Decrease of $3.3 million
	Change of design for the 220 kV Buronga - Red Cliffs transmission line	Increase of $5.3 million
Substation works	Changes in configuration of Phase Shift Transformers and power transformers at Buronga Substation	Increase of $19.4 million

Component impacted	TransGrid description of incremental changes that also impact the final PACR solution	Incremental impact to GHD comparative estimates used for tendered costs review
Total Net Impact		**Increase of $21.4 million**

5.9 Southern alternative route option

Table 28 summarises the incremental impact of the Southern Alternative Route scope as assessed by TransGrid and the changes in comparison to the Final PACR Solution using comparative estimates generated by GHD.

As assessed by TransGrid, this variance analysis focused on the incremental changes in costs associated with:

- Property acquisition costs for the proposed route between Buronga and Wagga 330 substations
- Changes in the construction for transmission lines between Buronga - Dinawan, and Dinawan - Wagga 330 compared with the previous route from Buronga to Wagga 330 substation via the existing Darlington Point Substation
- Changes in costs associated with the new Dinawan Substation (compared with the previous existing Darlington Point substation works) and the existing Wagga 330 substation

We adopted the forecast savings in property acquisition costs for our comparison.

During the BAFO phase, the need for an additional 20km of 330kV line between Dinawan and Wagga 330kV was identified by TransGrid. This additional cost of $32 million would increase the difference to 2.7%. GHD considers similar alignment requirements would have been likely around the Darlington Point substation for the Final PACR Solution, hence this has not been considered in the view of cost neutrality between the two routes.

Table 28 Variances for southern alternative route

Component impacted	TransGrid description of incremental impact of southern alternative route	GHD incremental impact compared to final PACR solution comparative estimates
Property acquisition costs (easement / substation site)	The length of easements to be acquired is 9 km less for the Southern Alternative Route, and the land may on average be lower value as there is less intensively farmed land impacted. This saving may be offset by higher environmental offset costs due to greenfield Southern Alternative Route.	Saving of $5 million
Transmission line construction	With potential different route configurations available, TransGrid has assumed the Southern Alternative Route is 9 km shorter than the Final PACR Solution. This saving is projected to offset by an increase in costs due to the change in	Increase of $7.4 million

Component impacted	TransGrid description of incremental impact of southern alternative route	GHD incremental impact compared to final PACR solution comparative estimates
	construction for the Dinawan - Wagga 330 line from Single Circuit to Double Circuit.	
Substation works	Changes in augmentation works at new Dinawan (compared to existing Darlington Point) Substation and Wagga 330 Substation	Increase of $17.4 million
Total Net Impact		**Increase of $19.8 million**

5.10 BAFO outcome findings

Table 29 summarises the findings, qualifications and verification of the review of the GHD comparative estimates for the work packages against the adjusted BAFO costs, and the incremental costs difference that would be applicable in comparing the Final PACR Solution to the Southern Alternative Route costs.

Table 29 Unit costs and capex forecast - findings, qualifications and verification

Findings	
1	The variance in the adjusted GHD comparative estimate ($1,628.6 million) to the BAFO outcome ($1,468.6 million) is 10% which is well within the ±20% range for assessing the procurement process to establish an efficient scope of work and costs for the project.
2	The Final PACR Solution is based on a revised scope of work from that used for the RFT Phase A Capex Forecast, and includes some changes in configuration of works at Buronga Substation - where more smaller PSTs and power transformers are used in the solution, and a reconfiguration of the 220 kV Buronga - Red Cliffs line.
3	Following the RFT Phase A, TransGrid assessed the incremental cost difference for the Southern Alternative Route based on changes in costs for the new Dinawan Substation (compared to the previous Darlington Point Substation augmentation), with increases in the works at the Wagga 330 substation, changes to the overall length of the transmission line between Buronga and Wagga 330, and changes to the line configuration between Dinawan and Wagga 330. TransGrid concluded that the two route options were cost neutral. GHD reviewed comparative estimates for the incremental changes to both routes and found a small increase of $19.8 million for the Southern Alternative Route compared with the Final PACR Solution. This small difference (approximate 1% of total project costs) confirmed TransGrid's finding of cost neutrality between the two routes. During the BAFO phase, the need for an additional 20km of 330kV line between Dinawan and Wagga 330kV was identified by TransGrid. This additional costs would increase the difference to 2.7%. GHD considers similar alignment requirements would have been likely around the Darlington Point substation, hence have not considered this changes the view of cost neutrality between the two routes.

Verification	
Review of the BAFO outcome	GHD has assessed the BAFO outcome and found that the cost variance to GHD's comparative estimate was 10% lower, supporting the outcome has achieve efficient scope and costs for the project.
Review of other construction costs	The other construction costs allowances made by TransGrid represents 4.0% of the BAFO outcome. The commissioning and safety assurance program are specific costs while the other components can be considered allowances for risk, amounting to 2.8% all of which GHD considers reasonable for a linear infrastructure project.
Review of incremental cost difference between the Southern Alternative Route to the Final PACR Solution	GHD's incremental step change analysis indicates an increase of $19.8 M, higher for the Southern Alternative Route. The variance is approximately 1% of the total projected capital cost and therefore not material against the overall cost of the project and the two options can be considered cost neutral.

6. Property and easement acquisition costs

TransGrid commissioned JLL to provide a desktop assessment of estimated compensation payable for the acquisition of easements for PEC.

In assessing this area GHD considered the following JLL reports:

- JLL Desktop Assessment of Compensation 29 November 2019
- JLL PEC Land Acquisition Costs 15 November 2019
- JLL PEC Land Acquisition Costs 1 December 2019
- JLL Report Land Acquisition Costs Revised 25 August 2020

JLL's 2019 assessments were:

- A desktop assessment of compensation only, with no physical inspections of the affected properties or comparable sales. Also, there has not been any discussions with affected land holders in relation to the assessment
- Based on route alignment from SA Boarder to Buronga, Buronga to Red Cliffs and Buronga to Wagga 330, and in accordance with the Land Acquisition (Just Terms Compensation) Act 1991 (NSW) (LAJTC)
- Based on the proposed acquisition of a new 50-80 meter wide easement to accommodate the transmission line and towers

Section 6 of the JLL's report, titled "Desktop Assessment of Compensation" sets out the basis of the valuation. This explains that in accordance with the LAJTC, the matters were considered in assessing compensation include:

- The market value of the land and the date of its acquisition
- Any special value of the land to the person on the date of its acquisition
- Any loss attributable to severance
- Any loss attributable to disturbance
- The disadvantage resulting from relocation
- Any increase or decrease in the value of any other land of the person at the date of acquisition which adjoins or is severed from the acquired land by reason of the carrying out of, or the proposal to carry out, the public purpose for which the land was acquired.

This represented the Initial PACR Solution estimate which involved using the existing substation at Darlington Point to locate reactive control equipment. This estimate has been updated by TransGrid, based upon the latest advice from JLL, to reflect the Southern Alternative Route, which involves constructing a new switching station at Dinawan, thereby bypassing Darlington Point.

TransGrid adjusted the capex forecast to account for the alternative route via Dinawan by reducing it (proportionally) where relevant to reflect the 9km reduction in route length (from 711 km to 702 km) and the reduction in the estimated landholders impacted by the revised route (from 220 to 200).

The JLL Report Land Acquisition Costs Revised 25 August 2020, indicates that their forecast has been changed to reflect a total easement length of 691.9 km, noting that the SSD 14 September 2020 summarises Bidder 1's total easement length at 705 km and Bidder 2 at 691 km.

The new JLL forecast includes the additional costs for the proposed Buronga-Red-Cliffs alignment.

Table 30 Direct land and environment cost estimates

Capex category	Capex sub-category (i.e. line item)	Total capex ($ million 2017/18)
Easement costs	Easement acquisition cost	59.8
	Commercial negotiating costs	29.9
	Unforeseen and unanticipated property costs	3.4
	Access easement	2.0
	Options fee	3.9
	Professional fees compensation to landholders	4.9
	Property and easement surveys	1.0
Land costs	Additional land to extend Buronga substation	0.3
	Land for Dinawan substation	2.9

Capex category	Capex sub-category (i.e. line item)	Total capex ($ million 2017/18)
Construction related costs	Construction licence cost	3.9
	Laydown/staging area cost	0.9
	Damage/disturbance claims post construction	6.0
Fees	Aboriginal cultural heritage fees	1.5
	NSW government land registration fees	0.6
	Stamp duty	0.3
	Valuer Generals Fees	0.2
Total		**121.5**

GHD has not undertaken or qualified to undertake a detailed analysis from a land valuation perspective of the easement/land acquisition estimate prepared by the registered land valuers JLL.

GHD did assist Pacific Power (predecessor to TransGrid) in the acquisition of the current Darlington Point to Buronga 220 kV transmission line easement and have recently been involved in the acquisition of easements for other linear projects in the Riverina and South Western NSW.

Based on this experience and experience in undertaking numerous other linear infrastructure easement acquisition projects in NSW on behalf of State and Company owned clients, we have prepared the following review.

1) **Risks**

a) **Aboriginal land rights claims**

As TransGrid may be aware, this route traverses several Crown land Travelling Stock Reserves (TSR's) which are likely to be subject to land claims under the terms of the *Aboriginal Land Rights Act 1983 (NSW)* (ALR Act)

A search of these land parcels is required to determine if they are subject to ALR Act claims.

As TransGrid would be aware the NSW Aboriginal Land Council (NSWALC) have claimed a substantial number of TSR's in NSW (on behalf of the area Local Aboriginal Land Council (LALC)) which remain undetermined by the Minister for Lands.

In recent negotiations to acquire an easement for a State owned Network Operator under the terms of the *Land Acquisition (Just Terms Compensation) Act (NSW).*(LAJTC Act), the NSWALC have stated their legal position is, that land subject to an ALC claim cannot be acquired under the LAJTC Act, claims must be determined by the Minister for Lands prior to the issue of a Proposed Acquisition Notice (PAN) under the LAJTC Act, and in the event the land is granted to the claimant LALC in accordance with section 36 of the ALR Act, the NSWALC may insist the land transferred be in the same condition as at the date of registration of the claim. I.e. the transmission line removed.

We understand that based on current legal advice in regard to the above, the Minister for Energy, in respect of easement acquisitions over Crown land subject to ALR Act claims by a State owned Network Operator, will not give consent to the issue PAN's until the claims are determined. In the event the land is granted to the respective LALC, section 42B of the ALR ACT precludes the easements being compulsorily acquired, which means easement negotiations would have no bounds.

We understand NSWALC are taking the above position in their endeavors to force the NSW Government to make determinations on the backlog of ALR claims.

b) Native title

A search of all Crown Land parcels traversed by the transmission line alignment for Native Title claims under the terms of the *Native Title Act 1993 (Cth)* (NT Act) would be required. In respect of the Barkandji NNTT determination[41] which includes the Buronga / Wentworth area, native title searches may reveal the granting of "Non Exclusive" title on some Crown land parcels. In the event of such cases and in addressing Native Title generally, we understand that considering the project is for a "public purpose", Native Title can be dealt with the issue of NT Act section od 24 KA non-extinguishment notices or section 24 MD notices under the terms of the LAJTC Act.

2) West Coleambally to Wagga 330 route option

In regard to adopting a route option to avoid Darlington Point we have included this option in the summary table below which can be expanded when more detail is available.

3) Summary table & comments

Table 31 is a brief summary table and particular comments regarding the proposed easement acquisition for the Initial PACR solution

Table 31 Proposed easement acquisition review for the initial PACR solution

Route section	Distance km used in JLL estimate (Approx.)	Distance km used in SSD 29 June 2020	Landownership	Comments
SA /NSW Border to Buronga	135	135	It is estimated 90% is Crown land held by Western Land Lease Lessees with 10% freehold properties.	Western Land Lease lessees are being encouraged by Crown Lands to convert to freehold and it is understood quite a few lessees are in the process of freeholding their properties. This should make acquisition easier providing the conversion to freehold is timely and does not delay negotiations.
Buronga to Red Cliffs	24	24	In NSW predominately Crown land held by Western Land Lease Lessees. The VIC	Western Land Lease lessees are being encouraged by Crown Lands to convert to freehold and it is understood freeholding their properties. This should make acquisition easier providing the conversion

[41] http://www.nntt.gov.au/searchRegApps/NativeTitleClaims/Pages/Determination_details.aspx?NNTT_Fileno=NCD2017/001

Route section	Distance km used in JLL estimate (Approx.)	Distance km used in SSD 29 June 2020	Landownership	Comments
			section within National Park	to freehold is timely and does not delay negotiations.
Buronga to Darlington Point	398	383	Between Buronga and Balranald it is estimated 95% of land is Crown land held by Western Land Lease Lessees with some freehold properties. Between Balranald to Darlington Point it is estimated 90% of the properties are freehold with some Crown land.	1. At Balranald the alignment traverses the Yanga National Park for a 20 km section of the route. The existing 220 kV line easement was acquired prior to the sale of "Yanga" Station to NPWS in 2007 and gazettal of it as a National Park. As in Victoria, the NSW NPWS will not grant easements and TransGrid will likely have to rely on a licence for the tenure of the transmission line. 2. As TransGrid are likely aware, this route traverses several Crown land Travelling Stock Reserves (TSR's) which are likely to be subject to land claims under the terms of the *Aboriginal Land Rights Act (NSW) (ALR Act)* A search of these land parcels is required to determine if they are in fact subject to ALR Act claims.
Darlington Point to Wagga 330	154	160	It is estimated 95% of the properties are freehold with some Crown land.	The same comment as 2) above applies in the event there are TSR's traversed by this alignment.
Total	**711**	**702**		

Table 32 Property and easement acquisition and costs – findings, qualifications and verification

Verification	
Property and easement acquisition and costs	Based on the experience of previous acquisitions, the brownfield sections of the route, where the alignment parallels the existing 220 kV line, the accumulative effect on property value of the additional 330 kV line and easement would need to be considered in assessing the easement compensation. The "Total Forecast

Verification	
	Cost" sum we understand would cover any increase in compensation in this regard.

7. Biodiversity 'offset' costs

In assessing the biodiversity offset costs, GHD considered the following documentation:

- JLL Desktop Assessment of Compensation 29 November 2019
- JLL PEC Land Acquisition Costs 15 November 2019
- JLL PEC Land Acquisition Costs 1 December 2019
- JLL Report Land Acquisition Costs Revised 25 August 2020
- WSP NSW State-listed Biodiversity Offset Liability Estimate – Project EnergyConnect: South Australian Border to Wagga Wagga 28 November 2019
- WSP Revised estimate of EnergyConnect Biodiversity Offset Liability and Update to Strategy – 27 August 2020
- WSP Revised estimate EnergyConnect Biodiversity Offset Liability and Update to Strategy – 9 September 2020

The initial environmental and biodiversity offset liability estimate for the Initial PACR Solution was based on:

- A desktop review of the potential offset requirements for PEC of biodiversity listed under the NSW Biodiversity Conservation Act 2016 (BC Act), undertaken by WSP
- An assumption that the PEC biodiversity offset liability can be determined using a limited clearing scenario.

As indicated by the WSP November 2019 memo, the assessment was a desk top estimate of the offset requirements for Project PEC for biodiversity listed under the NSW *Biodiversity Conservation Act 2016.* Credit liability estimates have been calculated in accordance with the Biodiversity Assessment Method (BAM) 2017 for the residual impacts to vegetation and potential habitat for threatened species.

The WSP memo also indicated that limited field assessments have been completed to date.

The estimate included in the CPA forecast adjusted this estimate based upon the Southern Alternative Route and a reduction in the 220kV easement width.

The WSP Revised estimate of EnergyConnect Biodiversity Offset Liability and Update to Strategy – 27 August 2020 updates the forecast included in the CPA. This details an increase in the forecast due to:

- Site investigation of the western section of PEC route revealed higher credit liability than the desktop analysis conducted for the June 2020 forecast
- An increase in land area under Biodiversity Stewardship Agreement (BSA) to offset the credit liability

In providing the range estimate, the Biodiversity Offsets Pricing Calculator (BOPC) was used as a method of estimating potential offsets costs and this approach is supported by GHD. The range estimates were based upon limited clearing and full clearing scenarios, with assumption set out in section 1 of the WSP memo.

GHD considered the assumptions detailed in section 8 and throughout the WSP memo and would like to highlight some key assumptions we support that can have a significant bearing on the outcome of the cost estimate:

- The use of 22-25 credits per ha as a suitable impact estimate for moderate/good vegetation in accordance with the BAM. WSP note this credit impact range has been determined based on field data collected throughout the western portion of the project. This approach improves the accuracy of the credit impact rates previously quoted in the WSP memo (May 2020).
- GHD also supports the credit impact range of 8-11 per ha associated with the 'maintenance areas' (as described in Section 1.2 and shown in Figure 1.1 of the WSP memo). GHD previously noted that it was unlikely the full 60m easement would require clearing. We also support the WSP position that the BAM does include provisions for adjusting Vegetation Integrity (VI) score when complete clearing is not proposed (i.e. VI score could be reduce without automatically defaulting to 0). This reduces the credit impact rate per ha accordingly.
- The use of 4 credits per ha as a suitable credit generation rate is in line with results we have obtained from GHD assessments using the BAM. GHD note there are proposed changes to the BAM which are due to commence in late September 2020 which support a higher credit generation rate at BSA's than the 3 quoted in the WSP memo (May 2020).
- There were considerable changes to the BOPC on 31 October 2019 and then further updates on 31 July 2020 as referenced by WSP. These changes have had the effect of listing considerably higher ecosystem credit prices in this region of NSW than was previously stated in this tool. It is important to note that the BOPC updates regularly as credit trades occur and these prices are only current on the date they were viewed (in this case 31 July 2020). Hence the cost of credits is going to be affected by the demand and the available supply of credits.
- GHD supports the assumptions at this stage for a per ha in perpetuity cost associated with stewardship site maintenance ($2,500 per ha). We are not able to comment on the average land value cost per ha listed in the WSP memo ($1,500 per ha) as part of this review.
- GHD concurs it is very difficult to provide an estimate for species credit offsets at this stage. The approach by WSP to include the BOPC value in credit value estimate models is reasonable at this stage.

WSP has included two general options for securing the necessary biodiversity offsets, these being:

1. Establishing Biodiversity Stewardship Site/s and generating biodiversity credits for the project.
2. Making a payment into the Biodiversity Conservation Fund (BCF) administered by the NSW Government through the Biodiversity Conservation Trust (BCT).

Both these options are supported by legislation in NSW as suitable options to provide biodiversity offsets for NSW listed threatened biota. In addition, The NSW and Commonwealth Governments have recently endorsed a Bilateral Agreement which endorses the BAM and NSW BOS as appropriate methodologies to assess the impacts the MNES and deliver biodiversity offsets. This effectively means projects no longer require 'duel consent' and that only one suite of biodiversity offsets is required. It is important to note the bilateral agreement endorses the 'like for like' trading rules and payment into the BCF as suitable option available under the NSW BOS for delivering offsets for MNES. The bilateral agreement does not endorse the use of the ‘variation to trading rules’ which is available under the NSW BOS. With the bilateral agreement in place, the use of the Biodiversity Offsets Pricing Calculator (BOPC) is a viable method of estimating potential offsets costs and this approach is supported by GHD.

Table 33 Summary of likely biodiversity offset liability for recommended BOS approach (for limited clearing scenario)

Project credit liability	Credit liability for limited clearing (Credits)	Offset option			Total ecosystem cost ($ million 2019-20)	Residual BCF payment (species)	Total cost ($ million nominal)
		BSA (Credits)	Additional BSA on preferred option	Payment into BCT (credits)			
Total Credit Liability	29,380	42,764	10,208	5,574			
Potential Offset Size (hectares)		12,000	9,632				
Land Value ($)		3,216,000	24,081,816		$27.3		$27.3
In perpetuity management ($)		28,274,000	25,499,262		$53.7		$53.7
Pay into BCT ($)		NA	NA	33,435,747	$36.0	$14.4	$47.8
Total cost of mixed option scenario ($M, 2019-20)					$69.37	$14.4	$128.9
Total cost ($M,2017-18)							**$127.4**

Source: WSP Revised estimate of EnergyConnect Biodiversity Offset Liability and Update to Strategy – 27 August 2020

Table 34 Biodiversity ‘offset’ costs – findings, qualifications and verification

Findings	
1	The estimates provided associated with the ‘Full clearing scenario’ and using the BOPC may be conservatively high due to 2 main reasons, these being: • It is unlikely the project will have native vegetation in moderate/good condition throughout the entire area of the proposed easement as assumed in the estimate. • The BOPC is currently referencing credit sales from other parts of NSW (including Western Sydney) where credit prices are considerably higher than in the South West and Riverina. The full clearing scenario is further considered in the allocation of risk which GHD has reviewed in section 9.
2	GHD’s recommendations moving forward would be similar to those from WSP. It will be important to gain an understanding of the actual biodiversity values of the easement once the preferred alignment is confirmed. The Biodiversity Offsets Liability Estimate should be updated each time additional information/more detail of the

Findings	
	project and site conditions come to hand. The level of accuracy of the estimate would improve accordingly after each update.

Qualifications	
1	GHD's assessment is limited to the documents listed above.

Verification	
Biodiversity 'offset' costs	GHD's considers that WSP has completed the analysis using a sound methodology and approach, especially at this stage of the project. GHD also notes the risk allowance detailed in section 9 based upon the probability that DPIE may adopt a full clearing scenario.

8. Corporate and network overheads

8.1 Forecast indirect capex

In assessing capitalised corporate and network overhead costs the following materials were considered:

- Corporate and Network Overhead Forecast for Project EnergyConnect August 2020
- Copy of A.8 - TransGrid - PEC - Corporate and Network Overheads Forecast - CONFIDENTIAL - NO LINKS.xlsx
- Corporate and Network Overhead Costs Draft 19 December 2019
- PEC_Indirect Costs_Workpapers_29Nov2019.xlsx

Under Chapter 6A of the NER, any proposed capital expenditure, including capitalised overheads must meet the capex objectives and criteria in clause 6A.6.7 (c) of the NER, having regard for the capex factors. This requires the proposed expenditure to be the expenditure that would be incurred in respect of a contingent project by an efficient and prudent operator in the particular circumstances of the TNSP and the project.

Table 35 Corporate and network overheads

Total estimation of corporate and network overheads	Reference	Amount ($ million)
Actual costs incurred January 2019 to 31 July 2020	-	27.8
Works delivery	Table 36	19.9
Project development	Table 37	39.4
Land and development costs	Table 38	19.6

Total estimation of corporate and network overheads	Reference	Amount ($ million)
Stakeholder and community engagement	Table 39	8.2
Insurance	Table 40	8.6
Procurement bidders payments	Table 41	12.3
Total		**135.8**

TransGrid's corporate and network capex represents 7% of the total CPA project costs.

Works delivery

Table 36 represents the costs associated with the Works Delivery team.

Table 36 Works delivery cost breakdown

Works delivery labour	Estimate ($ million)	Basis
Works delivery project management	1.6	Relates to 29 identified roles have been identified across the following three resources requirements: • Project management – 13 roles • Tech fitter – 4 roles • Site management & support – 13 roles As detailed in the TransGrid Project Delivery Resourcing document the resource profile has been based upon a detailed delivery schedule. Further the document details that the delivery schedule was based upon: • The identification of key product milestone dates and constraints • Individual substation schedules based on the base concept design general arrangements and single lines. • Individual line section schedules based on the base concept design line routes and quantities. • Development of an overall schedule linking the individual project elements. • Development of substation delivery time frames and resource requirements based on TransGrid reference projects and inputs from substation Subject Matter Experts (SME).
Site management	9.2	
Technical fitters	4.3	
Support	3.7	

Works delivery labour	Estimate ($ million)	Basis
		• Development of transmission line delivery time frames and resource requirements based on TransGrid reference and external project production inputs from transmission line SME's. • Identification of overarching project support resources structures to meet the project needs in contract management, reporting, HSE, cost management and scheduling. • A review and challenge process in assessing the highlighted resource needs with inputs from SME's that reflected on the size and complexity of the project. The resulting resource profile details 69 staff required for project management, site management, technical management and support. The resources are phased against the delivery schedule and costed at the Utilities prescribed resources cost rates. The costs estimates associated with the Major Projects Division have been proportioned between each of the major projects based on the anticipated total direct capital expenditure.
Works delivery - labour costs	**18.8**	
Sustenance	0.5	
Travel	0.1	
Training	0.1	
Recruitment	0.3	
IT Hardware	0.1	
Total	**19.9**	

Project development costs

These costs relate to set up and ongoing management of PEC by TransGrid. Approximately 50% relates to incremental labour, with 50 additional FTEs anticipated. Some of these employees will be working across four Major Projects and costs have been allocated accordingly.

Table 37   Project delivery

Category	Incremental cost estimate (S million)	Description	Commentary
Labour / People costs			
PEC project management team			
Project management team	18.5	25 FTEs - 100% attributable to PEC present over the duration of the project. Contains a project director at $500K and other team members at $250K which appears reasonable.	Rates based upon estimates and quotes from WSP, Calcutta Group, MBB, Beca and other TransGrid corporate functions that appear to be reasonable. Percentage allocation applied as detailed within the table.
Major projects team	3.6	5 FTEs at 46%	
Other support and corporate roles	6.6	19 other roles supporting PEC including engineering, regulatory, spatial, finance, HR, ongoing procurement at 46%	
Total	28.7		
Labour related costs			
Training	0.1	Training costs for incremental headcount in line with TransGrid standard allowances, not considered material.	
Recruitment	0.6	Recruitment costs in addition to business as usual costs relating to recruiting new Project Development resources, not considered material.	
Office Lease costs	1.3	New office to accommodate additional headcount, not considered material.	
Travel & Expenses	3.5	Project team members travel to site sites	
Labour related costs	5.5		
Non-labour related costs			
Geo Technical Studies	0.6	Field investigations, inspections, not considered material.	
Legal Costs	3.4	Legal advisors for contract setup and ongoing legal advisory for duration of the project, based on estimated annual rate supplied by Allens,	
Consultant costs	1.2	Forecasting support, benchmarking studies, not considered material.	
Total project development - non-labour	5.2		

Category	Incremental cost estimate (S million)	Description	Commentary
Total project development costs	**39.4**		

Land and environment overheads

The following Land & Environment Costs are currently included in the Incremental Corporate Cost estimate:

Table 38 Land and environment costs

Category	Incremental cost estimate ($ million)	Assessment
Labour – Land, Enviro and Communication Team	5.3	Based on 200-230 property easements or acquisitions.
Team Travel	0.4	Flights, accommodation and expenses.
EIS	7.8	Based upon tender results where WSP was identified as the preferred tenderer and were asked to provide an updated tender for environmental assessment services for the entire PEC (from South Australia/ New South Wales Border to Buronga).
Property Consulting Fees	4.5	Property consultants costs for Phase 1 (Border to Buronga) & Phase 2 (Buronga to Wagga 330) Not material
Training and recruitment	0.1	Costs associated with recruiting new positions and training of incremental headcount, not considered material.
Stamp Duty, Surveys, Legal and Misc. Fees	1.5	
Total	**19.6**	

Stakeholder and community engagement

Table 39 Stakeholder and community engagement

Category	Estimate ($ million)	Basis
Labour costs	2.9	The labour costs for Stakeholder and Community engagement have been estimated through a bottom up estimate of activities, which has identified three core roles being required specifically for PEC and one role to work across the Major Projects Division.

Category	Estimate ($ million)	Basis
		Rates based upon estimates that appear to be reasonable with regards market rates.
Community Engagement - External support	3.0	KJA contract based upon tender results.
Design / Communications costs	1.4	Considered appropriate but not material.
Travel	0.6	
Community improvement	0.3	
Total	**8.2**	

Insurance

Estimates have been provided through consultation with TransGrid legal, the PEC project development team and TransGrid's insurance partner [redacted]

Table 40 Insurance coverage cost estimates

Insurance coverage	Cost estimate ($ million)
Total	**8.6**

Procurement bidder's payments

The PEC Corporate and Network Overhead Costs DRAFT 19 December 2018 indicates that TransGrid undertook early market soundings to analyse market appetite and determine whether bid cost contributions would enhance tender efficiency and competitive tension in accordance with the Major Infrastructure Projects Practice Note[42].

It was determined that in order to encourage the competitive participation of multiple bidders, under bidder payments were necessary in order to guarantee the quality and quantity of bidders and submissions provided.

The Corporate and Network Overhead Forecast for Project EnergyConnect August 2020 indicates that the Phase A RFT and Phase B RFT payment amounts have been determined in line with NSW Government policy[43], supporting the reimbursement of up to 50% of the expected bid costs for projects exceeding $100 million. Given that PEC presents the first project of this nature and scope, TransGrid believes that the $6.5m tabled below, amounting to less than 25% the actual bid cost is a prudent and necessary spend.

[42] Major Infrastructure Projects Practice Note, Australian Constructors Association, 2019

[43] Bid Costs Contribution Policy, NSW Treasury, 2018

Table 41 Tender components cost estimates

Tender components	Cost estimate ($ million)
Bidder payment RFT A	0.5
Bidder payment RFT B	11.8
Total ($M, 2017-18)	**12.3**

8.2 GHD assessment of overhead costs

The first part of the assessment reviewed the build of the costs based on head count and hours required over the project duration, including costs already incurred in the early project development phase. This is a bottom up approach to estimating the project development and works delivery labour costs.

A second question relates to whether the overall costs for these owner costs are prudent and efficient.

GHD has used guiding metrics to arrive at an independent estimate of reasonable owner costs and used comparably major civil and electrical industry projects as a guide. This comparison needs to take into consideration of the scale of the PEC project, the allocation and management of risks, and the components TransGrid includes in their corporate and network overheads estimate, as distinct from other comparative estimates, and distinct from the actual capex allocation provided through the AER through Regulated Information Notices (RIN) reporting process.

Generally speaking, the larger the project, the smaller the project development and management owner costs will be as a percentage of the total. Hence larger projects can spread fixed overhead costs and the percentage will be lower.

The outsourcing model will also affect the level of resources required at the interface point with contracted development and construction services. The procurement of contracted services for the PEC project is based on an EPC model and covers around 67% of the total project costs. Other project elements required to be directly managed by TransGrid include property and easement acquisition, biodiversity offset costs, and managing costs contained in the allowed risks – around 33% of the total project costs.

Generally various reports on infrastructure projects, including transmission projects indicate project management costs in total for all phases of a project with project controls managed by the owner, generally this is somewhere in the range of 9-15 per cent of total project costs.

Ernst & Young Transport in 2011 prepared a report for the NSW Department of Transport titled "Infrastructure – Project Cost Benchmarking Study". The study collected data from eight road and rail authorities across Australia for projects above $0.50 Billion in total cost – ranging up to $1 Billion.

Overall this report found the average owner costs (excluding design costs) for road projects as a percentage of total construction costs was 11%. Including detailed design work the average percentage increased to 14%.

There were 14 road projects selected for analysis with owner costs (without design) varying from 7% to 16%. Removing the two outliers the range was from 8% to 14%. The average owner costs (excluding design costs) for rail projects was 16%. Including detailed design the average percentage increased to 21%. There were 14 rail projects selected for analysis with owner costs (without design) varying from 8% to 30%. Removing the two outliers the range was from 9% to 20%. This illustrates a relatively flat distribution between these ranges for both road and rail projects.

A guideline of direct relevance to transmission projects is the MISO[44] published "MTEP19 Transmission Cost Estimation Guide", last updated in December 2019. The MISO transmission planning process and role is similar to AEMO in Australia.

This guide is prepared to support MISO planning staff in developing cost estimates and deriving benefit-to-cost ratios for solutions proposed for the expansion of the MISO transmission network. In this respect this process is similar to the RIT-T process under the Australian NER.

MISO's transmission cost estimation guide describes the approach and cost data that MISO uses in developing its cost estimates. This document assumptions and cost data are reviewed annually with stakeholders.

In section 3.4 of this guide, project overheads applied to cover costs for developing and delivering a potential project are aggregated into three categories with the percentage of total project costs applied:

- Project management (including mobilisation and demobilisation) - 5.5%
- Engineering, environmental studies, testing and commissioning – 3.0%
- Administrative and General Overhead – 1.5%

The costs for the transmission and substations projects therefore includes a total margin of 10% for overheads. This is a margin on the total project estimate rather than a cost mark-up of the individual transmission and substation costs.

The costs for routing analysis, public outreach, the regulatory approval and permitting processes, property tracts and mapping, land owner negotiations, land acquisition and condemnation fees appears under direct "Land Costs". In comparison with TransGrid's corporate and network overheads, the MISO guide also does not appear to cover the planning and regulatory approvals which is part of MISO's own management costs and likely to be recovered by other mechanisms.

GHD's own experience and data relating to major transmission line projects also indicates project overhead costs align with the range found with the road projects which is also consistent with the MISO estimated project overheads. The key difference for the PEC project is the scale of this project compared to the average size of projects considered in these documents.

TransGrid reports annually on its actual overheads allocated with capex to AER through RINs. The reported data shows that following FY14 the level of allocated costs increased to percentage margins like those in the comparative reports[45]. The total capex program for TransGrid include a range capital works with differing complexity, scale and type (replacement, growth, brownfield, greenfield).

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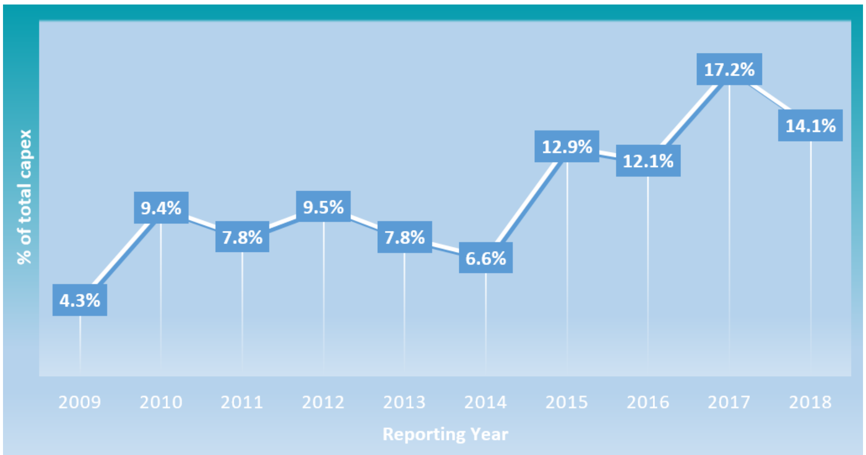
[44] The Midcontinent Independent System Operator (MISO) is an Independent System Operator providing open-access transmission service and monitoring the high-voltage transmission system in the Midwest United States and Manitoba, Canada and southern United States which includes much of Arkansas, Mississippi, and Louisiana.

[45] GHD is not aware of the reason for the apparent increase in FY15

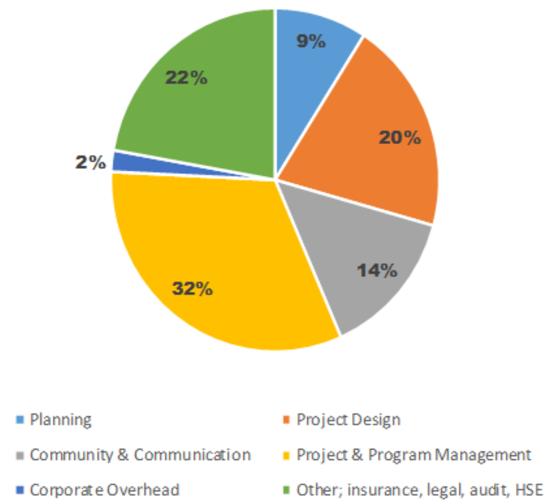
Figure 6 TransGrid Capex overheads - reported margin [46]



GHD considers that the range of road projects is a reasonable match to the PEC project except that the scale of the project size will be above the upper end of that covered in the Ernst & Young report.

Figure 7 shows the breakdown of costs over the category of expenditure from the projects analysed. Using this category breakdown and considering which categories partly or fully apply to the PEC project an estimate of reasonable project overheads can be made.

Figure 7 - Project overhead cost breakdown



These comparative estimate categories could be compared to TransGrid's categories using comments included below in Table 42.

[46] https://www.aer.gov.au/system/files/TNSP%202018%20Data%20report%20-%2024%20July%202019%20-%20FINAL%20for%20publication.xlsm

Table 42 TransGrid PEC project overheads comparative scope

Scope	Project overheads (Roads)	Applicable to the PEC Project	Apply to PEC	Comments
Planning	1.26%	100%	1.26%	A similar degree of planning would be required
Community & Communication	1.96%	75%	1.47%	A similar degree of community and communication costs would apply to this greenfield transmission project
Corporate Overhead	0.28%	100%	0.28%	A similar degree of planning would be required
Project Design	2.80%	10%	0.28%	90% of project design assumed to be contracted to service providers. Concept designs costs by TransGrid now contained within historical costs
Project & Program Management	4.90%	100%	4.90%	This project is full EPC with the Principal Contractor responsibilities with the contractor
Other Costs	2.80%	100%	2.80%	Considered split 40% work delivery, 40% development and 20% other indirect
Total project overheads	**14.00%**		**10.99%**	11% of total project costs

As indicated above, total project overheads in Table 43 needs to be adjusted for the scale of the project. Scaling is a combination of different exponential factors applied to estimated fixed and variable components of a typical size project (the assumption being a 11% margin is applicable to a project valued at $250 million). Table 43 provides comparative adjustments for larger and for smaller project sizes.

Table 43 Scale factors – project overhead margin

Project size ($ million)	Composite scale factor	Applicable % project overhead
2,000	0.53	5.9
1,500	0.58	6.4
500	0.81	8.9
250	1.00	11.0
100	1.33	14.6
50	1.66	18.2
25	2.57	28.2

GHD is of the view that the 5% margin included by TransGrid in the CPA is within an acceptable range of project margins for projects of this equivalent size and complexity.

9. Risk allowances

As detailed in the Supplementary Capex Forecasting Methodology - BAFO, TransGrid has created allowances for risks that:

- Exceed the materiality threshold of 0.5 per cent of the total forecast capex
- Are not BAU risks
- Are not within TransGrid's control
- Cannot be covered by contract terms or insurance
- Are not covered by pass-through provisions in the NER.

Based upon TransGrids' assessment, they detail that only Biodiversity offset one risks meet these criteria.

As indicated in section 7, a base case estimate was provided by WSP calculated on a limited clearing scenario. The limited clearing approach must however be approved (via a formal decision) by DPIE, and hence this carries significant risk as follows.

WSP has estimated the maximum biodiversity offset costs under the full clearing scenario would to be $257.8.2 million in Real $2019 with a 20 per cent to 40 per cent probability of occurring.

WSP have advised that:

- **Limited clearing scenario** (70 per cent likelihood) – DPIE will accept partial clearing along the transmission line route associated with 'maintenance areas'.
- **Full clearing scenario** (30 likelihood) – DPIE will reject limited clearing and require TransGrid us to offset the effects of complete vegetation clearing for the entire easement width and maintain into perpetuity

As detailed in the Supplemental Capex Forecasting Methodology, the environmental offset costs can range from the limited clearing cost of $128.9 million to the full clearing cost of $527.19 million. This yields a difference in cost of $128.9 million.

Table 44 Biodiversity offset risk estimate

Biodiversity estimate	Forecast ($m 2019/20)	Basis
Limited clearing scenario (used in base capex)	$128.9	Assumes that something less than full clearing is required to install the PEC assets, based on various project level assumptions. Agrees to forecast in section 7.
Full clearing scenario	$257.8	Assumes complete vegetation clearing in the entire nominated easement widths. Based upon a full clearing option

Biodiversity estimate	Forecast ($m 2019/20)	Basis
		Mixed delivery of offsets – secure large Biodiversity Stewardship Site (BSA) with the credit shortfall being secured via a payment to the Biodiversity Conservation Fund (BCF) The established BSA was estimated to generate a significant portion of the estimated credit requirement of approx. 62,788 ecosystem credits This would leave approx. 18,418 ecosystem credits to be offset via the BCF. The NSW Biodiversity Offsets Payment Calculator (BOPC) was used to estimate the costs of securing these credits. With the BOPC run on 31/7/2020 (as referenced in the WSP memo August 2020). Agrees with $257.8 million detailed in WSP memo (August 2020).
Difference	*$128.9*	Calculated as the difference between the limited and full clearing scenario offset values
(x) Likelihood	x 30%	WSP estimates that there is a 60% – 80% probability that the discounted approach would apply to determining the offset liability, which leaves a 20% – 40% chance that the full clearing scenario will apply[47]. Used 30% used as a mid-point of that range.
Risk cost ($,2018-19)	$38.7	Calculated by multiplying the difference between the limited and full clearing scenario offset values by 30%
Risk cost ($,2017-18)	$38.2	

As described in section 7, the range estimate using the Biodiversity Offsets Pricing Calculator (BOPC) was based on assumptions set out in section 1 of the WSP memo. GHD considers these assumptions will have significant bearing on the outcome of the final costs.

We consider the combined impact and generation rates for credits have been refined in the WSP memo (August 2020) when compared to the WSP memo (May 2020)

- The use of 22-2530 credits per ha as a suitable impact estimate for moderate/good vegetation in accordance with the BAM.
- The credit impact range of 8-11 per ha associated with the 'maintenance areas' (as described in Section 1.2 and shown in Figure 1.1 of the WSP memo).
- The increase in credit generation rate from 3 to 4 credits per hectare.
- The updated BOPC values (run by WSP on 31 July 2020). As previously noted, the BOPC is updated regularly as credit trades occur and these prices are only current on the date they were viewed.

GHD considers that while the actual final Biodiversity costs is very difficult to assess within the possible limits, it is our view that the risk allocation has been refined since the WSP memo (May 2020) and figures quoted in the WSP memo (August 2020) more accurately describe the potential biodiversity offsets liability at this point in time.

10. Real input cost escalation

As indicated by the Capex Forecasting Methodology for PEC 29 June 2020, labour costs make up a large component of our forecast capital expenditure for PEC – and those costs tend to increase over time by more than inflation. To recognise that, TransGrid have included the forecast impact of these costs, which are commonly referred to as real input cost escalation.

Forecast real input cost escalation have been calculated by multiplying the labour cost components of the tendered expenditure, property costs, and indirect expenditure by the forecast real labour cost escalators allowed by the AER in its 2018-23 Revenue Determination.[48] Consistent with that determination, no real input cost escalation was included for non-labour components of the expenditure.

The real labour input cost escalators for 2018-19 to 2022-23 are set out in Table 52 These are converted into a cumulative index from the 2017-18 year.

Table 45 Real labour input cost escalator and cumulative index

	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Real labour input cost escalator	N/A	0.81%	0.95%	1.21%	1.46%	1.46%
Cumulative index	1.00	1.01	1.02	1.03	1.05	1.06

The approach is applied in our PEC Capex Model, which is included as an attachment to this Application.

Applying this approach gives forecast real input cost escalation of $15.5 million over the 2018-23 regulatory period, as set out in Table 46.

Table 46 Forecast real input cost escalation ($M, 2017-18)

	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Real input cost escalation	>0	0.1	2.7	6.0	6.6	15.5

48 See, Australian Energy Regulator, May 2018, *AER - Final decision TransGrid transmission determination - Capex model - May 2018*. The labour escalators adopted by the AER are at cells H23:H27 of the 'Input_Fixed' sheet.

The Supplementary Capex Forecasting Methodology - BAFO indicates that the forecast capex for real input cost escalation has been recalculated based on tenderer responses that indicate that some labour cost escalation is now being captured within the tender pricing. TransGrid has updated their forecast to $3.2M.

11. Variance to RIT-T PACR forecast

11.1 RIT-T and variances to the PEC capex forecast

The Capex Forecasting Methodology 29 June 2020[49] explained the key drivers of the initial PACR cost estimate of $1.15 billion and the RFT Phase A Capex Forecast of $2.27 billion. These are illustrated in the waterfall **Error! Reference source not found.** below.

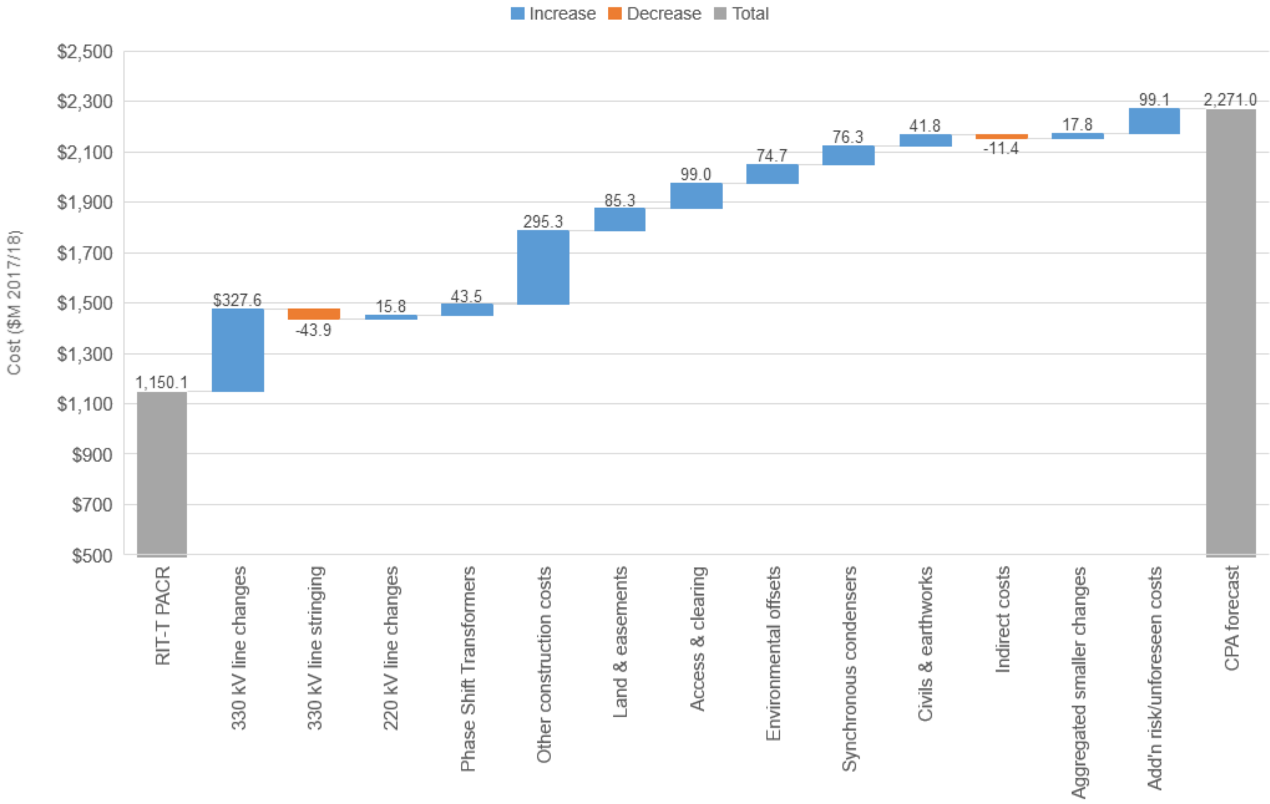
GHD considers the key differences driving the changes since the RFT Phase A Capex Forecast and the adjusted BAFO costs are:

- The EPC contractor has incorporated changes to the transmission line designs and substation layouts which have contributed to cost savings
- Some of the costs ($295.3 million) considered under “Other construction costs” have been transferred and accepted by the EPC contractor and included within the BAFO outcome.
- The competitive procurement process and the refinement of scope and risks has overall reduced costs

The high level specification changes since the RIT-T PACR broadly remain the same.

[49] Initial CAPEX Forecast Methodology, Table 3.1 section 3.1

Figure 8 Key changes between RIT-T PACR capex forecast and the RFT phase A capex forecast ($'000, 2017/18)

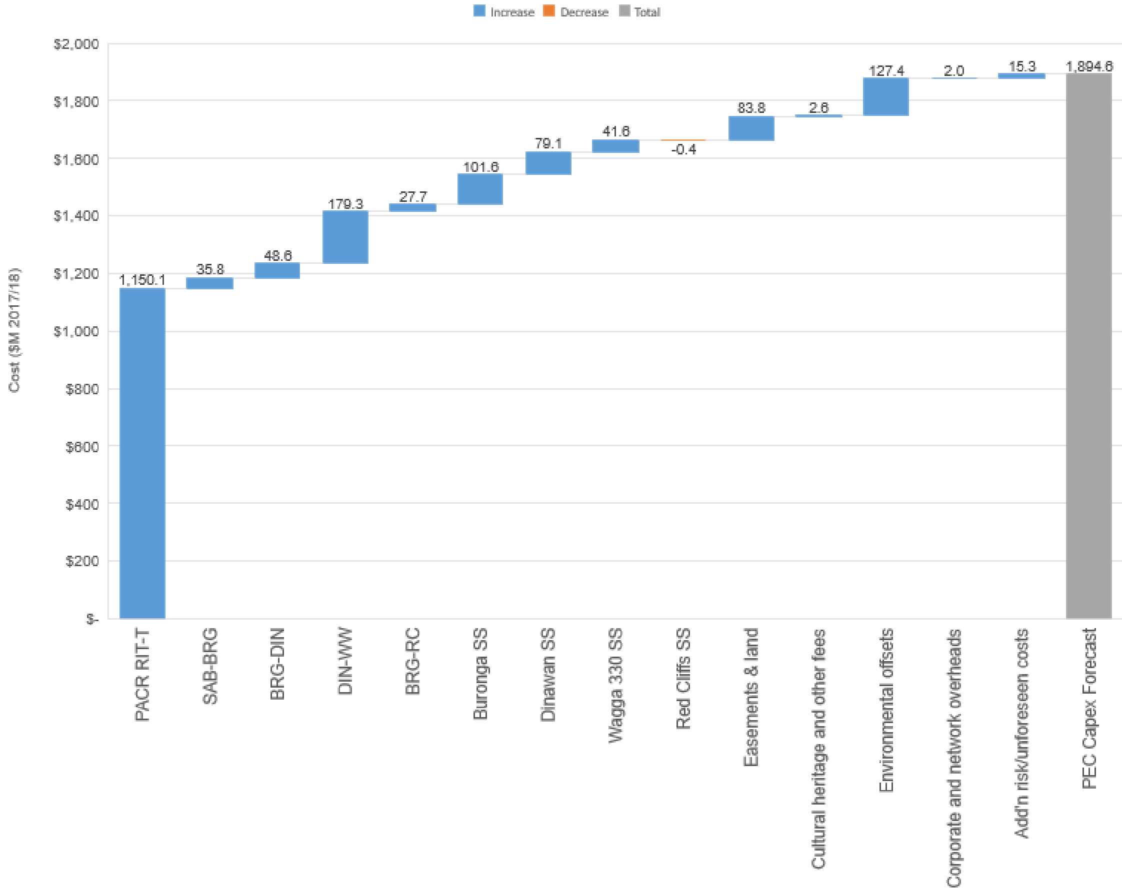


Source: TransGrid initial CPA capex forecast

The Capex Forecast Methodology 29 June 2020 detailed the key changes since the RFT Phase A through to the RFT Phase B outcome - Table 3.2 (section 3.2) and furthermore the respective capex forecasts in Table 3.3. GHD provided a likely mid-point ($1,884.9 million) for the expected final forecast within a range as presented in the Capex Forecast Methodology of $1,866.0 million to $1,903.8 million ($Real, 2017-18).

Figure 9 below shows how GHD has assessed the variances by scope element between the original RIT-T PACR forecast ($1,150.1 million) and the BAFO Capex Forecast ($1,894.6 million). The changes in some elements reflect the different line lengths either side of Darlington Point (the initial PACR Solution) versus either side of Dinawan for the Southern Alternative Route. The individual cost elements reflect the use of the adjusted BAFO costs presented in section 5 of this report.

Figure 9 Key changes - RIT-T PACR to the final PEC capex forecast ($'000, 2017/18)



Source: GHD's analysis of the Phase B and BAFO pricing

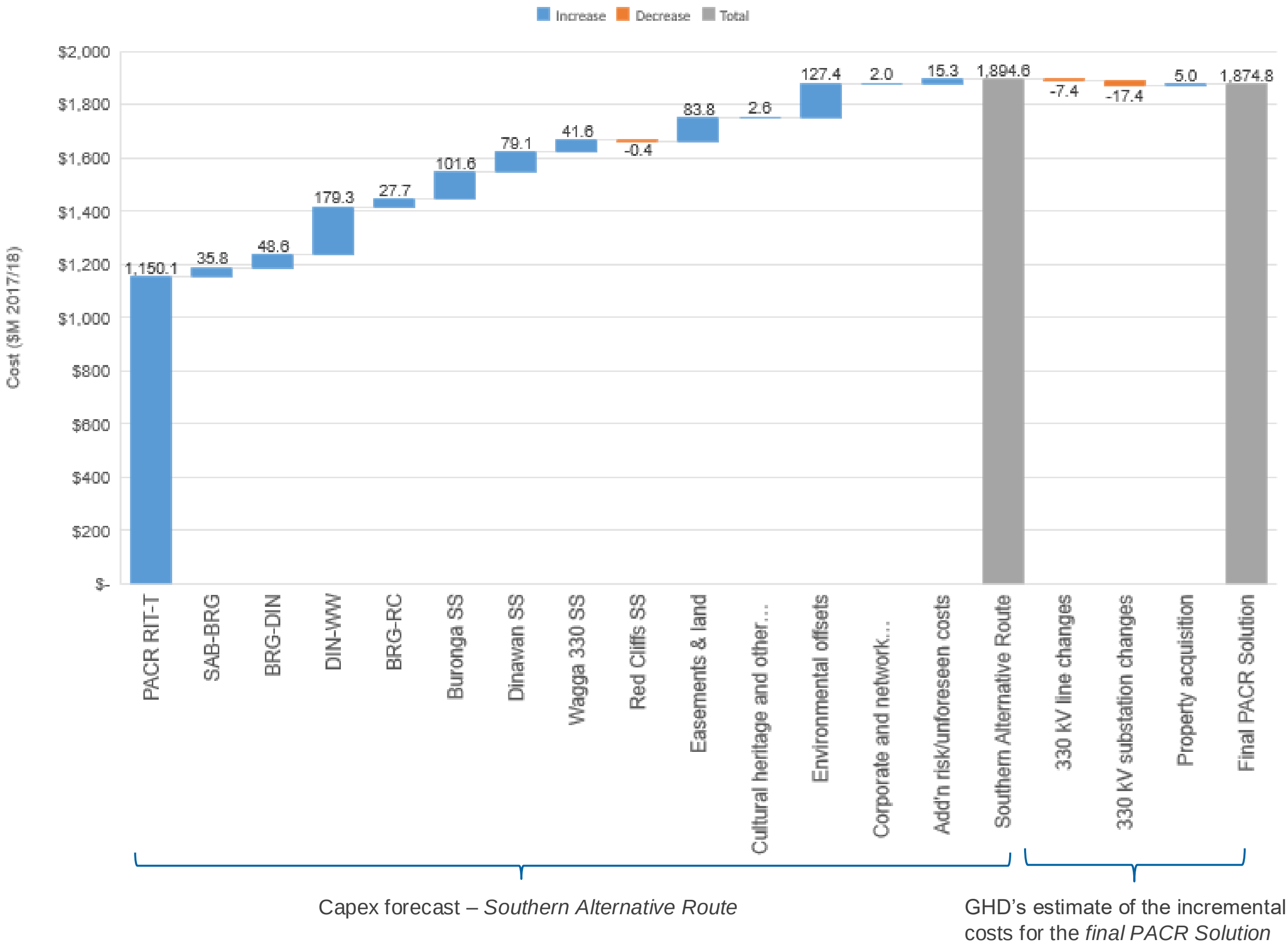
11.2 RIT-T and the alternative route capex forecasts

GHD found via review of the Phase A (the initial PACR Solution scope) and then the Phase B documentation (Southern Alternative Route scope) and via discussions with TransGrid that there has been necessary scope changes that would apply to the final PACR Solution had that project scope had proceeded. These findings were required in order for us to confirm TransGrid's own finding that the Southern Alternative Route was cost neutral with the PACR Solution.

Error! Reference source not found. shows the changes between the RIT-T PACR and the final Capex F orecast representing the capex for the Southern Alternative Route and then GHD has added estimates of the incremental cost difference between the final PACR Solution and the Southern Alternative Route. The estimates are based on our comparative estimates that were previously determined for the final PACR Solution and for the Southern Alternative Route and incorporates common scope changes applicable to both routes. GHD discussed these scope changes in section 5.8 and 5.9.

This provides some indication of the comparable costs between the two route options had the bidding process continued into a Phase for the final PACR Solution. It must be noted that it is an indication only of cost difference based on our comparative estimates and that many site related matters for both route options particularly around the Darlington Point and Dinawan substations respectively, could change the indicated costs difference.

Figure 10 Incremental cost differences – Southern Alternative Route to the final PACR Solution ($'000, 2017/18)



Sources: GHD's analysis of tender pricing and GHD's comparative estimates

With the adjusted costs made for scope changes in the final PACR Solution, the approximate $20 million difference in costs is still very small compared to the overall capex forecast for the project (around 1%). GHD can verify TransGrid's finding that the Southern Alternative Route can be considered cost neutral with a final PACR Solution had it proceeded.

12. Project schedule phasing

12.1 Project phasing and capex recognition

The EnergyConnect project has the following key delivery milestones to align with the requirements of the transmission network[50]:

- First Power to South Australia - 31 December 2022
- Practical Completion - 31 December 2023
- Energisation - 31 March 2024
- Final Completion - 30 June 2024

Key delivery milestones to achieve the practical completion date are outlined in the following table[51]:

Table 47 Key project milestones

Date	Milestone
30 September 2020	Execution of Commitment Deed
1 October 2020	Commence Detailed Design Place orders for Long Lead Items Commence other Early Works not requiring Planning Approval
3 November 2020	Public Exhibition of EIS-1 (Western)
15 December 2020	Target FID & Execution of EPC Deed
May 2021	Public Exhibition of EIS-2
June 2021	State & Federal Environmental Planning Approval of EIS-1
November 2021	State & Federal Environmental Planning Approval of EIS-2
1 September 2021	EIS-1 Site Possession Transferred to the Contractor
1 February 2022	EIS-2 Site Possession Transferred to the Contractor
December 2022	First Power to South Australia
December 2023	Practical Completion (Remaining Portions)
June 2024	Final Completion

[50] 1.0.0.1 Request for Tender Phase B, page 12

[51] 1.0.0.1 Request for Tender Phase B, page 13

This schedule indicates that with the exception of, procurement of long lead time equipment, design and environmental approvals, site work does not progress until September 2021. This allows the contractor 26 months for practical completion.

The schedule broadly aligns with the forecast expenditure per year in the following table:

Table 48 Capex forecast expenditure by asset class

Asset Class	2018	2019	2020	2021	2022	2023	Total
Transmission lines		2.1		77.5	513.3	506.1	1098.9
Substations		0.6		43.6	124.6	160.3	329.1
Secondary Systems				3.6	8.2	6.4	18.2
Communications				0.5	1.7	0.7	2.9
Land and Easements		0.5	23.3	46.3	218.5	6.4	295.0
Synchronous Condensors		0.3		51.3	48.3	50.7	150.6
Total		**3.5**	**23.3**	**222.7**	**914.6**	**730.6**	**1,894.6**

12.2 Summary of project schedule phasing

Table 50 provides the summary of GHD findings related to the review of the project schedule phasing and capex recognition.

Table 49 Project scheduling phasing - findings, qualifications and verification

Findings	
1	The profile of capital expenditure broadly aligns with that set out in the Capex Forecast Model.

13. Procurement

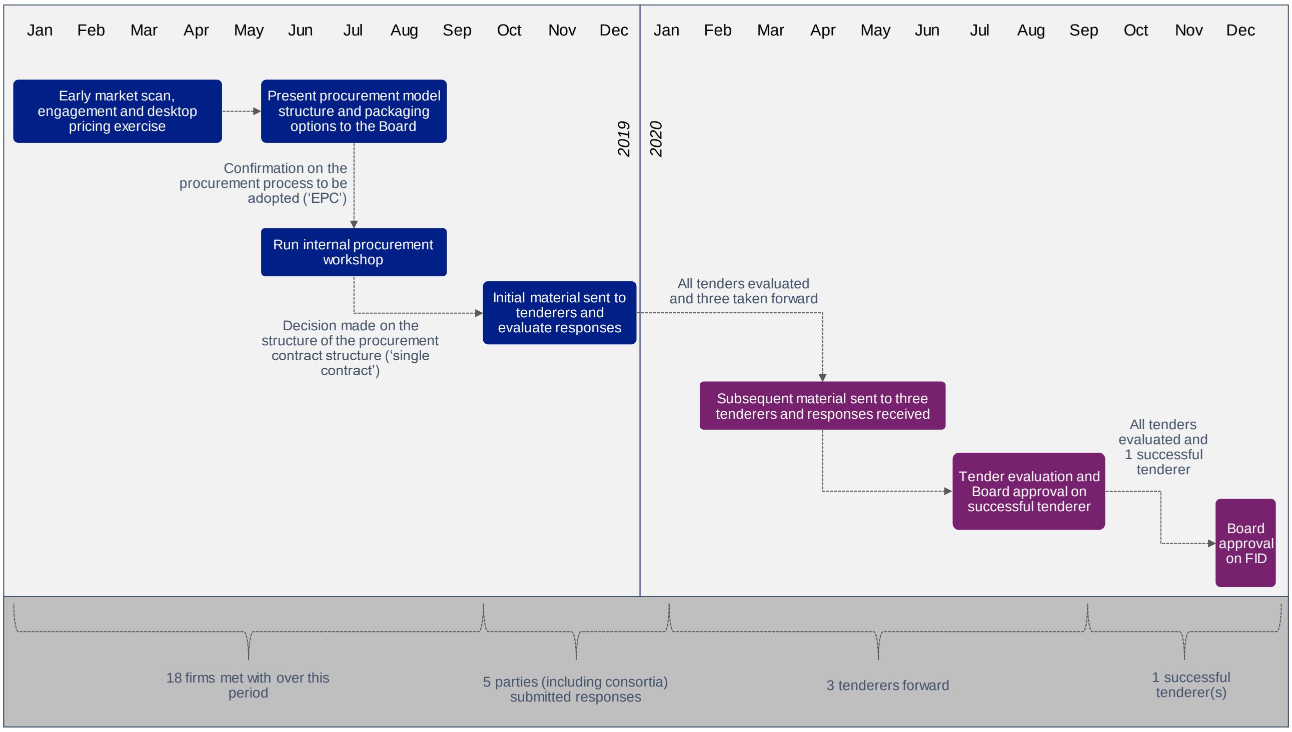
13.1 Overview

As indicated above, TransGrid has continued to refine the projects scope and has issued a tender in February 2020, incorporating the updated scope to the three short-listed tenderers. The tenders closing date being 29 June 2020.

This represents the latest stage of an extended procurement process that included:

- Early market sounding and procurement strategy development
- Numerous interactive sessions to test ideas, concepts and inform tenderers
- Phase A tender to short list tenders
- Phase B tender, the February 2020 tender.

Table 50 Key stages to the PEC procurement



The Capex Forecasting Methodology for PEC 29 June 2020 sets out an anticipation that a Commitment Deed setting out the terms of the EPC Deed will potentially be executed in September 2020.

Section 4.5 outlines that the Phase A tender, that underpins the tendered estimate, provided sufficient materials to communicate the scope. The same conclusion applies to the Phase B tender.

TransGrid engaged MBB Group and Calcutta Group to support the overall program management and procurement for the delivery of PEC.

In determining whether the procurement process supports efficient costs to deliver the PEC project and the appropriate allocation of risks, GHD considered:

The governance structure and the procurement process:

- What early work was done on market testing
- What work was done with respect to development of the procurement strategy and how this aligns to other projects of a similar size and nature
- How the tender process is aligned to the procurement strategy
- Tender timelines.

GHD also considered the following documents in our assessment of the procurement process:

- Project EnergyConnect Transaction Management Plan (TMP) Version: Draft/BRONZE dated 16 October 2019
- Project EnergyConnect Tender Evaluation Plan Phase A (EP) Version: Draft/GOLD dated 31 October 2019.

13.2 Procurement governance and objectives

Governance

Consideration of adequate governance over the procurement process is required to validate that competitive forces and decision making processes have been carried out in the evaluation and review of tender prices and that this oversight will support the aim of achieving an efficient scope, cost and delivery of the PEC project. The procurement governance structure was outlined in Figure 1 within the TMP[52].

Procurement strategy objectives

The documents considered the objectives of the procurement process as follows:

- Supports deliverability
- Meets project objectives and protects the interests of security holders
- Ensures that the forecast costs included in the CPA are prudent and efficient, while remaining adequate for TransGrid to deliver PEC
- Mitigates project risks.

The procurement process followed a staged approach detailed in Table 50 above.

GHD considers the procurement process developed for this major project in particular the process governance and the procurement objectives is appropriate for a major infrastructure project of this size.

13.3 Market sounding and procurement strategy development

Early market scan, engagement and desktop pricing exercise

The documents considered details that TransGrid conducted an early market engagement and a desktop pricing exercise.

It was estimated that the project would likely receive around six submissions from contractors for Phase A (current tender) and the number of contractors would then be reduced to three for Phase B. Three

[52] Project Energy Connect Transaction Management Plan, Bronze 16 Oct 2019 Draft, Section 2 Fig.1, Page 9

Australian-based contractors TransGrid typically have used to deliver its capital program as well as a range of new potential contractors in Australia and overseas were approached.

The market sounding involved one-on-one meetings to:

- Update participants on TransGrid's strategy, timetable and elicit participants' appetite and issues
- Assist TransGrid further understand of participants' potential interest, capability, capacity and to demonstrable experience delivering projects of a similar size and complexity to PEC
- Test the emerging strategy around packaging, risk allocation and process.

Results of this initial process were reported back to the TransGrid Board in September 2019, prior to the Phase A current tender phase.

Procurement strategy and packaging options

Incorporating the market sounding information, TransGrid considered three procurement options for PEC, namely:

- EPC
- An Alliance
- Multiple packages with high level of TransGrid technical oversight and coordination ('BAU Plus').

Various packaging options were considered as part of the EPC model from one single contract, two contracts (civil and electrical), two contracts (transmission lines + substations) and two contracts by geographical split. The pros and cons were evaluated considering the packaging options. The preference was finalised based on market engagement and put to the Board before the current Phase A tender.

It was determined that the EPC procurement model was the optimal procurement model structure.

GHD considers one of the major risks for this project will be resourcing and managing several working fronts with specialised skills required in grid substation and transmission line design, procurement and construction. The length of this line will make it one of the largest transmission lines projects being constructed and hence skilled resources and project management will be key.

GHD considers the selection of a single EPC contractor through and early contractor involvement approach for this project is appropriate and commensurate with current approaches taken on other large infrastructure projects in Australia.

13.4 Phase A RFT

TransGrid developed an RFT with the following objectives:

1. Define TransGrid's expectations and requirements in relation to the relevant package
2. Obtain pricing information to support the CPA
3. Allow the market to devise solutions and/or form joint ventures/consortia
4. Assess tenderers' capability, experience and capacity in relation the scope of works and services required
5. Enable tenderers to demonstrate their understanding of the scope of the project and range of issues, risks, challenges to be managed and present opportunities that may exist

6. Gain further feedback on the proposed project in general, commercial model and risk allocation to shape Phase B (outlined below)
7. Provide TransGrid with a basis for shortlisting tenderers for Phase B.

RFT scope package definition

The RFT includes the scope of equipment specification and quantities, with the concept designs and TransGrid standard manuals and specifications to enable pricing to this scope. These aspects were considered and discussion within section 4.6 and were found to adequately define the concept designs and the specifications for substation plant and equipment and for the transmission lines.

RFT price capture

Under the current RFT tender all parties submitted prices based on the concept designs and TransGrid standards. This confirms market based pricing against the same scope, specifications and concept designs provided by TransGrid, and the same designs and scope forming the basis in the Success BOE 5.0 final estimates. Again these aspects where considered in section 4.6 and the process was seen capable of capturing the pricing information required.

Commercial Contracts

Under the RFT contractor's risk is be priced on a basis consistent with the term sheet mark-up submitted by the applicant.

Findings

The current tender process has formed the basis to obtain market competitive pricing information to support the CPA.

GHD considers the current tender process has met the objectives of the RFT and the pricing received through the process has provide an accurate estimate to meet the purposes of the CPA.

13.5 Phase B RFT

As indicated in the executive summary, Phase B tender responses have been received from the three pre-selected parties. Based upon preliminary evaluations, two bidders are progressing into a BAFO process with submissions due 1 September 2020.

The two parties were selected based on TransGrid's consideration of the following as outlined in their EnergyConnect Evaluation Presentation dated 6 August 2020:

- Price
- Comparative cost breakdown
- Cash flow timing
- Risk
- TransGrid normalisation adjustments
- Scope alignment.

13.6 Procurement summary

All submissions were evaluated in accordance with the Tender Evaluation Plan and a weighted approach to determining the CPA estimate which GHD has considered in section 5.6.

Table 51 Procurement - findings, qualifications and verification

Findings	
1	The current tender process has formed the basis to obtain market competitive pricing information to support the tendered estimate component of the total estimate detailed in the CPA.
2	GHD considers the awareness of the approach within the current tender will have contributed positively to competitive and realistic pricing received from the market from this current tender.
3	TransGrid has followed industry practices[53] with regards market sounding, procurement strategy development and RFT execution.
Qualifications	
1	GHD's assessment was limited to the documentation listed within this section.

Verification	
Procurement governance and objectives	GHD considers the procurement process developed for this major project, in particular the process governance and the procurement objectives, is appropriate for a major infrastructure project of this size.
Procurement strategy development	GHD considers the selection of a single EPC contractor through and early contractor involvement approach for this project is appropriate and commensurate with current approaches taken on other large infrastructure projects in Australia.
Phase A and B tenders	GHD considers the current tender process has met the objectives of the RFT and the pricing received through the process has provide an accurate estimate to meet the purposes of the CPA. The RFT included the scope of equipment specifications and quantities with concept designs and TransGrid standard manuals and specifications to enable pricing to accurate scope.

[53] Good electricity industry practice

Appendices

Appendix A Scope definition for the tendered work (the initial PACR Solution)

A.1 General

In this appendix, GHD considers whether TransGrid has provided the prospective EPC tenderers sufficient detail on the concept designs and whether the specifications are sufficiently efficient with respect to the costs and performance required from the assets whilst providing opportunities for the tenderers to be able to refine designs and specifications in this regard. This review is commensurate with the scope of work pertaining to the *Tendered Costs*.

The key documents reviewed generally for this purpose were:

- SSD
- 02.01.01.01.01 Technical Specification Rev5
- 07.01.01 RFT Phase A

GHD's review of the procurement documentation contained within the following Phase A RFT documents:

- Generally the scope and specifications contained within the tender
- The transmission line scope and specifications
- The substation scope and specifications
- The LSE specifications.

Further details of the review is contained in Appendix B**.**

A.2 Concept designs and specifications

GHD's review of the concept designs contained in the procurement packages provided a means to consider whether these designs are efficient towards meeting the asset performance requirements.

The specifications in the tender documents were provided with fundamental design information with a reasonable level of specific details and requirements for the project.

TransGrid's electrical substations and transmission lines have been designed to provide very long term reliable operational service and high availability. Hence capital construction costs may not be the lowest costs possible however the designs and specifications should aim to minimise costs over the lifetime of the assets.

It was stated in the overarching technical specification document that the total design concept by tenderers is to consider the operation and maintenance of the substation without interruption to supply and in accordance with the safety rules and operating procedures[54].

TransGrid also stated that "This Specification provides fundamental design information with specific details and requirements for the project and guidelines to provide a baseline for the contractor to achieve the

[54] 02.01.01.01.01 Technical Specification Rev5, p12

reliability and availability objectives." GHD did not find a direct statement defining the reliability and availability objectives other than in the following statement which states "These include the provision of access and facilities for operation; the ability to carry out maintenance on any item of plant or equipment with minimal disturbance to other systems; emergency response in all weather and at all times; and efficient fault finding." It was assumed then that reliability and availability in this context refers to maintainability and not network reliability and availability.

The specifications were also prepared generally consistent with other TransGrid substation and transmission line projects. GHD considers these specifications in line with good industry practice. The specifications consider long term operating and maintenance efficiencies having standard plant and equipment across the network, and having consistent, safe and efficient operating protocols.

A.3 Transmission lines

The following concept designs and specification for transmission structures and lines were reviewed:

- 02.01.02.01 Transmission Line Concept Design Information
- 02.01.02.04 Beca - EnergyConnect - Structure Concept Design Report - 330 kV Double Circuit
- 02.01.02.02 Beca - Energy Connect - Basis of Design - Access Tracks Report (Appendix C - Cost Estimate

1. Transmission structures and design

The "EnergyConnect Structure Concept Design Report 330 kV Double Circuit – Border to Darlington Point" document states, for example, that Trans-Africa Project were engaged as a sub-consultant to provide guyed structure expertise based on their experience with ESKOM (South Africa) and states that V-string insulator designs should be considered as an option at the detailed design stage.

A review of the technical specification document[55], in relation to the technical and standard practice specifications for the transmission line portion of works shows a requirement to adhere to the TransGrid technical standards during the Phase A RFT process but with scope to further develop designs based on good engineering practice.

Generally transmission utility standards are recognised as having a high standard of requirements, given the extended duration that utility assets are expected to function potentially in perpetuity and with refurbishment as needed. For example the design life for the transmission line have been defined as 50-100 years for determining the minimum ultimate design wind speed.

Tenderers were required to base their pricing upon TransGrid's concept design and quantities. Following shortlisting, tenderers will be expected to challenge and improve upon the concept design, focussing on current areas of uncertainty, while complying with the technical specification to achieve the objectives and key performance and delivery outcomes for PEC[56].

A detailed review of the document "EnergyConnect Structure Concept Design Report 330 kV Double Circuit – Border to Darlington Point" shows the scope requirements being interpreted and reflected in the concept tower structures and example footing designs. This report specifies the design criteria that aligns well with, the requirements of the TransGrid standards and the relevant Australian Standards for new transmission

[55] 02.01.01.01.01 Technical Specification Rev5

[56] 07.01.01 RFT Phase A, p21

lines. The document shows a slight exceedance of the base TransGrid requirements in relation to the Base Ultimate Wind Speed – Downdraft, specifying 49 m/s vs the required 47 m/s.

The introduction of this document shows evidence that there has been a continual evolution of the design process along an expected engineering path leading to this document, and shows a good alignment with the stated project aims.

The line has been assigned a line security rating of Level III, which is the highest rating available, showing that the asset is expected to be constructed and maintained with a view to the worst case consequences if there was to be a failure. This level of security is consistent with other TNSP transmission line standards.

2. Access tracks

A review of the document 02.01.02.02 Beca - Energy Connect - Basis of Design - Access Tracks Report (Appendix C - Cost Estimate ex) was performed. This documented covered the construction access tracks only, for the section of required tracks from the SA Border to Wagga 330.

By necessity the document was only an interpretation of expected track routes, as the final routing will be dependent on final transmission line design and construction preferences. The route selection process followed was logical given the limitations of information and the route determined in the PACR. It would also likely to align well with final construction access requirements.

A unit cost based on a typical culvert solution was allowed for minor waterway crossings, however no costing was included in the estimate to cover major (60m+) crossings. This may have impacts on the project timeline and costing as construction of bridges or alternative access across major waterways will be subject to additional planning and permitting requirements on top of that required for the base project.

The access tracks are specified for a service life of three months to cover the construction period only, with the accessibility requirement reduced to dry weather only, from the initial all weather specification. This may impact schedule, as the presence of clay throughout most of the likely route may impact accessibility during construction, with this risk being identified. Two proposed solutions were identified - an increase in specification of the road and an increase in maintenance during construction, with the preference for additional maintenance. This may have cost implications for the final project as any cost savings in lowering the specification of the initial construction track is offset by the construction of permanent maintenance tracks unable to leverage from the work involved in the construction tracks. The tenderers were requested to price according to their accessed approach.

3. Geotechnical

The 330 kV double circuit structure concept report[57] states the ground profile used for the designs and footings is taken from limited available geological information and that further refinement of soil profile requires site-specific ground information at each tower site as soils may vary significantly.

Groundwater levels at each tower location may influence the foundation design, however at the time of this report, site-specific groundwater levels were unknown.

Groundwater levels, expansive clay soils and areas of aggressive soils with corrosive properties may exist along the route which will likely influence foundation designs and costs. The report also states that in some areas, it may not be practical or cost effective to deliver pre-mixed concrete or establish a concrete batch plant on site. Alternate foundation solutions such as soil-cement pad foundations using on-site materials may be required. The report recommend that further studies be undertaken to assess this risk.

[57] 02.01.02.04 Beca - EnergyConnect - Structure Concept Design Report - 330kV Double Circuit, p17

All of the above places a high degree of risk which will need to be factored into pricing offered by contractors at this stage of the procurement process, even though pricing is expected to be based on the concept designs and foundations. Foundations form a significant cost of an overall transmission line project and therefore this presents a major risk for the number of structures that will be required for this project.

GHD has found the concept designs for transmission structures and foundations typical of electricity industry practice and that tenderers would have been able to develop their own concept designs and pricing accordingly based on the information provided. There was some geotechnical data available, although limited, and GHD has some concerns that there is considerable risks at this point due to the limited knowledge of geotechnical factors which will need to be addressed in risk assessment by the tenderers.

A direct review of the indicative "special" soil condition foundation sketches[58,59] against the Structure Concept Design report is not possible as the soil conditions covered are different between the documents. A general review shows that both conceptual designs are robust and have margin for reduction in concrete volumes and excavations required once further geotechnical information is obtained.

A.4 Substations

The following substation concept designs were reviewed;

- 02.01.03.01 Substations Concept Design Information
- 02.01.03.02 BRG-PYD-SK-101-D (ES)
- 02.01.03.03 DNT-PYD-SK-101_D (ES)
- 02.01.03.04 WG1-PYD-SK-002-C
- 02.01.03.05 BRG-PYD-SK-100-G (SLD)
- 02.01.03.06 BRG-PYD-SK-111-P (GA)_OPTION 1
- 02.01.03.07 DNT-PYD-SK-100-E (SLD)
- 02.01.03.08 DNT-PYD-SK-111-H (GA_Option 1
- 02.01.03.10 WG1-PYD-SK101-C (GA)
- 02 Geo Tech Investigation Buronga 220 kV Substation
- 04.02.01.05 TS1025 - Part 1 Sect 06 - High Voltage Plant and Equipment - 190912

A review of the technical specification document[60], in relation to the technical and practice specifications for the substations portions of works shows - a requirement to adhere to the TransGrid technical standards and adherence to generally recognised good engineering practice.

Adherence to the TransGrid standard design requirements were required in the Phase A RFT. Generally transmission utility standards are recognised as having a high standard of requirements, given the extended duration that utility assets are expected to function as specified before upgrade or retirement.

The document demonstrates correlation to the project scope requirements and the design criteria is aligned with the requirements of TransGrid standards.

[58] 02.01.02.09 SK-001_Medium Strain_Special soil footing_Indicative_B

[59] 02.01.02.10 SK-002_Suspendion Pole_Special Soil footing_Indicative_B

[60] 02.01.01.01.01 Technical Specification Rev5

A review of the documents within the Substation Concept Designs package shows alignment to industry standards for substations layout, configuration, and plant requirements for major 330 kV transmission network substations.

GHD did not find any matter of concern regarding the substation specifications that may have led to uncertainty in scope by tenderers.

While there were areas with some discrepancies identified in documentation reviewed leading up to the current tender scope (covered in detail in section 4.5), the procurement documentation was found to comply and align with the scope in the CPA estimate.

GHD found the concept configurations and layouts for the substation and the substation standards manuals is typical of electricity industry practice and that tenderers would have been able to develop their own concept designs and pricing accordingly based on the information provided.

Geotechnical information was available for the Buronga, Darlington Point and Wagga 330 substation locations - 02.05.01 Geotechnical Studies. The Buronga substation site is located in a flood zone with inadequate natural drainage and tenderers were advised of the opportunity to optimise the arrangement of the site to minimise the cost of earthworks and engineered fill.

A.5 Reactive plant

The following documents were reviewed;

- 04.02.01.05 TS1025 - Part 1 Sect 06 - High Voltage Plant and Equipment – 190912.
- 02.02.01 PEC - Capacitor Bank Planning Info (TENTATIVE DATA).
- 02.02.02 PEC - Capacitor Bank - Returnable Schedules (TENTATIVE DATA).
- 02.02.03 PEC Power Transformer & Reactor - Returnable Schedules Rev1 (1).

The specifications for the reactive plant for use at the Buronga and Darlington Point stations were reviewed. These specifications consisted of the general HV Plant and Equipment specification[61], the capacitor planning data document[62] and the associated returnable schedules for the capacitor[63] and reactor[64] units.

The specification of equipment found in the general HV specification was found to be in accordance with expected utility practise for specifying this form of equipment.

When reviewing the returnable schedule for the reactor, an omission of the 65 MVAr reactor required at Buronga was noted, this may be due a scope change, or an intent to repurpose the 60 MVAr schedule. The specifications for the 50 MVAr and 60 MVAr reactor units (Buronga and Darlington Point) were comprehensive and generally aligned with the requirements of the project scope. This difference in capacity may also be to allow coverage of standard designs by equipment manufacturers.

The returnable schedule for the capacitor filter units, was comprehensive, with separate sections of the schedule for each of the main components of the filter unit – capacitor, reactor, current transformers, surge arresters and insulators. Only the 50 MVAr unit was shown in the schedule, however this was a match for the requirements outlined in the capacitor planning document.

[61] 04.02.01.05 TS1025 - Part 1 Sect 06 - High Voltage Plant and Equipment - 190912

[62] 02.02.01 PEC - Capacitor Bank Planning Info (TENTATIVE DATA)

[63] 02.02.02 PEC - Capacitor Bank - Returnable Schedules (TENTATIVE DATA)

[64] 02.02.03 PEC Power Transformer & Reactor - Returnable Schedules Rev1 (1)

Reviewing the schedule shows a mismatch between component ratings, with the filters themselves having the highest typical voltage ratings (Power frequency and Lightning impulse) available in the 330kV and the reactors having the second highest. Other equipment specified has the higher requirement, however this rating is in accordance with the planning document. The rest of the schedule was generally aligned with the requirements of the planning document, however the schedule contained information for additional equipment not listed in the planning document. The source of this information could not be identified.

A.6 Large specialist equipment

The following equipment specifications were reviewed for the LSE:

- 04.02.01.04 TS1025 – Part 1 Sect 05 – Synchronous Condenser Requirements
- 04.03.08 PEC Synchronous Condenser Functional Specification Rev2
- 04.03.09 PEC Phase Shift Transformer Functional Specification Rev2
- 03.01.05 20191003 Phase Shift Transformers Technical Response
- 03.01.06 20191003 Synchronous Condenser Technical Response

LSE forms a significant part of the overall project cost, in particular Synchronous Condensers and PSTs.

The technical specification document[65] states that network performance studies are still being undertaken in conjunction with ElectraNet to refine the performance requirements for the equipment. Access issues are also being considered, particularly the loading constraints on road access to Buronga.

Tenderers were requested to consider opportunities to develop more cost-effective equipment solutions that still provide the performance outputs required by TransGrid.

TransGrid's preferred position in the Phase A RFT was that tenderer's would procure the specified LSE from an approved supplier as part of a binding bid. The document also stated that TransGrid reserved the right to separately procure LSE and novate or free issue to the EPC Contractor. The tenderers were requested to include details of any positive and negative aspects of each approach in their responses. This approach would allow TransGrid to obtain a range of market tested pricing to include delivery logistics, construction installation costs.

The project specific requirements for the LSE RFI[66] were reviewed against the included specifications.

The LSE RFI allows for an alternate configurations of the PST, with either 3 x 400 MVA (9 single phase units) or 5 x 200 MVA (it was unspecified if this is to be single phase or 3 phase units) sets to be supplied. The option with 5 sets would require additional HV equipment in the Buronga substation and a revision to the site layout which may impacts on land availability and cost. Additional available land appears to be available at the site.

The configuration of the PST in the single line diagram shows bypass arrangements for each PST, but the section of the specification related to the parallel operation of the 200 MVA option does not appear to allow for the correct number of PSTs to operate in parallel. This however may have some impact on equipment operation or impact procurement costs.

[65] 02.01.01.01.01 Technical Specification Rev5

[66] 04.01.01 LSE Request for Information

Review of the PST functional specification[67] shows some accord to good engineering practise, however the document rather appears as a datasheet to support a specification than a full specification.

The ratings of this equipment is aligned with the highest end of the electrical ratings possible, and specifying industrially recognised branded equipment for sub-assemblies. Financial incentives are included, which is typical for power transformers, to encourage efficient operation through reduced losses.

A possible area of concern is that the expected service life of the transformers is listed as a minimum of 40 years, with the overall project lifespan listed at 50 years. This should not be an issue as cyclic loading of the interconnector is expected to be between 67%- 80% of full capacity which provides for a longer actual operating life compared to design life.

What appears to be lacking is a specification for some of the ambient and electrical conditions the PST will be required to operate in (temperature, pollution levels, and frequency range).

The overall specification when read as a datasheet is clear but not complete in regard to the electrical, key subcomponent and physical requirements of the equipment, while allowing tenders freedom in the final specification of ancillary items.

A review of the LSE RFI documents for the synchronous condensers[68,69] was performed, with the requirements document appearing to be a full specification and the functional specification as a supporting datasheet.

The requirements document appears to be a comprehensive technical specification, covering all expected items. The requirements for 'Principal" review of documentation through the design and construction process is not made clear in the document and appears to be one of the work in progress sections.

The functional specification appears to be generally in accordance with good engineering practice, and allows for the units including surrounding buildings to be delivered whole, with clear demarcation points.

A.7 Summary

GHD has reviewed the specification of key scope items for the project contained within the Phase A RFT the review considered;

- Transmission Specifications – structures, route, soil and ground conditions
- Substation Specifications – balance of plant specs, ground conditions etc
- LSE specifications.

The review also considered the aim of the procurement process;

- To obtain market tested pricing of the included scope, being the majority of the project costs, and to revise cost estimates accordingly
- To select tenderers to participate in a second Phase B RFT process to firm scope detail and risk allocation to reach final pricing and selection of the EPC contractor to deliver the project.

GHD's review found:

[67] 04.03.09 04.03.09 PEC Phase Shift Transformer Functional Specification Rev2

[68] 04.02.01.04 TS1025 - Part 1 Sect 05 - Synchronous Condenser Requirements – 1909

[69]04.03.08 04.03.08 PEC Synchronous Condensor Functional Specification Rev2

- The specifications represent standards expected for transmission infrastructure and good electricity industry practice.
- The specifications consider the need to operate reliability over the life expectancy of the transmission interconnector.
- Certain gaps in the specifications were identified where uncertainty may impact the reliability of pricing submitted by tenderers. These included the geotechnical information available for the transmission line foundation design and the final configuration of the PST units (3 versus 5 units) which has the ability to impact the amount of HV equipment and civil footprint required at the Buronga substation.
- The specifications and concept designs allow and encouraged innovation to be offered by the tenderers.

Appendix B Scope changes RIT-T PACR to the final PACR solution

The following tables show the variances in asset quantities due to the refinement of scope from the original RIT-T PACR to the final PACR Solution.

Table 52 Transmission lines – RIT-T PACR to the final PACR solution scope

Transmission line segment	Scope stage	Quantities					Design span length (m)	Route (km)	Comments
		Pole	Medium strain	Heavy strain	Light susp.	Heavy susp.			
330 kV DDCT circuit twin Mango NSW border to Buronga	RIT-T PACR							140	Line estimates based on $/km
	Tendered Works	3	25	9	251	5	461	135	Phase A RFT Concept Designs and Procurement Specifications
	Final PACR Solution	3	25	9	251	5	461	135	No change
330 kV DDCT twin Mango conductor transmission line between Buronga and Darlington Point	RIT-T PACR							400	Lines estimates based on $/km
	Tendered Works	2	60	26	746	10	475	401	Phase A RFT Concept Designs and Procurement Specifications
	Final PACR Solution	2	64	27	792	10	475	426	Assumed quantity increases due to 25km route increase
330 kV SCCT twin Mango conductor transmission line between Darlington Point and Wagga 330	RIT-T PACR							152	Lines estimates based on $/km
	Tendered Works	3	26	23	152	102	493	151	Phase A RFT Concept Designs and Procurement Specifications
	Final PACR Solution	3	26	23	152	102	493	151	No change
220 kV DDCT twin Lemon	RIT-T PACR							24	Original tower structure designs

Transmission line segment	Scope stage	Quantities					Design span length (m)	Route (km)	Comments
		Pole	Medium strain	Heavy strain	Light susp.	Heavy susp.			
between Buronga to Red Cliffs strung on one side**	Tendered Works	0	6*	0	56*	0	387	24	* Monopole Structures
	Final PACR Solution							24	** Change to DDCT twin Mango tower structures as per the Phase B RFT

Table 53 Transformers - RIT-T PACR to the final PACR solution scope

Substation site	Scope stage	Specification and Quantities		Comments
		Phase Shift Tx (MVA)	330/220kV Tx (MVA)	
Buronga Substation	RIT-T PACR	400 (9 single phase)	400 (2)	9 single phase PST transformer units
	Tendered Works	400 (9 single phase)	400 (2)	Phase A RFT
	Final PACR Solution	200 (15 single phase)	200 (3)	Change to 200MVA as per the Southern Alterative Route in Phase B RFT

Table 54 Reactive plant – RIT-T PACR to the final PACR solution

Substation site	Scope stage	Specification and quantities			Comments
		Synchronous condenser (MVAr)	Shunt capacitor (MVAr)	Shunt reactors (MVAr)	
Buronga Substation	RIT-T PACR	100 (2)	50 (2)	50 (2)	
	Tendered Works	100 (2)	50 (2)	50 (2) 60 (2)	Addition of 2 x 60 Mvar
	Final PACR Solution	100 (2)	50 (2)	50 (2) 60 (2)	Unchanged
Darlington Point Substation	RIT-T PACR	100 (2)	50 (2)	60 (2)	

Substation site	Scope stage	Specification and quantities			Comments
		Synchronous condenser (MVAr)	Shunt capacitor (MVAr)	Shunt reactors (MVAr)	
	Tendered Works	100 (2)	50 (2)	60 (2)	
	Final PACR Solution	100 (2)	50 (2)	60 (2)	Unchanged

Table 55 Number of circuit breakers - RIT-T PACR to the final PACR solution

Substation site	Scope stage	Quantities			Comments
		330 kV CB	330 kV CB POW	220 kV CB	
330 kV Buronga Substation	RIT-T PACR	21	6	2	
	Tendered Works	21	6	2	No change to configuration
	Final PACR Solution	24	6	3	Increased due to additional power transformers
330 kV Darlington Point Substation	RIT-T PACR	8	4	0	
	Tendered Works	8	4	0	No change to configuration for Final PACR Solution
Wagga 330 Substation	RIT-T PACR	0	0	0	
	Tendered Works	0	0	0	No change to configuration for Final PACR Solution

Table 56 Number of switchbays – RIT-T PACR to the final PACR solution

Substation site	Scope stage	Quantities					Comments
		1.5 x CB	Lines	Reactive Plant	Transf.	Bus	
330 kV Buronga Substation	RIT-T PACR	4	2*	8	12	**17	** 5 bays duplicated in estimate scope assumed in error
	Tendered Works	4	2*	8	7	17	* Darlington Point feeders supplied from 1.5 x CB bays
	Final PACR Solution	4	2	8	11	17	Increased due to additional power transformers
330 kV Darlington Point Substation	RIT-T PACR	2	4	6	0	16	
	Tendered Works	2	4	6	0	16	
220 kV Red Cliffs Substation	RIT-T PACR		2			0	
	Tendered Works		2			0	
Wagga 330 Substation	RIT-T PACR		1			2	
	Tendered Works		1			2	

Table 57 Substation site area – RIT-T PACR to the final PACR solution scope

Substation site	Scope stage	Switchyard Site area (m^2)	Comments
330 kV Buronga Substation	RIT-T PACR	101,270	The land required to establish the new assets at Buronga has been extended since the PACR to accommodate future extensions to allow for new connections.
	Tendered Works	101,270	No change for the final PACR Solution
330 kV Darlington Point Substation	RIT-T PACR	32,000	The land required to establish the new assets at Darlington point has been extended to accommodate future extensions to allow for new connections.

Substation site	Scope stage	Switchyard Site area (m^2)	Comments
	Tendered Works	32,000	No changed for the final PACR Solution
220 kV Red Cliffs Substation		1,760	No allowance for extension of site. GHD considers additional space will be required (refer section 5.5.8).
	Tendered Works	Unknown	GHD allowed a switchyard extension for the initial PACR Solution because aerial views suggested there was no spare space available.
Wagga 330 Substation		0	Existing space available
	Tendered Works	Unknown	GHD assumed there was sufficient spare space.

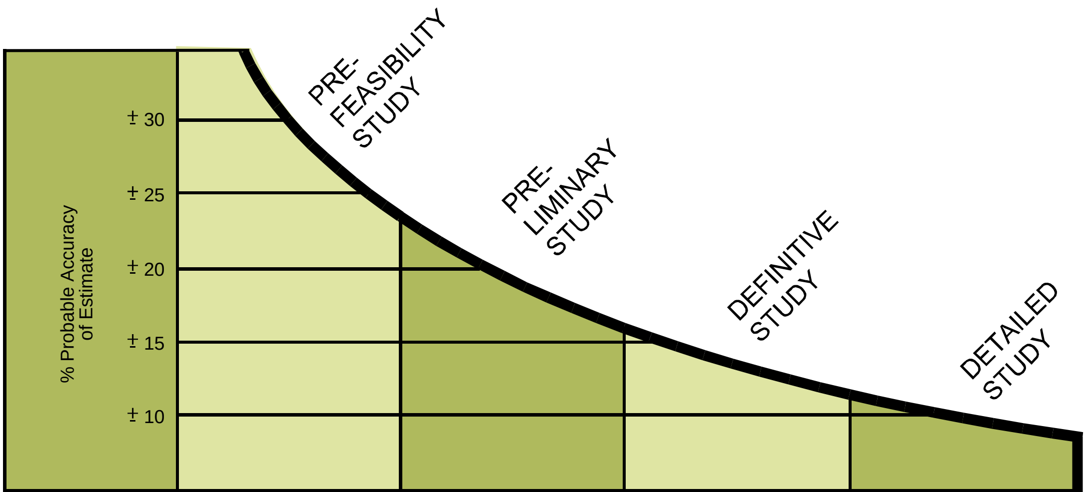
Appendix C Unit cost benchmarking methodology and assumptions

C.1 Estimate accuracy for assessment

In assessing the CPA, consideration must be given to the level of accuracy that can be achieved in generating indicative cost estimates for the network augmentation work packages identified.

The graph shown in Figure 11 indicates the levels of accuracy that can be expected for estimates prepared for capital works at various stages of a project development. Due to the different levels of engineering input, and completeness in the design, there are various levels of accuracy that can be reasonably expected.

Figure 11 Standard estimate accuracy levels



Type of Estimate	Order of Magnitude	Preliminary	Definitive	Detailed
Provided Documentation	• Product capacity and Location • Cost Data on Similar Projects • Major Equipment List	• Preliminary Equipment List • Engineering Line Diagram • Plant Outline General Arrangement • Maps and Surveys • Bench Test Results • Nature of Facilities	• Equipment Specifications and Vendor Quotations • Construction Schedule • Electrical One Lines • Piping and Instrumentation Flow Diagrams • Soil Data and Architect Features • Site Survey and Labour Complete	• Bulk Material Specifications and Vendor Quotes • Construction Specification and Sub Contractor Quotations • Engineering Advanced Approximately 10%
Definition of Scope of Work	Conceptual	Approximate	Clearly Described Essentially Complete	Complete. Well Detailed
Estimating Procedure	Factoring	Combination of Factoring and Quantity Take-Off	Most Quantity Take-Off. Very little Factoring	Complete Quantity Take-Off
Use of Study	Comparison/ Rejection	Final Feasibility	Budget	Funding

Table 58 AACE IRP No. Shows the classification of estimates as defined in the AACE International *Recommended Practice No. 17R-97 Cost Estimating Classification System*.

Table 58 AACE IRP No. 17R-97 generic cost estimate classification matrix[70]

Estimate class	Primary characteristic	Secondary characteristic			
	Level of project definition Expressed as % of complete definition	**End usage** Typical purpose of estimate	**Methodology** Typical estimating method	**Expected accuracy range** Typical +/- range relative to best index of 1 (a)	**Preparation effort** Typical degree of effort relative to least cost index of 1 (b)
Class 5	0% to 2%	Screening or Feasibility	Stochastic or judgement	4 to 20	1
Class 4	1% to 15%	Concept Study or Feasibility	Primarily stochastic	3 to 12	2 to 4
Class 3	10% to 40%	Budget, Authorisation or Control	Mixed, but primarily stochastic	2 to 6	3 to 10
Class 2	30% to 70%	Control or Bid/Tender	Primarily deterministic	1 to 3	5 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Deterministic	1	10 to 100

a. If the range index value of 1 represents +10/-5%, then an index value of 10 represents +100/-50%

(a) If the cost index of 1 represents 0.005% of project costs, then an index value of 100 represents 0.5%

The level of information available to us for assessing the augmentation work packages was typical of concept study level. Therefore, we consider our comparative estimates are based on 1% to 15% project definition and should be classified as Class 4 estimates with an accuracy of ±30%.

C.2 Unit cost and capex forecasting assessment methodology

GHD has adopted a nominal criterion of ±20% as the first pass for comparing the TransGrid estimates with our reference comparative estimates for similar projects as a test for reasonableness.

Where there are is a variance between the TransGrid allowance for a network capacity augmentation project and our comparative estimate of less than ±20%, GHD will consider the TransGrid estimate to be reasonable and realistic, and no further detailed assessment will be undertaken.

For those TransGrid estimates where the variation is outside our nominal range, GHD has reviewed any known project specific issues to identify the potential reasons.

[70] AACE International, *Recommended Practice No. 17R-97: Cost Estimating Classification System (TCM Framework: 7.3 – Cost Estimating and Budgeting)*, 12 August 1997, p. 2

C.3 Data sources

The data sources used for the development of unit rates include:

- Costs for LSE from recent projects that TransGrid has undertaken
- Contract and procurement costs available for recent projects completed by electricity utilities
- Material cost data that may be obtained from suppliers
- Market cost data available through recent operational and capital expenditure reviews for electricity transmission utilities
- Recent asset valuations by GHD
- Cost data available in the public domain, including standard labour costs.

As such, these costs may not necessarily reflect the actual costs for individual asset material cost or installation costs held in the TransGrid Success estimating system.

GHD has also considered recent project or vendor cost information provided by TransGrid, where these have been market tested through a tender process, or can be demonstrated to be material costs provided directly by suppliers.

Our market data costs have been used in project cost comparative estimates for both substation and transmission works, and potential augmentation works to support development of REZ in Queensland and NSW. These building block costs have also been used as benchmarks for unit rate comparisons for capital and operational expenditure reviews for Australian electricity utilities.

C.4 Unit rates

Our standard estimating unit rates have been based on the following:

- Our standard 330 kV and 220 kV switchbay configurations, and HV substation switchyard establishment components
- Our standard transmission line configurations for overhead lines on steel support structures (towers and poles)
- All steel support structures considered to have normal or typical foundations.

The following adjustment factor has been applied to the unit rates in our estimates:

- Remote area working allowance of 5% for labour costs.

C.5 Inclusions and exclusions

GHD considers our comparative estimates to be class 4 (±30%), based on the level of project definition and network data available in the public domain.

Our estimates include consideration of the following:

- No contingency allowance in line with the TransGrid Success PEC Contract and Plant estimates
- No allowance for any overtime associated with an accelerated construction program based on a 6-day working week
- Project specific costs as nominated by TransGrid for design and development, site mobilisation and demobilisation, and site management and operation

- Land acquisition costs for new substations, as specified by TransGrid in the Success Contract and Plant estimates[71]

The following have been excluded from the estimates:

- No Goods and Services Tax (GST) allowance
- All new transmission lines are assumed to be on flat or undulating terrain, and therefore no terrain factors have been included
- No consideration of construction difficulties with transmission line support structure foundations
- No separate consideration of any transmission line crossings
- All substation sites to be extended have sufficient spare space available for the extension, the land is flat and suitable for construction, and has ready access
- No relocation works are required within existing substations for the proposed augmentations
- No switching costs associated with work on existing 330 kV and/or 220 kV lines
- No allowance for costs associated with line easements, other than any specific lump sum allowances included in the TransGrid Contract and Plant estimates.

C.6 Concept design diagrams

GHD initially relied upon high-level definition of scope of works at switchbay level for substations, and tower and conductor types and quantities for transmission lines as defined within the Success estimate.

GHD refined our reference switchbay configurations to reflect switchbay configurations and general arrangement in Buronga, Darlington Point, Wagga 330 and Red Cliffs substations as shown on Concept Design Single Line Diagrams (SLDs) and General Arrangement drawings (GAs):

- BRG-PYD-SK-100 Buronga 220/330 kV Substation Single Line Diagram - amendment G
- BRG-PRD-SK-111 Buronga 330/220 kV Substation General Arrangement - amendment P
- DNT-PYD-SK-100 Darlington Point 330 kV Substation Single Line Diagram - amendment E
- DNT-PYD-SK-111 Darlington Point 330 kV Substation General Arrangement - amendment H
- WG1-PYD-SK-101 Wagga 330 kV Substation General Arrangement - amendment C

[71] PEC Success 5.0 Final

C.7 Comparative estimate approach

GHD used market data available to develop standard building block costs for switchbays, substation establishment, transmission line structures and conductor stringing. These we have applied to each of the identified work packages, relying upon the defined scope of work as provided by TransGrid and modified to suit the SLDs and GAs provided (refer above).

This generated an estimate for the primary and secondary plant based on a building block approach, and provided us with a benchmark of our understanding of typical market costs against the TransGrid estimated costs.

In generating the final project estimate for each work package, we have used the lump sum allocations nominated by TransGrid for project-specific costs such as:

- Project design and development
- Site mobilisation, management and operating costs
- Land acquisitions.

Where TransGrid has included these project-specific costs in the Success estimates, GHD has adopted these values in our comparative estimates so that these particular allocations do not distort any comparison of the substation and transmission line primary and secondary building block estimates.

In some instances, TransGrid has nominated bespoke large electrical primary plant, such as phase shift transformers and synchronous condensers, for which, due to their specialised nature, there is little market data available for estimating. We have used a nominal lump sum for these assets, with the final value for this equipment to be refined after the evaluation and selection of the preferred tenderer.

We completed this assessment against the scope of work as detailed in the final 5.0 version of the TransGrid Success estimate, with consideration of any changes that may have be made to the previous version 4.1 and 5.0 draft stages of the project estimate.

Appendix D Glossary

Term	Definition
AAMP	Adjusted average market price
AEMO	Australian Energy Market Operator
ALR Act	Aboriginal Land Rights Act 1983
BAFO	Best and Final Offer
BAM	Biodiversity Assessment Method
BAU	Business as Usual
BCF	Biodiversity Conservation Fund
BCT	Biodiversity Conservation Trust
BOE	Basis of Estimate
BOPC	Biodiversity Offsets Pricing Calculator
CPA	Contingent Project Application
DPIE	NSW Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
EPC	Engineer, Procure and Construction
GST	Goods and Services Tax
ISP	Integrated System Plan
JLL	Jones Lang LaSalle
kV	Kilovolt
LAJTC Act	Land Acquisition (Just Terms Compensation) Act
LALC	Local Aboriginal Land Council
LSE	Large Specialist Equipment
MNES	Federally listed threatened biota
MVA	Megavolt Ampere
MVAr	Megavolt Ampere Reactive
MW	MegaWatts

Term	Definition
NEM	National Energy Market
NSW	New South Wales
NSWALC	NSW Aboriginal Land Council
NT Act	Native Title Act 1993
OFS	Option Feasibility Study
OSA	Options Screening Assessment
PACR	Project Assessment Conclusion Report
PADR	Project Assessment Draft Report
PEC	Project Energy Connect
PST	Phase Shift Transformers
REZ	Renewable energy zones
RFI	Request for Information
RFT	Request for Tender
RIN	Regulated Information Notices
RIT-T	Regulatory Investment Test for Transmission
SA	South Australia
SAET	South Australia Energy Transformation
SLD	Single Line Diagrams
SME	Subject Matter Expert
SSD	Scope and Specification Description
TCC	Total Construction Cost
TMP	EnergyConnect Transaction Management Plan
TNSP	Transmission Network Service Provider
TSR	Travelling Stock Reserves
TNSP	Transmission Network Service Provider
WBE	Work breakdown element

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