2018-22
POWERLINK QUEENSLAND REVENUE PROPOSAL

APPENDIX 7.04

Jacobs
Cost Data Review to Support Repex Modelling

Delivering better value

Cost Data Review to Support REPEX Modelling

Powerlink

Report

RO028600R001 | E

10 December 2015

JACOBS

Cost Data Review to Support REPEX Modelling

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Contents

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to review the cost data in support of the replacement expenditure modelling as part of the Powerlink regulatory proposal to the Australian Energy Regulator in accordance with the scope of services set out in the contract between Jacobs and Powerlink ("the Client"). That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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1. Introduction

Powerlink is preparing for the submission of its revenue proposal to the Australian Energy Regulator (AER) as part of the process to determine the Maximum Allowable Revenue (MAR) for Powerlink for the 2017/18 to 2021/22 regulatory control period.

A critical part of the revenue proposal is the capital and operational expenditure forecasts for the regulatory period, and the demonstration of their prudency and efficiency in meeting Powerlink's network augmentation and performance needs.

1.1 Objective

Powerlink has derived unit costs for the replacement expenditure (repex) model, and sought an independent assessment of the replacement unit costs, including independent benchmarking/verification that the comparative estimates are reasonable. The comparative estimates were to include all direct and indirect costs that apply to replacing equipment such as commissioning the new unit, and removal and disposal of the previous equipment being replaced.

1.2 Scope of work

A key component of Powerlink's regulatory proposal is the repex forecast. Powerlink has based its repex forecast on the model provided by the AER and which the AER will be using to assess Powerlink's expenditure projection. A pivotal input to the repex model is the unit cost associated with the replacement of the various assets identified in the replacement program for the next regulatory period. In support of Powerlink's regulatory proposal Jacobs has been engaged to develop a set of comparative unit cost estimates for a nominated set of asset building blocks within the following asset categories:

- Conductors
- Tower replacement and refit/refurbishment
- Substation switchbays, including selected power transformers
- SCADA, network control and protection systems
- Reactive plant including static VAR compensators (SVCs), capacitors and shunt reactors

Our report will be developed in a format that will be suitable to be used as a supporting document to Powerlink's regulatory proposal to the AER. The report will include:

- method, data sources and assumptions used to derive the estimates
- relationship of the unit cost, and its derivation, to historical replacement costs
- process used to verify the unit costs generated
- verification as to whether risk components, such as contingencies, have been included

Our unit cost estimates will be generated independently and Powerlink will separately assess any variance or reasonableness in comparing their internal unit costs against our industry average unit costs using their own criteria.

2. Method

Powerlink has prepared a list of asset building blocks to be used in generating their REPEX forecast as part of the regulatory proposal for the next control period 2017/18 to 2021/22:

- conductor of various voltages and ratings for replacement works
- tower replacement/refurbishment
- decommissioning old structure and installing new tower, conductor, OPGW and OHEW
- refurbishing tower and retaining fittings, OPGW and OHEW
- refurbishing tower and replacing fittings, OPGW and OHEW
- substation switchbay assets of various voltages for replacement works
- substation power transformers of selected voltages and ratings for replacement works
- substation reactive plant (SVCs, capacitors and shunt reactors) of various voltages and ratings for replacement works
- SCADA and network control and protection systems for replacement works

The general descriptions of the assets and their intended use (new installed/replacement/refurbishment) are the descriptions provided by Powerlink for this assignment. In developing the unit costs, it is necessary for all costs to be identified (direct and indirect) related to putting the replacement equipment in service, and to remove and dispose of any redundant equipment.

The report shall be in a format suitable for inclusion in the Powerlink revenue proposal, and include commentary relating to:

- all cost data sources and assumptions
- development of hourly labour rates for work in South East Queensland
- process used to verify the reasonableness of the cost data used in relation to typical market costs
- method used in developing the comparative estimates
- any risk components, such as nominal contingencies, that may have been included in the comparative estimate, or that should be considered as an addition to the asset building block cost estimate

No locality factors or escalation are to be included in the estimates.

2.1 Tasks

2.1.1 Scope building blocks

To allow for a reasonable comparison between the unit rates generated by Jacobs and Powerlink's internally derived costs, Jacobs will generate concise building block definitions for each asset category to identify all direct and indirect costs that have been included, and any assumptions that have been applied.

As an example, each high level building block definition will include a brief description of any assumptions relating to:

- Direct costs
  - fixed assets/equipment
  - bulk materials, including civil works
  - field labour
  - testing and commissioning

- removal and disposal of any redundant assets/equipment
- construction plant
- freight
- temporary construction facilities

- Indirect costs
  - EPCM costs (15%)

A summary of typical exclusions which are generally not included in any costing exercise is listed below:

- Working capital
- Operating costs
- Finance charges
- Residual value of temporary equipment and facilities
- Residual value of any redundant equipment
- Cost to Client of any downtime
- Cost to Client of any isolation and de-isolation of plant and equipment
- Costs due to any construction power / transport outages
- Environmental approvals
- Escalation
- Growth
  - Growth allowance is to cover the variations and changes that occur between estimate preparation and construction completion
  - The growth allowances cover these unknown, but expected, increases in both cost and quantity
  - Growth allowances can be categorised as:
    - Design allowance
    - Quantity allowance
    - Cost growth allowance

2.1.2 Generate hourly labour rates

Jacobs will generate hourly labour rates based on publically available award rates and market average on-costs and corporate overheads sourced from a market price survey of electricity industry participants.

The Jacobs labour hourly rates will be based on the following parameters:

- Basic hourly rates and allowances based on industry awards
- Market average values for on-costs including:
  - Payroll tax
  - Superannuation
  - Annual, Long Service and Sick leave
  - Workers Compensation
  - Public holidays

These hourly rates will be benchmarked against publically available certified work agreements (and equivalents) and industry project estimates to verify their reasonableness for use in the Jacobs comparative estimates.

Where available, we propose to review our hourly rates with information from contracting firms, or alternatively review the proposed hourly rates against any available capital or replacement data from other electricity utilities.

2.1.3 Generate comparative estimates

The quality of the market data used by Jacobs supports class 4 type estimates, as defined by the Association for the Advancement of Cost Engineering (AACE) International Recommended Practice No. 17R-97 for electricity network assets.

This market data is drawn from multiple sources including:

- recent expenditure reviews for electricity transmission and distribution utilities to support regulatory revenue proposals to the AER
- procurement studies of transmission and distribution asset costs involving the collecting, collating and analysing actual contract prices from seven Australian electricity distributors and four transmission companies for primary items such as circuit breakers, current transformers, voltage transformers, disconnectors, power transformers and conductor
- Jacobs market price surveys of material costs and construction and maintenance activities - activity man-hours used in comparative estimates were based on responses to a market price survey of construction and maintenance activities in the electricity distribution system, conducted by Jacobs over the period June 2001 to May 2003. The surveys included a wide range of capital and operating activities, and attracted between 10 and 15 participants to each survey. Survey participants included government owned utilities, privately owned utilities and private contracting businesses
- contract and procurement costs incurred by utilities on recent projects
- recent asset valuations and comparative class 4 estimates by Jacobs
- Jacobs valuation database

These data sources represent the reference asset database used by Jacobs primarily for asset valuation purposes, as well as supporting project specific comparative estimates. All of this input data is based on what Jacobs believes the cost of these goods and services would be in a reasonably mature competitive marketplace.

Jacobs will generate the comparative unit rates with consideration of the standard asset descriptions developed by us for each building block.

Due to their specialised nature, for the substation reactive plant, our comparative estimates for the capacitor banks and shunt reactors will be based on a supply-and-install basis, and excluding any costs of the associated switch bay for each item (including any secondary protection and control systems). As SVCs are typically units of a particular design for a particular application, we will source comparative costs for the core SVC equipment (power electronics, protection and control, primary equipment) and the main transformer, and will rely upon some average costs with regards to the civil works based on any available project budget costs.

Jacobs may not be able to source cost data for capacitor banks > 500kV due to their rare nature.

2.1.4 Verification

Where such information is available to Jacobs, we will compare base material cost data with other market data to assess the reasonableness of the material cost information being used for the generation of the comparative estimates.

To verify that a comparative estimate is reasonable, Jacobs has typically applied a ±15% test against market values for similar asset building blocks for other electricity entities. The unit rate is first reviewed to determine if it is within the nominal ±15% range, and if so, it is deemed reasonable. If not, the unit rate definition is reviewed against the market value to determine if there are any fundamental differences in the scope of the building block, and if so, the Jacobs comparative estimate is adjusted for any identified difference where it is considered that the original building block definition should be amended. For example, this may mean that removal/disposal costs may have been omitted from the reference market building block; or that the market value may not have included provisions for the same assumptions as allowed for in the Jacobs comparative estimate.

For SCADA and network protection and control systems, as part of the unit rate estimation process, Jacobs will undertake a thorough market review of available products and associated costs from major suppliers, and combine this with knowledge and experience from peer providers in electricity and across the utilities sectors for similar installations. By utilising the depth of Jacobs' contacts and experience across the industry, the control system components will be priced to capture both current market conditions and also the full lifecycle and end project costs. For this process Jacobs will outline the assumptions for this analysis which may include assets to be integrated with, presence of existing systems, assumed performance level requirements, size and scope of secondary systems.

Jacobs will make use of any publically available cost data, including Regulatory Information Notice (RIN) data published by the AER as a check against the comparative building block estimates prepared by Jacobs to assess their reasonableness.

2.1.5 Identify any contingencies

Jacobs does not envisage inclusion of any contingency allowances in its comparative estimates. However, should this change for any reason, Jacobs will highlight the level of contingency allowed and the risk it is addressing.

3. Powerlink building blocks

Powerlink has requested comparative unit costs for the asset groups and categories shown in the following tables.

Table 1 Powerlink substation switchbays

Asset category	Comment	UOM
< = 33kV; air insulated circuit breaker		ea
> 33kV & < = 66kV; air insulated circuit breaker		ea
> 66kV & < = 132kV; air insulated circuit breaker	132kV AIS 1 x 3ph CB from Single Feeder Bay	ea
> 132kV & < = 275kV; air insulated circuit breaker	275kV AIS 1 x 3ph CB from 1 ½ CB dia Feeder Bay	ea
> 275kV & < = 330kV; air insulated circuit breaker		ea
< = 33kV; air insulated isolator/earth switch		ea
> 33kV & < = 66kV; air insulated isolator/earth switch		ea
> 66kV & < = 132kV; air insulated isolator/earth switch	132kV AIS 3ph 2 x isolator/1 x earth switch from Single Feeder Bay	ea
> 132kV & < = 275kV; air insulated isolator/earth switch	275kV AIS 3ph 3 x isolator/4 x earth switch from 1 ½ CB dia Feeder Bay	ea
> 275kV & < = 330kV; air insulated isolator/earth switch		ea
< = 33kV; voltage transformer		ea
> 33kV & < = 66kV; voltage transformer		ea
> 66kV & < = 132kV; voltage transformer	132kV AIS 3 x 1ph CVT from Single Feeder Bay	ea
> 132kV & < = 275kV; voltage transformer	275kV 3 x 1ph CVT from 1 ½ CB dia Feeder Bay	ea
> 275kV & < = 330kV; voltage transformer		ea
< = 33kV; current transformer		ea
> 33kV & < = 66kV; current transformer		ea
> 66kV & < = 132kV; current transformer	132kV AIS 3 x 1ph CT from Single Feeder Bay	ea
> 132kV & < = 275kV; current transformer	275kV 3 x 1ph CT from 1 ½ CB dia Feeder Bay	ea
> 275kV & < = 330kV; current transformer		ea
> 66kV & < = 132kV; < = 30MVA power transformer	132/33kV 25MVA ONAF power transformer	ea
> 66kV & < = 132kV; > 30MVA & < = 60MVA power transformer	132/33kV 60MVA ONAF power transformer	ea
> 66kV & < = 132kV; > 60MVA power transformer	132/33kV 125MVA ODAN power transformer	ea
> 220kV & < = 275kV; > 50MVA & < = 100MVA power transformer	275/110kV 100MVA ODAN power transformer	ea
> 220kV & < = 275kV; > 100MVA power transformer	275/132kV 375MVA ODAF power transformer	ea
> 275 kV & < = 330kV; < = 100MVA power transformer	330/132/11kV 100MVA ODAF power transformer	ea
> 275kV & < = 330kV; > 100MVA & < = 250MVA power transformer		ea
> 275kV & < = 330kV; > 250MVA power transformer	330/275kV 1500MVA ODAF power transformer	ea

Table 2 Powerlink substation reactive plant

Asset category	Comment	UOM
< = 33kV; SVCs		ea
> 33kV & < = 66kV; SVCs		ea
> 66kV & < = 132kV; SVCs	STATCOM 132kV 200MVAr (-100 to +100)	ea
> 132kV & < = 275kV; SVCs	SVC 275kV 300MVAr (-50 to +250)	ea
> 275kV & < = 330kV; SVCs		ea
> 330kV & < = 500kV; SVCs		ea
> 500kV; SVCs		ea
< = 33kV; Capacitors		ea
> 33kV & < = 66kV; Capacitors		ea
> 66kV & < = 132kV; Capacitors	Shunt capacitor 145kV 3ph 50MVAr (nominally @ 132kV)	ea
> 132kV & < = 275kV; Capacitors	Shunt capacitor 300kV 3ph 120MVAr (nominally @ 275kV)	ea
> 275kV & < = 330kV; Capacitors	Shunt capacitor 362kV 3ph 120MVAr (nominally @ 330kV)	ea
> 330kV & < = 500kV; Capacitors		ea
> 500kV; Capacitors		ea
< = 33kV; Oil filled reactors		ea
> 33kV & < = 66kV; Oil filled reactors		ea
> 66kV & < = 132kV; Oil filled reactors		ea
> 132kV & < = 275kV; Oil filled reactors	Shunt reactor 300kV 35MVAr oil immersed (nominally 275kV 30MVAr)	ea
> 275kV & < = 330kV; Oil filled reactors		ea
> 330kV & < = 500kV; Oil filled reactors	Shunt reactor 500kV oil immersed (nominally 500kV 1000MVAr)	ea
> 500kV; Oil filled reactors		ea

Table 3 Powerlink transmission line assets

Asset group	Asset category	UOM
Total cost per tower replacement: • assuming whole line to be replaced • old tower decommissioning • new tower costs: materials, construction • conductors: typical span length for voltage • average 400m of conductor, OPGW, OHEW	< = 33kV; Single Circuit	Twr
	> 66kV & < = 132kV; Single Circuit	Twr
	> 132kV & < = 275kV; Single Circuit	Twr
	> 275kV & < = 330kV; Single Circuit	Twr
	> 33kV & < = 66kV; Multiple Circuit	Twr
	> 66kV & < = 132kV; Multiple Circuit	Twr
	> 132kV & < = 275kV; Multiple Circuit	Twr
	> 275kV & < = 330kV; Multiple Circuit	Twr
Total cost per tower for tower refit/refurbishment • existing tower retained • for each structure - 1% of members, 5% of bolts plus painting • insulator (suspension & tension) retained • OHEW & OPGW retained	< = 33kV; Single Circuit	Twr
	> 66kV & < = 132kV; Single Circuit	Twr
	> 132kV & < = 275kV; Single Circuit	Twr
	> 275kV & < = 330kV; Single Circuit	Twr
	> 33kV & < = 66kV; Multiple Circuit	Twr
	> 66kV & < = 132kV; Multiple Circuit	Twr
	> 132kV & < = 275kV; Multiple Circuit	Twr
	> 275kV & < = 330kV; Multiple Circuit	Twr

Asset group	Asset category	UOM
Total cost per tower for tower refit/refurbishment	< = 33kV; Single Circuit	Twr
• existing tower retained	> 66kV & < = 132kV; Single Circuit	Twr
• for each structure	> 132kV & < = 275kV; Single Circuit	Twr
- 1% of members, 5% of bolts plus painting	> 275kV & < = 330kV; Single Circuit	Twr
• insulator (suspension & tension) replaced	> 33kV & < = 66kV; Multiple Circuit	Twr
• OHEW & OPGW replaced	> 66kV & < = 132kV; Multiple Circuit	Twr
	> 132kV & < = 275kV; Multiple Circuit	Twr
	> 275kV & < = 330kV; Multiple Circuit	Twr
Conductor replacement works only	> 33kV & < = 66kV; > 40MVA	km
	> 66kV & < = 132kV; < = 100MVA	km
	> 66kV & < = 132kV; > 100MVA & < = 400MVA	km
	> 66kV & < = 132kV; > 400MVA	km
	> 132kV & < = 275kV; > 200MVA & < = 600MVA	km
	> 132kV & < = 275kV; > 600MVA	km
	> 275kV & < = 330kV; 1200MVA	km

Table 4 Powerlink SCADA & network control and protection systems

Asset category	Comment	UOM
Communications Network	Telecommunications system for large substation including medium size building	ea
Master Station Assets	Master Station equipment & equipment installation costs	ea
Control equipment/systems	Control system , HMI/LCF - rev 7-12000-full	ea
	Standard RTU & installation cost	ea
	132kV cap bank bay control system equipment supply, install include FAT & SAT test cost	ea
	132kV coupler bay control system equipment supply, install include FAT & SAT test cost	ea
	132kV transformer bay control system equipment supply, install include FAT & SAT test cost	ea
	275kV cap bank bay control system equipment supply, install include FAT & SAT test cost	ea
	275kV coupler bay control system equipment supply, install include FAT & SAT test cost	ea
	275kV transformer bay control system equipment supply, install include FAT & SAT test cost	ea
	TFLV control system equipment supply, install include FAT & SAT test cost	ea
Infrastructure: protection & control	HZBZ equipment supply, install include FAT & SAT test cost	ea
	LZBZ_X equipment supply, install include FAT & SAT test cost	ea
	LZBZ_Y equipment supply, install include FAT & SAT test cost	ea
Metering	Duplicate type 2 metering, install include FAT & SAT test cost	ea
Protection scheme/systems	132FDR_2CDIF equipment supply, install include FAT & SAT test cost	ea
	132CDIFDIST equipment supply, install include FAT & SAT test cost	ea
	132FDR_2DIST equipment supply, install include SAT & FAT test cost	ea
	275FDR_2CDIF equipment supply, install include SAT & FAT test cost	ea
	275FDR_2DIST equipment supply, install include FAT & SAT test cost	ea
	275FDR_CDIFDIST equipment supply, install include FAT & SAT test cost	ea
Site establishment	Secondary system establishment - 275kV common large sub establishment - construct related Fixed cost & common services cost	ea

4. Standard Jacobs assumptions

From an international recommended practice[1] for cost estimating:

- There are 5 classes of estimate, with class 5 based upon the lowest level of project definition, and class 1 closest to full project definition
- The level of project definition roughly corresponds to the percentage complete of engineering, and includes project scope definition, requirements documents, specifications, plans, environmental considerations and other information that must be developed to define the project
- For the standard building block unit rates, there would be limited engineering definition for the inclusions and exclusions, and would be regarded as a class 4 estimate with a range of accuracy of approximately +30/-15%

Based on the categorisation of estimates by study type and the AACE 17R-97 recommended practice, Jacobs considers that its standard unit rate estimates satisfy the definition of a class 4 estimate, and has therefore adopted a criterion of ±15% for comparing with other similar comparative cost data as an assessment of reasonableness against available market values.

4.1 Data sources

The standard Jacobs unit rate estimates for this cost data review were developed using a variety of sources, including:

- procurement studies of transmission and distribution asset costs involving the collecting, collating and analysing actual contract prices from seven Australian electricity distributors and four transmission companies for primary items such as circuit breakers, current transformers, voltage transformers, disconnectors, power transformers and conductor
- Jacobs market price surveys of material costs and construction and maintenance activities - activity man-hours used in comparative estimates were based on responses to a market price survey of construction and maintenance activities in the electricity distribution system, conducted by Jacobs over the period June 2001 to May 2003. The surveys included a wide range of capital and operating activities, and attracted between 10 and 15 participants to each survey. Survey participants included government owned utilities, privately owned utilities and private contracting businesses
- contract and procurement costs incurred by utilities on recent projects
- market data from recent operational and capital expenditure reviews for electricity distribution utilities
- recent asset valuations by Jacobs
- Jacobs valuation database

These data sources represent the reference asset database used by Jacobs primarily for asset valuation purposes, as well as supporting project specific estimates. All of this input data is based on what Jacobs believes the cost of these goods and services would be in a reasonably mature competitive marketplace.

As such, these costs may not necessarily directly reflect the actual costs incurred by Powerlink.

4.2 Material costs

We have applied a 12% Stores on-cost for all materials included in the unit rate estimates. This is a nominal amount for material storage which has been considered.

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

4.3 Labour rate

Jacobs has previously conducted surveys with utilities, service providers and contractors to review labour costs associated with a selected range of electricity construction and maintenance activities. As part of these surveys, Jacobs was able to establish average allocations allowed for overhead and on-cost provisions within labour rates across a sample of the Australian market.

Jacobs developed labour hourly rates for this unit rate review was based on the following parameters:

- Basic hourly rates and allowances were based on market data available to Jacobs for electricity utility in-house field personnel
- Market average values for on-costs including:
  - Payroll tax
  - Superannuation
  - Annual, Long Service and Sick leave
  - Workers Compensation
  - Public holidays

The labour rate adopted for the Jacobs estimates was based on the assumption that Powerlink will be utilising their own field personnel; the transmission line unit rates considered the standard linesman labour rate.

The standard hourly rates used by Jacobs (as shown below) have been applied to all estimates in this report except for the transmission line estimates:

- Technical Officer/Supervisor - $104 per hour
- Transmission lineworker - $97 per hour
- Substation/Technical - $87 per hour
- Plant & Transport operator/Labourer - $71 per hour
- Electrical Apprentice - $59 per hour

These labour rates have no provisions for either profit or GST.

For the substations estimate, it should be noted that the above Jacobs hourly rates do not include any allowances for corporate overheads. Jacobs will include a single line item in our building block unit rate estimates for 35% corporate overheads on the labour component of the estimate.

For the building blocks which would typically use contract labour, Jacobs has included an additional 15% onto the labour rate to reflect the nominal profit margin (of 5%) and applicable Goods and Services Tax (GST of 10%) for an external service.

The hourly rates used in the Jacobs comparative estimates have been used in the standard reference assets developed by Jacobs, and were not intended to directly reflect the various skill levels and associated hourly rates used by Powerlink in its unit rates.

For the transmission line estimate, the hourly labour rate was based on $150/hour. There were no corporate overheads separately assumed for this portion of the REPEX calculations. A 15% EPCM loading was applied on the transmission line estimate which is in line with previously constructed projects within the transmission line industry for REPEX purposes.

4.4 Work practices

While Jacobs has independently estimated the unit rate costs for the nominated list of capital and maintenance works from its own data sources, Jacobs recognises that Powerlink has particular design requirements and work practices due to the nature of its network and the specific issues that network presents.

4.5 Accuracy

In establishing a criterion for assessing the reasonableness of the building block unit rates against other available market information, Jacobs is of the opinion that consideration must be given to the level of accuracy that can be achieved.

The graph shown in Appendix A.1 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 in forecasts.

Most of the Powerlink building block unit rate estimates have been based a relatively high level of detail, including allowance for overtime and engineering/supervisory support, as described in the building block definitions (refer section 5). Therefore, Jacobs would consider the estimates to be within the Preliminary Study phase

The overtime is categorised as an allowance for a 6 day construction program.

5. Standard Jacobs building block definitions

The following sections define the standard building blocks that were used to support the generation of the Jacobs unit cost estimates.

5.1 Substation assets

Table 5 Substation switchbay assets descriptions

Works description	Specification	Exclusions/assumptions
• < = 33 kV Air Insulated Circuit Breaker • > 33 kV & < = 66 kV Air Insulated Circuit Breaker • > 66 kV & < = 132 kV Air Insulated Circuit Breaker • > 132 kV & < = 275 kV Air Insulated Circuit Breaker • > 275 kV & < = 330 kV Air Insulated Circuit Breaker	**Scope of work:** • retiring of existing circuit breaker including foundations supply & installation of new footings and circuit breaker, including earthing**Material/hardware (supply & install):** *Equipment* • 1 x 33kV/66kV/132kV AIS 1 x 3ph CB from single feeder bay 1 x 275kV/330kV 1½ CB diameter - 1½ diameter feeder bay*Structure* • Assume included in the equipment cost *Foundations* • New foundations *HV & LV cabling* • Nominal HV & LV cabling allowance *Minor Materials* • Nominal allowance *Associated Bay equipment/works:* • Apportioned allowance for associated bay works including: surge diverters, additional earth switches, line trap & coupling set, coupling capacitor, cabling. busbar, landing span, tower, and beam works *Brownfield Factor* • Nominal allowance for barricaded construction activities and requirements around existing live equipment *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 3/4 man crew typically including: engineer, senior technical/supervisor, technical assistant, cable jointer, technician, protection technician, plant operator *Installation hours*	**Exclusions:** • Engineering, Design, Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour • Traffic control, transport logistics **Assumptions:** • Clear access to site • Design & works plan provided • No reinstatement requirements • No civil, earth grid, ground works required outside of equipment foundation works • No switchbay works, or line works required • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed • Redundant assets removed from installed location, for removal from site and disposal

Works description	Specification	Exclusions/assumptions
	• Normal working hours **Construction equipment:** • Typically crane truck, mini crane, extended work platform **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	

Works description	Specification	Exclusions/assumptions
• < = 33 kV Air Insulated Isolator/Earth Switch • > 33 kV & < = 66 kV Air Insulated Isolator/Earth Switch • > 66 kV & < = 132 kV Air Insulated Isolator/Earth Switch • > 132 kV & < = 275 kV Air Insulated Isolator/Earth Switch • > 275 kV & < = 330 kV Air Insulated Isolator/Earth Switch	**Scope of work:** • retiring of existing isolator/earth switch including foundations • supply & installation of new footings and isolator/earth switch, including earthing **Material/hardware (supply & install):** *Equipment* • 2 x 3ph 33kV/66kV/132kV AIS isolator/earth switch from single feeder bay • 3 x 3ph 275kV/330kV AIS isolator/4 x earth switch from 1½ CB diameter feeder bay *Structure* • New structure (except 33kV) *Foundations* • New foundations *HV & LV cabling* • Nominal HV & LV cabling allowance *Minor Materials* • Nominal allowance *Associated Bay equipment/works:* • Apportioned allowance for associated bay works including: surge diverters, additional earth switches, line trap & coupling set, coupling capacitor, cabling. busbar, landing span, tower, and beam works *Brownfield Factor* • Nominal allowance for barricaded construction activities and requirements around existing live equipment *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 3/4 man crew typically including: engineer, senior technical/supervisor, technical assistant, cable jointer, technician, protection technician, plant operator *Installation hours* • Normal working hours **Construction equipment:** • Typically crane truck, mini crane, extended work platform **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	**Exclusions:** • Engineering, Design, Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour • Traffic control, transport logistics **Assumptions:** • Clear access to site • Design & works plan provided • No reinstatement requirements • No civil, earth grid, ground works required outside of equipment foundation works • No switchbay works, or line works required • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed • Redundant assets removed from installed location, for removal from site and disposal

Works description	Specification	Exclusions/assumptions
• < = 33 kV Voltage Transformer • > 33 kV & < = 66 kV Voltage Transformer • > 66 kV & < = 132 kV Voltage Transformer • > 132 kV & < = 275 kV Voltage Transformer • > 275 kV & < = 330 kV Voltage Transformer	**Scope of work:** • retiring of existing cap voltage transformer set, structure and footings • supply & installation of new footings and cap voltage transformer set, including earthing, protection & control **Material/hardware (supply & install):** *Equipment* • 3 x 1ph 33kV/66kV/132kV CVT from single feeder bay • 3 x 1ph 275kV/330kV CVT from 1½ CB diameter feeder bay *Structure* • New structure *Foundations* • New foundations *HV & LV cabling* • Nominal HV & LV cabling allowance *Minor Materials* • Nominal allowance *Associated Bay equipment/works:* • Apportioned allowance for associated bay works including: surge diverters, additional earth switches, line trap & coupling set, coupling capacitor, cabling. busbar, landing span, tower, and beam works *Brownfield Factor* • Nominal allowance for barricaded construction activities and requirements around existing live equipment *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 2/3 man crew typically including: engineer, senior technical/supervisor, technical assistant, cable jointer, technician, protection technician, plant operator *Installation hours* • Normal working hours **Construction equipment:** • Typically crane truck, mini crane, extended work platform **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	**Exclusions:** • Engineering, Design, Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour • Traffic control, transport logistics **Assumptions:** • Clear access to site • Design & works plan provided • No reinstatement requirements • No civil, earth grid, ground works required outside of equipment foundation works • No switchbay works, or line works required • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed • Redundant assets removed from installed location, for removal from site and disposal

Works description	Specification	Exclusions/assumptions
• < = 33 kV Current Transformer • > 33 kV & < = 66 kV Current Transformer • > 66 kV & < = 132 kV Current Transformer • > 132 kV & < = 275 kV Current Transformer • > 275 kV & < = 330 kV Current Transformer	**Scope of work:** • retiring of existing current transformer set, structure and footings • supply & installation of new footings and current transformer set, including earthing **Material/hardware (supply & install):** *Equipment* • 3 x 1ph 33kV/66kV/132kV CT from single feeder bay • 3 x 1ph 275kV/330kV CT from 1½ CB diameter feeder bay *Structure* • New structure (except 33kV) *Foundations* • New foundations *HV & LV cabling* • Nominal HV & LV cabling allowance *Minor Materials* • Nominal allowance *Associated Bay equipment/works:* • Apportioned allowance for associated bay works including: surge diverters, additional earth switches, line trap & coupling set, coupling capacitor, cabling. busbar, landing span, tower, and beam works *Brownfield Factor* • Nominal allowance for barricaded construction activities and requirements around existing live equipment *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 2/3 man crew typically including: engineer, senior technical/supervisor, technical assistant, cable jointer, technician, protection technician, plant operator *Installation hours* • Normal working hours **Construction equipment:** • Typically crane truck, mini crane, extended work platform **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	**Exclusions:** • Engineering, Design, Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour • Traffic control, transport logistics **Assumptions:** • Clear access to site • Design & works plan provided • No reinstatement requirements • No civil, earth grid, ground works required outside of equipment foundation works • No switchbay works, or line works required • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed • Redundant assets removed from installed location, for removal from site and disposal

Works description	Specification	Exclusions/assumptions
• > 66 kV & < = 132 kV, < = 30MVA Power Transformer • > 33 kV & < = 66 kV, > 30MVA & < = 60MVA Power Transformer • > 66 kV & < = 132 kV, > 60MVA Power Transformer • > 220 kV & < = 275 kV, > 50MVA & < = 100MVA Power Transformer • > 220 kV & < = 275 kV, > 100MVA Power Transformer • > 275 kV & < = 330 kV, < = 100MVA Power Transformer • > 275 kV & < = 330 kV, > 100MVA & < = 250MVA Power Transformer • > 275 kV & < = 330 kV, 250MVA Power Transformer	**Scope of work:** • retiring of existing power transformer including retaining foundation, oil containment • supply & installation of new power transformer, including earthing **Material/hardware (supply & install):** *Equipment* • 1 x 25MVA/60MVA/125MVA 132/33kV power transformer • 1 x 100MVA/375MVA 275/132kV power transformer • 1 x 100MVA 275/110kV power transformer • 1 x 375MVA 330/132kV power transformer • 1 x 1000MVA/1500MVA 330/132kV power transformer *Structure* • Not applicable *Foundations* • Use existing oil containment *HV & LV cabling* • Nominal HV & LV cabling allowance *Minor Materials* • Nominal allowance *Brownfield Factor* • Nominal allowance for barricaded construction activities and requirements around existing live equipment *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 6/8 man crew typically including: engineer, senior technical/supervisor, technical assistant, cable jointer, technician, protection technician, plant operator *Installation hours* • Normal working hours **Construction equipment:** • Typically crane truck, mini crane, extended work platform **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	**Exclusions:** • Engineering, Design, Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour • Traffic control, transport logistics **Assumptions:** • Clear access to site • Design & works plan provided • No reinstatement requirements • No civil, earth grid, ground works required outside of equipment foundation works • No transformer bay works, or line works required • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed • Redundant assets removed from installed location, for removal from site and disposal
• Site Infrastructure • Substation Building • Communication Network assets	**Scope of work:** • Associated site infrastructure retirement, supply & installation works • Associated substation building retirement, supply & installation works • Associated communication network asset retirement, supply & installation	**Exclusions:** • Engineering, Design, Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour

Works description	Specification	Exclusions/assumptions
	works **Material/hardware (supply & install):** *Site Infrastructure* • Busbar & Landing Span Towers & Beams (nominal allowance for works on these assets) • Busbar & Landing Span (nominal allowance for works on these assets) • Lightning protection • Switchyard Lighting • Fence earthing • Drawing records update • Aux transformer • Battery bank • RMU *Substation Buildings* • Demountable Control/Communications building • Climate control A/C • Fire system • Security system *Communication network assets* • S&C communications *HV & LV cabling* • Nominal HV & LV cabling allowance *Minor Materials* • Nominal allowance *Brownfield Factor* • Nominal allowance for barricaded construction activities and requirements around existing live equipment *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 2/3 man crew typically including: engineer, senior technical/supervisor, technical assistant, cable jointer, technician, protection technician, plant operator *Installation hours* • Normal working hours **Construction equipment:** • Typically crane truck, mini crane, extended work platform **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	• Traffic control, transport logistics **Assumptions:** • Clear access to site • Design & works plan provided • No reinstatement requirements • No civil, earth grid, ground works required outside of equipment foundation works • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed • Redundant assets removed from installed location, for removal from site and disposal

All asset groups include allowances for:

- Mobilisation/demobilisation for total project

- Induction and training
- Site offices and crib huts
- Nominal weather delays

5.2 Substation reactive plant

All equipment discussed in this category is manufactured overseas. Costing provided is not supplier-specific however we have assumed that all equipment is sourced in Euro currency. The exchange rated used for overseas sourced equipment and services is EUR:AUD=0.62:1.00.

The overseas cost component for each category differs somewhat for each item, with the averages as follows:

- SVCs: 67%
- Statcoms: 86%
- Shunt capacitor banks: 83%
- Shunt reactors: 81%

5.2.1 General assumptions regarding costing:

The following has not been considered in our cost estimates:

- Allowances for traffic control, and special transport logistics
- Cost specific and internal to Powerlink: Engineering, Design, Project Management, and approvals, procurement overhead costs, storage costs, transport to site
- Administration and negotiations, travel to site
- Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour
- All categories include provision for removal and disposal of redundant assets and replacement of foundations under the title of “Preparation” for capacitor banks and reactors, and are included in the “Civil, installation and commissioning “CIC” category of the SVC and Statcom costing.

The approach to establishing costs differs for the three groups in this category. The costing for shunt capacitor banks and shunt reactors can be based on the replacement cost of primary assets in line with the expectations of this report. The equipment itself is relatively simple to design, deliver and install, and it can be safely assumed that not much site work is required in terms of civil work or structural modifications.

5.2.2 Cost basis for SVC/Statcoms:

For SVCs/Statcoms it is difficult to determine replacement costs, as in such systems there is a close relationship between the technology used, primary equipment, secondary systems, and even footprint. Replacing such systems is possible and Powerlink has done such work in the past; however the cost and scope of work for such replacement work is determined to a large extent by the condition of the primary and secondary systems, the requirements for continuity of supply, and the suitability of using newer technology with older existing equipment.

We have therefore based the cost of dynamic reactive power compensation (SVCs/Statcoms) on our estimates of completely new systems, including the necessary civil work on a turnkey basis.

It should be pointed out that the SVCs rated 250 MVA require more than one TCR, hence there is substantial duplication of associated equipment required.

Cost basis for shunt capacitor banks:

- Shunt capacitor banks at 500kV and above are not feasible, due mainly to the very tall structures involved and the cost of the associated support structures. All high voltage capacitor banks consist of a number of insulated racks that provide insulation grading from line potential to earth. At 500kV a large number of such racks will be required, and the base of these will need to be insulated to line potential. An alternative solution will always be to provide the necessary reactive power compensation at the lower voltage of a transmission station (typically 362kV or 300kV) where shunt capacitor banks are relatively simple to apply.
- Costs provided exclude any costs associated with switchbays or any secondary equipment. Such costs are provided elsewhere in this report.
- No fencing, gates and gate locks are included.
- Shunt capacitors consist of capacitor units mounted in racks, with damping reactors to reduce the effects of switching, and one or more unbalance protection current transformers. The costs of these components are included in our estimate.
- Site installation is relatively simple with limited crane and elevated working platform requirements. The location of the site and site specific working conditions can have a major impact on the cost of site work. We have assumed that the sites are normal, metropolitan sites with relatively easy access for delivery and lifting equipment.

Table 6 Substation reactive plant descriptions

Work description	Brief specification	Assumptions
SVCs	Estimates to be based on: 33kV +50MVAr to -10MVAr 66kV +50MVAr to -10MVAr 132kV +100MVAr to -50MVAr 275kV +250MVAr to -50MVAr 330kV +250MVAr to -50MVAr 500kV +250MVAr to -50MVAr Battery limit is HV terminals of main transformer Civil work to include switchroom for protection & control equipment, valve room, and water cooling system for power electronics	**Construct cost for major components:** Transformer, TCR, filters, valve, protection & control system, engineering, civil design and contracting, installation **Commissioning of:** SVCs, transformer, power modules, protection & control system
Shunt capacitors	Estimates to be based on: 24kV 6MVAr 66kV 15MVAr 145kV 50MVAr 300kV 120MVAr 362kV 120MVAr Based on damped banks, and considers equipment cost, nominal transport costs, installation costs	No rates available for 500kV or above units Excludes consideration of switchbay or secondary systems Assumes site is prepared and fit-for-purpose
Shunt reactors	Estimates to be based on: 24kV 6MVAr 66kV 12MVAr 145kV 18MVAr 300kV 30MVAr 362kV 120MVAr 500kV 1000MVAr 765kV 1000MVAr	Includes nominal design costs, material, labour, nominal transport costs and site installation work Excludes consideration of switchbay Assumes site is prepared and fit-for-purpose and excludes firewall and oil water treatment system

5.3 Transmission lines

5.3.1 General

Transmission Line Asset Group should include nominal allowances for daily travel allowances to site from yard, traffic management, scaffolding / hurdles, biosecurity management, existing line removal / disposal (incl. foundation to 1m below ground level), access works and site restoration.

Qualifications

- Standard EPCM (project management, site supervision, quality management) costs for the Utility to be considered at 15% of the total REPEX cost assumed
- Statutory approvals and environmental permits will be in place in accordance with the Projects' schedule requirements - client to provide all required environmental permits
- The costs of permits, fees and building licences will not been included
- Access to work areas will be provided as required by the Client
- Client is to supply primary survey control points
- Adequate skilled workforce and supervision including accommodation facilities are available for the duration of project - construction workforce is based on local transport and no FIFO has been assumed
- Exchange rate variations are an Owner's cost
- Project delivery will not be constrained due to concurrent projects

Assumptions

- Australian Work Place agreements are in place
- Statutory permits are in place prior to construction
- Trade practice agreements are in place prior to construction
- Site access granted
- No client supplied equipment

Exclusions

The known exclusions to the REPEX estimate at the time of this Estimate include the following:

- No allowance for environmental approvals for stringing equipment access to the stringing locations
- No other allowance has been made for the identification and removal of asbestos and/or other hazardous materials
- No allowance for costs associated with remediation of hydrocarbon contaminated soil or groundwater
- No allowance in estimate for Client costs incurred from Terminal Station Shut-downs
- Cost for Temporary Power/Standby Generation
- Finance charges
- Residual value of temporary equipment and facilities
- Residual value of any redundant equipment
- Cost to Client of any downtime
- Cost to Client of any isolation and de-isolation of plant and equipment
- Environmental approvals
- Construction camp capital costs

- Project financing
- Royalties
- Water and electricity utility consumption
- Development approvals
- Any environmental requirements not identified in the scope
- Removal or relocation of existing underground services that are not part of the current scope of work
- Contract cancellation costs/ Project suspension
- Costs associated with “brownfields discovery” on existing plant or equipment
- That contingency does not allow for the effect of abnormal weather conditions, such as may be associated with cyclones
- That contingency does not allow for any changes to market conditions arising during the course of the project that could affect the cost of labour or materials
- That contingency does not allow for changes of scope within the general production and operating parameters outside the detailed scope of work defined by this study phase
- That contingency does not allow for changes in special industry award allowances in addition to those included in the labour rates
- The effect of industrial disputations
- GST
- Any escalation

5.4 SCADA and network control and protection systems

For the purpose of this exercise, a medium scale SCADA system is assumed with the following characteristics.

5.4.1 Architecture

- System consists of a SCADA Server, I/O Server, Data Server and Historian. Each Server has a backup server
- System consists of 1 central control room and 2 remote access terminals
- System supports 30 RTUs with a maximum capacity of 256 RTUs and 30,000 data points
- All communication and control equipment is battery back for up to 8 hours

5.4.2 Assumptions

- Communication infrastructure is IP based Ethernet and not Power Line Carrier
- Each RTU is IEC 61850 compliant
- The RTUs support RS232/485 byte oriented interface
- The RTUs are capable of sequence of event recording and accept GPS clock
- Site access granted
- No client supplied equipment
- Nominal allowance for replacement of LV cabling up to the switchyard marshalling kiosk

5.4.3 Exclusions

The known exclusions to the REPEX estimate at the time of this Estimate include the following:

- Communication infrastructure is not Power Line Career based

- No allowance for costs associated with programming or reprogramming of SCADA
- No allowance in estimate for building costs
- Cost for Temporary Power/Standby Generation
- Finance charges
- Residual value of temporary equipment and facilities
- Residual value of any redundant equipment
- Cost to Client of any downtime
- Cost to Client of any isolation and de-isolation of plant and equipment
- Environmental approvals
- Construction camp capital costs

Table 7 SCADA and Network Control and Protection System building block descriptions

Works description	Specification	Exclusions/assumptions
Communications Network Asset	**Scope of work:** • Removal of existing cabling infrastructure and addition of new cabling infrastructure • Changes to Control Room to accommodate new racks/equipment. • Installation, configuration and commissioning of networking equipment • testing and commissioning **Material/hardware (supply & install):** *Equipment* • Fibre Cable (5km) • Ethernet (Copper Cable - 500m) • Network Switches (x2) • SFP Modules • Communication Racks Cable pathways and support equipment*Structure* • Not applicable *Foundations* • Not applicable *Minor Materials* • Nominal allowance *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 2/3 man crew typically including: engineer, senior technical/supervisor, cable jointer, technician, tradesperson *Commissioning team* • 1/2 man crew typically including: engineer, senior technical/supervisor *Installation hours* • Normal working hours **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	**Exclusions:** • Engineering, Design, Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour • Traffic control, transport logistics **Assumptions:** • 30 devices per Substation with a maximum capacity of 256. • Maximum 30,000 data points • Communication infrastructure is IP based Ethernet. • Clear access to site • Design & works plan provided • Network Capacity Calculations and Tests performed • No reinstatement requirements • No civil, earth grid, ground works required outside of equipment foundation works • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed • Redundant assets removed from installed location, for removal from site and disposal

Works description	Specification	Exclusions/assumptions
Master Station Assets	**Scope of work:** • retiring of existing Master Station equipment • supply & installation of new equipment • configuration • testing and commissioning **Material/hardware (supply & install):** *Equipment* • I/O Server • SCADA Server • Backup for each Server • Data Storage • Historian • 2/3 Control Desks *Minor Materials* • Nominal allowance *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 3/4 man crew typically including: engineer, senior technical/supervisor, technical assistant, cable jointer, technician, protection technician, plant operator *Installation hours* • Normal working hours **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	**Exclusions:** • Engineering, Design, Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour • Traffic control, transport logistics • No new programming allowed • No new construction allowed **Assumptions:** • 1 Central room and 2 Remote Access Terminals • 1 redundant I/O Server • 1 redundant SCADA Server • Clear access to site • All equipment is battery backed for 8 hours • Design & works plan provided • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed

Works description	Specification	Exclusions/assumptions
Control Equipment/ Systems	**Scope of work:** • Retiring of existing SCADA, RTUs and I/O Modules. • Supply & installation of new SCADA, RTUs and I/O Modules. • Replacement of 132kV Capacitor bank bay control system equipment • Replacement of 132kV Coupler bank bay control system equipment • Replacement of 132kV Transformer bank bay control system equipment • Replacement of 275kV Capacitor bank bay control system equipment • Replacement of 275kV Coupler bank bay control system equipment • Replacement of 275kV Transformer bank bay control system equipment • Replacement of TFLV control system equipment Control System Configuration • testing and commissioning **Material/hardware (supply & install):** *Equipment* • RTU (x30) • Digital Input (x32) • Digital Output (x16) • Analogue Input (x16) • Analogue Output (x4) *LV cabling* • Nominal LV cabling allowance *Minor Materials* • Nominal allowance *Brownfield Factor* • Nominal allowance for barricaded construction activities and requirements around existing live equipment *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 2/3 man crew typically including: engineer, senior technical/supervisor, technical assistant, cable jointer, technician, protection technician, plant operator *Installation hours* • Normal working hours **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	**Exclusions:** • Engineering, Design, Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour **Assumptions:** • RTUs are capable of IEC 61850 • RTUs are capable of sequence of event recording and accept GPS clock • RTUs have RS232/485 byte oriented interface • Clear access to site • Design & works plan provided • No reinstatement requirements • No new PLC Coding required. Existing Code, configuration sufficient. • All equipment is battery backed for 8 hours • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed • Redundant assets removed from installed location, for removal from site and disposal

Works description	Specification	Exclusions/assumptions
Infrastructure: protection and control	**Scope of work:** • retiring of existing protection and control equipment • supply & installation of new protection and control equipment **Material/hardware (supply & install):** *Equipment* • HZBZ • LZBZ_X • LZBZ_Y *Structure* • New structure (except 33kV) *Foundations* • New foundations *HV & LV cabling* • Nominal HV & LV cabling allowance *Minor Materials* • Nominal allowance *Brownfield Factor* • Nominal allowance for barricaded construction activities and requirements around existing live equipment *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 2/3 man crew typically including: engineer, senior technical/supervisor, technical assistant, cable jointer, technician, protection technician, plant operator *Installation hours* • Normal working hours **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	**Exclusions:** • Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour • Traffic control, transport logistics **Assumptions:** • Clear access to site • 1 panel each • Design & works plan provided • No reinstatement requirements • No civil, earth grid, ground works required outside of equipment foundation works • No switchbay works, or line works required • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed • Redundant assets removed from installed location, for removal from site and disposal

Works description	Specification	Exclusions/assumptions
Metering and Protection scheme/systems	**Scope of work:** • retiring of existing metering equipment and protection systems • Factory acceptance testing • supply & installation of new type 2 metering equipment and protection systems • testing and commissioning **Material/hardware (supply & install):** *Equipment* • Type 2 Metering equipment • 132FDR_2CDIF • 132CDIFDIST • 132FDR_2DIST • 275FDR_2CDIF (x 2 panels) • 275FDR_2DIST (x 2 panels) • 275FDR_*CDIFDIST* (x 2 panels) *Structure* • Not applicable *Foundations* Not applicable *LV cabling* • Nominal LV cabling allowance *Minor Materials* • Nominal allowance *Brownfield Factor* • Nominal allowance for barricaded construction activities and requirements around existing live equipment *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 6/8 man crew typically including: engineer, senior technical/supervisor, technical assistant, cable jointer, technician, protection technician, plant operator *Installation hours* • Normal working hours **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	**Exclusions:** • Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour • Traffic control, transport logistics **Assumptions:** • Clear access to site • Design & works plan provided • No reinstatement requirements • No civil, earth grid, ground works required outside of equipment foundation works • No transformer bay works, or line works required • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed • Redundant assets removed from installed location, for removal from site and disposal

Works description	Specification	Exclusions/assumptions
Site establishment	**Scope of work:** • Preparing of the secondary site • supply & installation of new site establishment equipment. • testing and commissioning **Material/hardware (supply & install):** *Equipment* • *2 x 200 kVA s/service transformers* • *1 x AC C/O board* • *2 x AC Distribution Boards* • *2 x DC Distribution Boards* • *2 x batteries & chargers* *Structure* • Not applicable *HV & LV cabling* • Nominal HV & LV cabling allowance *Minor Materials* • Nominal allowance *Brownfield Factor* • Nominal allowance for barricaded construction activities and requirements around existing live equipment *System Operations* • Nominal allowance for testing & commissioning, system switching and operating costs **Labour:** *Installation team* • 6/8 man crew typically including: engineer, senior technical/supervisor, technical assistant, cable jointer, technician, protection technician, plant operator *Installation hours* • Normal working hours **Redundant Equipment:** • Nominal allowance for removal of redundant asset from installed position, for removal from site & disposal	**Exclusions:** • Engineering, Design, Project Management, approvals • Procurement overhead costs, storage costs • Administration & negotiations, travel to site • Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour • Traffic control, transport logistics **Assumptions:** • Clear access to site • Design & works plan provided • No reinstatement requirements • No civil, earth grid, ground works required outside of equipment foundation works • No transformer bay works, or line works required • Estimates based on work undertaken in South East Qld, no project specific costs and locality factors allowed • Redundant assets removed from installed location, for removal from site and disposal

6. Corporate and engineering allocations

Jacobs has applied an allocation of 35% as a corporate overhead costs to all labour and 12% stores on-cost on material base costs. This allocation aligns with the overhead recovery adopted by other utilities in the Australian market.

Where required for the building block definition, we applied an allocation of 10% as an allowance to labour costs for field overtime costs. The overtime is categorised as an allowance for a 6 day construction program.

7. Comparative Jacobs unit rate estimates

The following sections summarise the building block unit cost comparative estimates generated by Jacobs based on the general assumptions described in section 4 and the building block high-level definitions shown in section 5.

7.1 Substation assets

Table 8 shows the comparative estimates for the nominated substation switchbay assets and transformers.

Table 8 Jacobs unit rate comparative estimates for substation switchbays

Asset category	Comment	UOM	Unit Cost (A$)
< = 33kV; air insulated circuit breaker		ea	[redacted] [redacted]
> 33kV & < = 66kV; air insulated circuit breaker		ea	[redacted] [redacted]
> 66kV & < = 132kV; air insulated circuit breaker	132kV AIS 1 x 3ph CB from Single Feeder Bay	ea	[redacted] [redacted]
> 132kV & < = 275kV; air insulated circuit breaker	275kV AIS 1 x 3ph CB from 1 ½ CB dia Feeder Bay	ea	[redacted] [redacted]
> 275kV & < = 330kV; air insulated circuit breaker		ea	[redacted] [redacted]
< = 33kV; air insulated isolator/earth switch		ea	[redacted] [redacted]
> 33kV & < = 66kV; air insulated isolator/earth switch		ea	[redacted] [redacted]
> 66kV & < = 132kV; air insulated isolator/earth switch	132kV AIS 3ph 2 x isolator/1 x earth switch from Single Feeder Bay	ea	[redacted] [redacted]
> 132kV & < = 275kV; air insulated isolator/earth switch	275kV AIS 3ph 3 x isolator/4 x earth switch from 1 ½ CB dia Feeder Bay	ea	[redacted] [redacted]
> 275kV & < = 330kV; air insulated isolator/earth switch		ea	[redacted] [redacted]
< = 33kV; voltage transformer		ea	[redacted] [redacted]
> 33kV & < = 66kV; voltage transformer		ea	[redacted] [redacted]
> 66kV & < = 132kV; voltage transformer	132kV AIS 3 x 1ph CVT from Single Feeder Bay	ea	[redacted] [redacted]
> 132kV & < = 275kV; voltage transformer	275kV 3 x 1ph CVT from 1 ½ CB dia Feeder Bay	ea	[redacted] [redacted]
> 275kV & < = 330kV; voltage transformer		ea	[redacted] [redacted]
< = 33kV; current transformer		ea	[redacted] [redacted]
> 33kV & < = 66kV; current transformer		ea	[redacted] [redacted]
> 66kV & < = 132kV; current transformer	132kV AIS 3 x 1ph CT from Single Feeder Bay	ea	[redacted] [redacted]
> 132kV & < = 275kV; current transformer	275kV 3 x 1ph CT from 1 ½ CB dia Feeder Bay	ea	[redacted] [redacted]
> 275kV & < = 330kV; current transformer		ea	[redacted] [redacted]
> 66kV & < = 132kV; < = 30MVA power transformer	132/33kV 25MVA ONAF power transformer	ea	[redacted] [redacted]
> 66kV & < = 132kV; > 30MVA & < = 60MVA power transformer	132/33kV 60MVA ONAF power transformer	ea	[redacted] [redacted]
> 66kV & < = 132kV; > 60MVA power transformer	132/33kV 125MVA ODAN power transformer	ea	[redacted] [redacted]
> 220kV & < = 275kV; > 50MVA & < = 100MVA power transformer	275/110kV 100MVA ODAN power transformer	ea	[redacted] [redacted]
> 220kV & < = 275kV; > 100MVA power transformer	275/132kV 375MVA ODAF power transformer	ea	[redacted] [redacted]
> 275 kV & < = 330kV; < = 100MVA power transformer	330/132/11kV 100MVA ODAF power transformer	ea	[redacted] [redacted]
> 275kV & < = 330kV; > 100MVA & < = 250MVA power transformer		ea	[redacted] [redacted]
> 275kV & < = 330kV; > 250MVA power transformer	330/275kV 1500MVA ODAF power transformer	ea	[redacted] [redacted]

Table 9 shows the comparative estimates for associated substation site infrastructure, buildings and communication assets generally included in Powerlink’s replacement scope of works.

Table 9 Jacobs unit rate comparative estimates for associated substation site infrastructure, buildings and communication assets

Asset category	Comment	UOM	Unit Cost (A$)
33kV AIS site infrastructure	Site infrastructure retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
66kV AIS site infrastructure	Site infrastructure retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
132kV AIS site infrastructure	Site infrastructure retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
275kV AIS site infrastructure	Site infrastructure retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
330kV AIS site infrastructure	Site infrastructure retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
33kV AIS Substation Building	Substation building retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
66kV AIS Substation Building	Substation building retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
132kV AIS Substation Building	Substation building retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
275kV AIS Substation Building	Substation building retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
330kV AIS Substation Building	Substation building retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
33kV AIS Communication network assets	Communication network asset retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
66kV AIS Communication network assets	Communication network asset retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
132kV AIS Communication network assets	Communication network asset retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
275kV AIS Communication network assets	Communication network asset retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]
330kV AIS Communication network assets	Communication network asset retirement, supply & installation works generally included in bay replacement scope of works	ea	[redacted] [redacted]

7.2 Substation reactive plant

7.2.1 Currency

All equipment discussed in this category is manufactured overseas. Costing provided is not supplier-specific however we have assumed that all equipment is sourced in Euro currency. The exchange rated used for overseas sourced equipment and services is EUR/AUD of 0.62.

The overseas cost component for each category differs somewhat for each item, with the averages as follows:

- SVCs: 67%
- Statcoms: 86%
- Shunt capacitor banks: 83%

- Shunt reactors: 81%

7.2.2 General assumptions regarding costing

The following has not been considered in our cost estimates:

- Allowances for traffic control, and special transport logistics
- Removal and disposal of redundant assets
- Cost specific and internal to Powerlink: Engineering, Design, Project Management, and approvals, procurement overhead costs, storage costs, transport to site
- Administration and negotiations, travel to site
- Allowances for overtime work, contingency, interest during construction, cost escalation, GST on material and internal labour

The approach to establishing costs differs for the three groups in this category. The costing for shunt capacitor banks and shunt reactors can be based on the replacement cost of primary assets in line with the expectations of this report. The equipment itself is relatively simple to design, deliver and install, and it can be safely assumed that not much site work is required in terms of civil work or structural modifications.

7.2.3 Cost basis for SVC/Statcoms

For SVCs/Statcoms it is difficult to determine replacement costs, as in such systems there is a close relationship between the technology used, primary equipment, secondary systems, and even footprint. Replacing such systems is possible and Powerlink has done such work in the past; however the cost and scope of work for such replacement work is determined to a large extent by the condition of the primary and secondary systems, the requirements for continuity of supply, and the suitability of using newer technology with older existing equipment.

We have therefore based the cost of dynamic reactive power compensation (SVCs/Statcoms) on our estimates of completely new systems, including the necessary civil work on a turnkey basis.

It should be pointed out that the SVCs rated 250 MVA require more than one TCR, hence there is substantial duplication of associated equipment required.

Table 10 shows the building block unit costs for SVCs and Table 11 shows the unit costs for Statcoms. The SVC estimates include:

- equipment - transformer, filters, TCR, valve and cooling, protection and control, auxiliary equipment
- engineering and project management
- civil, installation and commissioning

Table 10 Powerlink substation SVCs

Asset category	Description	UOM	Unit Cost ($k AUD)
< = 33kV; SVCs	33kV +50MVAr to -10MVAr	ea	[redacted] [redacted]
> 33kV & < = 66kV; SVCs	66kV +50MVAr to -10MVAr	ea	[redacted] [redacted]
> 66kV & < = 132kV; SVCs	132kV +100MVAr to -50MVAr	ea	[redacted] [redacted]
> 132kV & < = 275kV; SVCs	275kV +250MVAr to -50MVAr	ea	[redacted] [redacted]
> 275kV & < = 330kV; SVCs	330kV +250MVAr to -50MVAr	ea	[redacted] [redacted]
> 330kV & < = 500kV; SVCs	500kV +250MVAr to -50MVAr	ea	[redacted] [redacted]

For the Statcom estimates shown in Table 11, the unit costs include consideration of the transformer, power modules, smoothing reactors, protection and control and auxiliary equipment.

Table 11 Powerlink substation Statcoms

Asset category	Description	UOM	Unit Cost ($k AUD)
< = 33kV; Statcom	33kV +50MVAr to -50MVAr	ea	[redacted] [redacted]
> 33kV & < = 66kV; Statcom	66kV +50MVAr to -50MVAr	ea	[redacted] [redacted]
> 66kV & < = 132kV; Statcom	132kV +100MVAr to -100MVAr	ea	[redacted] [redacted]
> 132kV & < = 275kV; Statcom	275kV +250MVAr to -250MVAr	ea	[redacted] [redacted]
> 275kV & < = 330kV; Statcom	330kV +250MVAr to -250MVAr	ea	[redacted] [redacted]
> 330kV & < = 500kV; Statcom	500kV +250MVAr to -250MVAr	ea	[redacted] [redacted]

7.2.4 Cost basis for shunt capacitor banks

The following assumptions have been applied to the shunt capacitor bank estimates:

- Shunt capacitor banks at 500kV and above are not feasible, due mainly to the very tall structures involved and the cost of the associated support structures. All high voltage capacitor banks consist of a number of insulated racks that provide insulation grading from line potential to earth. At 500kV a large number of such racks will be required, and the base of these will need to be insulated to line potential. An alternative solution will always be to provide the necessary reactive power compensation at the lower voltage of a transmission station (typically 362kV or 300kV) where shunt capacitor banks are relatively simple to apply.
- Costs provided exclude any costs associated with switchbays or any secondary equipment. Such costs are provided elsewhere in this report.
- No fencing, surface finishing, gates and gate locks are included.
- Shunt capacitors consist of capacitor units mounted in racks, with damping reactors to reduce the effects of switching, and one or more unbalance protection current transformers. The costs of these components are included in our estimate.
- Site installation is relatively simple with limited crane and elevated working platform requirements. The location of the site and site specific working conditions can have a major impact on the cost of site work. We have assumed that the sites are normal, metropolitan sites with relatively easy access for delivery and lifting equipment.

The estimates for the shunt capacitors in include consideration of:

- capacitor bank, reactor and auxiliary equipment
- installation and pre-commissioning

Table 12 Powerlink substation shunt capacitors

Asset category	Description	UOM	Unit Cost (A$)
< = 33kV; shunt capacitors	24kV 6MVAr	ea	[redacted] [redacted]
> 33kV & < = 66kV; shunt capacitors	66kV 15MVAr	ea	[redacted] [redacted]
> 66kV & < = 132kV; shunt capacitors	145kV 50MVAr (nominally @ 132kV)	ea	[redacted] [redacted]
> 132kV & < = 275kV; shunt capacitors	300kV 120MVAr (nominally @ 275kV)	ea	[redacted] [redacted]
> 275kV & < = 330kV; shunt capacitors	362kV 120MVAr (nominally @ 330kV)	ea	[redacted] [redacted]

7.2.5 Cost basis for shunt reactors

Shunt reactors are very similar to power transformers in the sense that they consist of a core, windings, tank, oil cooling system, and bushings. The same exclusions that apply to transformers therefore also apply here:

- Costing is not provided for shunt reactors at 765kV and above. Such devices are highly specialised and even cost estimates require substantial design in order to provide a price.
- Costing is not provided at voltages lower than 66kV. At voltages lower than 66kV it will be advantageous to implement dry-type, air core reactors. Such reactors have a reasonably small footprint, and avoiding oil as a coolant has significant advantages in terms of life time and initial civil engineering costs.
- Estimates are based on work undertaken in South East Qld, no project specific costs and locality factors allowed.
- It is assumed that redundant assets have been removed from installed location, for removal from site and disposal by others
- Clear access to site
- No reinstatement requirements
- Assumes site is prepared and fit-for-purpose
- No reactor bay works, line works required
- No consideration of the cost of the switchbay is included.
- Costing includes nominal design costs, material, labour, nominal transport costs and site installation work

Table 13 shows the estimates for unit costs for shunt reactors and includes:

- material, fabrication and auxiliary equipment
- engineering and design

Table 13 Powerlink substation shunt reactors

Asset category	Description	UOM	Unit Cost ($k AUD)
> 33kV & < = 66kV; Oil filled reactors	66kV 12MVAr	ea	[redacted] [redacted]
> 66kV & < = 132kV; Oil filled reactors	145kV 18MVAr	ea	[redacted] [redacted]
> 132kV & < = 275kV; Oil filled reactors	300kV 30MVAr	ea	[redacted] [redacted]
> 275kV & < = 330kV; Oil filled reactors	362kV 120MVAr	ea	[redacted] [redacted]
> 330kV & < = 500kV; Oil filled reactors	500kV 1000MVAr	ea	[redacted] [redacted]

A more detailed breakdown of these estimates is shown in Appendix 0.

7.3 Transmission lines

Table 14 Powerlink transmission line assets

Asset group	Asset category	Voltage	UOM	Unit Cost (A$)	Comment
A) Total cost per tower replacement:	< = 33kV; Single Circuit	33kV	Twr	N/A	
• assuming whole line to be replaced	> 66kV & < = 132kV; Single Circuit	132kV	Twr	[redacted]	Single “Phosphorus”, S/C
• old tower decommissioning	> 132kV & < = 275kV; Single Circuit	275kV	Twr	[redacted]	Twin “Sulphur”, S/C
• new tower costs: materials, construction	> 275kV & < = 330kV; Single Circuit	330kV	Twr	[redacted]	Twin “Sulphur”, S/C
• conductors: typical span length for voltage	> 33kV & < = 66kV; Multiple Circuit	66kV	Twr	[redacted]	Single “Neon”, S/C

Asset group	Asset category	Voltage	UOM	Unit Cost (A$)	Comment
• average 400m of conductor, OPGW, OHEW • including a 15% EPCM loading on all prices	> 66kV & < = 132kV; Multiple Circuit	132kV	Twr	[redacted]	Single “Phosphorus” D/C
	> 132kV & < = 275kV; Multiple Circuit	275kV	Twr	[redacted]	Twin “Sulphur”, D/C
	> 275kV & < = 330kV; Multiple Circuit	330kV	Twr	[redacted]	Twin “Sulphur”, D/C
B) Total cost per tower for tower refit/refurbishment • existing tower retained • for each structure - 1% of members, 5% of bolts plus painting • insulator (suspension & tension) retained • ,OHEW & OPGW retained • including a 15% EPCM loading on all prices				**Suspension**	**Tension**
	< = 33kV; Single Circuit	33kV	Twr	N/A	N/A
	> 66kV & < = 132kV; Single Circuit	132kV	Twr	[redacted]	[redacted]
	> 132kV & < = 275kV; Single Circuit	275kV	Twr	[redacted]	[redacted]
	> 275kV & < = 330kV; Single Circuit	330kV	Twr	[redacted]	[redacted]
	> 33kV & < = 66kV; Multiple Circuit	66kV	Twr	[redacted]	[redacted]
	> 66kV & < = 132kV; Multiple Circuit	132kV	Twr	[redacted]	[redacted]
	> 132kV & < = 275kV; Multiple Circuit	275kV	Twr	[redacted]	[redacted]
	> 275kV & < = 330kV; Multiple Circuit	330kV	Twr	[redacted]	[redacted]
C) Total cost per tower for tower refit/refurbishment • existing tower retained • for each structure - 1% of members, 5% of bolts plus painting • insulator (suspension & tension) replaced • OHEW & OPGW replaced • including a 15% EPCM loading on all prices				**Suspension**	**Tension**
	< = 33kV; Single Circuit	33kV	Twr	[redacted] [redacted] [redacted]	[redacted] [redacted] [redacted]
	> 66kV & < = 132kV; Single Circuit	132kV	Twr	[redacted] [redacted]	[redacted] [redacted]
	> 132kV & < = 275kV; Single Circuit	275kV	Twr	[redacted] [redacted]	[redacted] [redacted]
	> 275kV & < = 330kV; Single Circuit	330kV	Twr	[redacted] [redacted]	[redacted] [redacted]
	> 33kV & < = 66kV; Multiple Circuit	66kV	Twr	[redacted] [redacted]	[redacted] [redacted]
	> 66kV & < = 132kV; Multiple Circuit	132kV	Twr	[redacted] [redacted]	[redacted] [redacted]
	> 132kV & < = 275kV; Multiple Circuit	275kV	Twr	[redacted] [redacted]	[redacted] [redacted]
	> 275kV & < = 330kV; Multiple Circuit	330kV	Twr	[redacted] [redacted]	[redacted] [redacted]
• Conductor replacement works only • including a 15% EPCM loading on all prices	> 33kV & < = 66kV; > 400MVA	66kV	km	N/A	Not feasible
	> 66kV & < = 132kV; < = 100MVA	132kV	km	[redacted]	Single “Krypton”, S/C
	> 66kV & < = 132kV; > 100MVA & < = 400MVA	132kV	km	[redacted]	Twin “Phosphorus”, S/C
	> 66kV & < = 132kV; > 400MVA	132kV	km	[redacted]	Twin “Sulphur”, S/C
	> 132kV & < = 275kV; > 200MVA & < = 600MVA	275kV	km	[redacted]	Single “Sulphur”, S/C
	> 132kV & < = 275kV; > 600MVA	275kV	km	[redacted]	Twin “Sulphur” S/C

Asset group	Asset category	Voltage	UOM	Unit Cost (A$)	Comment
	> 275kV & < = 330kV; 1200MVA	330kV	km	[redacted]	Twin "Sulphur" D/C

7.4 SCADA and network control and protection systems

Table 15 Powerlink SCADA & network control and protection systems

Asset category	Comment	UOM	Unit Cost (A$)
Communications Network	Telecommunications system for large substation including medium size building	ea	[redacted] [redacted]
Master Station Assets	Master Station equipment & equipment installation costs	ea	[redacted] [redacted]
Control equipment/systems	Control system , HMI/LCF - rev 7-12000-full	ea	[redacted] [redacted]
	Standard RTU & installation cost	ea	[redacted] [redacted]
	132kV cap bank bay control system equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
	132kV coupler bay control system equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
	132kV transformer bay control system equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
	275kV cap bank bay control system equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
	275kV coupler bay control system equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
	275kV transformer bay control system equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
	TFLV control system equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
Infrastructure: protection & control	HZBZ equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
	LZBZ_X equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
	LZBZ_Y equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
Metering	Duplicate type 2 metering, install include FAT & SAT test cost	ea	[redacted] [redacted]
Protection scheme/systems	132FDR_2CDIF equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
	132CDIFDIST equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
	132FDR_2DIST equipment supply, install include SAT & FAT test cost	ea	[redacted] [redacted]
	275FDR_2CDIF equipment supply, install include SAT & FAT test cost	ea	[redacted] [redacted]
	275FDR_2DIST equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
	275FDR_CDIFDIST equipment supply, install include FAT & SAT test cost	ea	[redacted] [redacted]
Site establishment	Secondary system establishment - 275kV common large sub establishment - construct related Fixed cost & common services cost	ea	[redacted] [redacted]

The unit costs provided in Table 15 provides a level of componentisation that the AER Repex model doesn't allow for. Rather the Repex model requires an averaged unit cost for secondary system bay and secondary system non bay equipment. Based on typical Powerlink 132kV and 275kV switchyard configurations the applicable averaged secondary systems unit costs are provide in Table 16 below.

Table 16 Secondary systems averaged unit costs

Asset category	Comment	UOM	Unit Cost (A$)
132kV averaged secondary systems bay rate	Typical 132kV switchyard configuration including coupler bay, capacitor bank bay, transformer bay, and feeder bay protection and control	ea	[redacted] [redacted]

Asset category	Comment	UOM	Unit Cost (A$)
275kV averaged secondary systems bay rate	Typical 275kV switchyard configuration including capacitor bank bay, transformer bay, and feeder bay protection and control	ea	[redacted]
132kV secondary systems non bay rate	Typical inclusions per switchyard: control system, HMI/LCF, TFLV control system, master station, standard RTU installation, metering, HZBZ equipment supply, HZBZ_X equipment supply, HZBZ_Y equipment supply.	ea	[redacted]
275kV secondary systems non bay rate	Typical inclusions per switchyard: control system, HMI/LCF, TFLV control system, master station, standard RTU installation, metering, HZBZ equipment supply, HZBZ_X equipment supply, HZBZ_Y equipment supply.	ea	[redacted]

8. Benchmarking of Jacobs unit rates

Where such information was available to us, we have compared base material cost data with other market data to assess the reasonableness of the material cost information being used for the generation of the comparative estimates.

To verify that a comparative estimate is reasonable, Jacobs has typically applied a ±15% test against market values for similar asset building blocks for other electricity entities. The unit rate is first reviewed to determine if it was within the nominal ±15% range, and if so, it is deemed reasonable. If not, the unit rate definition was reviewed against the market value to determine if there are any fundamental differences in the scope of the building block, and if so, the Jacobs comparative estimate was adjusted for any identified difference where it was considered that the original building block definition should be amended. For example, this may mean that removal/disposal costs may have been omitted from the reference market building block; or that the market value may not have included provisions for the same assumptions as allowed for in the Jacobs comparative estimate.

Jacobs made use of any publically available cost data as a check against the comparative building block estimates prepared by Jacobs to assess their reasonableness.

8.1 Substation assets

The review of the comparative unit cost estimates was conducted in 4 asset types:

- Circuit breakers
- Insulators/earth switches
- Instrument transformers
- Power transformers

Typically, the comparison has been done by adjusting the unit cost based on the standard building block definition shown in section 5.1.

8.1.1 Circuit breakers

We examined the unit rates for circuit breakers we have used for previous asset valuations for ElectraNet and Power and Water Corporation, and previous work with the Australian Energy Market Operator (AEMO) and adjusted our comparative unit cost estimate to remove the allocations and associated works that are excluded from valuations, such as:

- allowances for asset decommissioning and removal
- nominal allowance for barricaded construction activities
- allowance for overtime
- mobilisation/demobilisation for project work
- delivery costs
- allowances for contract labour
- associated equipment (eg. line trap & coupling set, coupling capacitor, busbar, tower, and beam works)

Asset valuation unit rates do not include these allocations, and therefore as part of the verification process, we have removed these considerations from the unit cost estimates prepared for Powerlink as part of this assignment to allow for verification against other unit rates previously generated by us for other entities.

The following table shows the variances between the adjusted unit cost estimates for Powerlink and previous estimates prepared for other third parties.

Table 17 Comparison of CB unit cost estimates (in A$) for Powerlink vs other cost estimates

Asset category	Unit Cost Generated	Unit Cost Adjusted	Comparative Unit Cost Estimate	Variance
< = 33kV; air insulated circuit breaker	[redacted] [redacted]	[redacted] [redacted]	$ -	
> 33kV & < = 66kV; air insulated circuit breaker	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	-5.3%
> 66kV & < = 132kV; air insulated circuit breaker	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	-6.9%
> 132kV & < = 275kV; air insulated circuit breaker	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	-1.8%
> 275kV & < = 330kV; air insulated circuit breaker	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	5.1%

In each case, the variance is well within the nominal ±15% range we use for assessing reasonableness, and therefore we have concluded that the unit cost estimates for circuit breakers we have generated for Powerlink based on the standard building block definitions described in section 5.1 are reasonable in comparison to previous estimates for similar assets we have provided to other third parties.

8.1.2 Insulators/earth switches

We examined the unit rates for isolator/earth switches we have used for previous assignments for the AEMO, ElectraNet and Ergon Energy and adjusted our comparative unit cost estimate to remove the allocations and associated works that are excluded from valuations, such as:

- allowances for asset decommissioning and removal
- nominal allowance for barricaded construction activities
- allowance for overtime
- mobilisation/demobilisation for project work
- delivery costs
- allowances for contract labour
- associated equipment (eg. line trap & coupling set, coupling capacitor, busbar, tower, and beam works)

The unit rates developed for these third parties did not include these allocations, and therefore as part of the verification process, we have removed these considerations from the unit cost estimates prepared for Powerlink as part of this assignment to allow for verification against other unit rates previously generated by us for other entities.

The following table shows the variances between the adjusted unit cost estimates for Powerlink and previous estimates prepared for other third parties.

Table 18 Comparison of isolator/earth switch unit cost estimates (in A$) for Powerlink vs other cost estimates

Asset category	Unit Cost Generated	Unit Cost Adjusted	Comparative Unit Cost Estimate	Variance
< = 33kV; air insulated isolator/earth switch	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	-10.9%
> 33kV & < = 66kV; air insulated isolator/earth switch	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	-8.8%
> 66kV & < = 132kV; air insulated isolator/earth switch	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	-7.7%
> 132kV & < = 275kV; air insulated isolator/earth switch	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	8.3%
> 275kV & < = 330kV; air insulated isolator/earth switch	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	12.4%

In each case, the variance is well within the nominal ±15% range we use for assessing reasonableness, and therefore we have concluded that the unit cost estimates for isolator/earth switches we have generated for

Powerlink based on the standard building block definitions described in section 5.1 are reasonable in comparison to previous estimates for similar assets we have provided to other third parties.

8.1.3 Instrument transformers

We examined the unit rates for instrument transformers we have used for previous assignments for the ElectraNet and asset valuation work for both Australian and international utilities, and adjusted our comparative unit cost estimate to remove the allocations and associated works that are excluded from valuations, such as:

- allowances for asset decommissioning and removal
- nominal allowance for barricaded construction activities
- allowance for overtime
- mobilisation/demobilisation for project work
- delivery costs
- allowances for contract labour
- associated equipment (eg. line trap & coupling set, coupling capacitor, busbar, tower, and beam works)

The unit rates developed for these third parties did not include these allocations, and therefore as part of the verification process, we have removed these considerations from the unit cost estimates prepared for Powerlink as part of this assignment to allow for verification against other unit rates previously generated by us for other entities.

The following tables show the variances between the adjusted unit cost estimates for Powerlink and previous estimates prepared for other third parties.

Table 19 Comparison of VT unit cost estimates (in A$) for Powerlink vs other cost estimates

Asset category	Unit Cost Generated	Unit Cost Adjusted	Comparative Unit Cost Estimate	Variance
< = 33kV; 3ph cap voltage transformer	[redacted]	[redacted]	[redacted]	-12.7%
> 33kV & < = 66kV; 3ph cap voltage transformer	[redacted]	[redacted]	[redacted]	15.4%
> 66kV & < = 132kV; 3ph cap voltage transformer	[redacted]	[redacted]	[redacted]	6.5%
> 132kV & < = 275kV; 3ph cap voltage transformer	[redacted]	[redacted]	[redacted]	11.8%
> 275kV & < = 330kV; 3ph cap voltage transformer	[redacted]	[redacted]	[redacted]	1.4%

Table 20 Comparison of CT unit cost estimates (in A$) for Powerlink vs other cost estimates

Asset category	Unit Cost Generated	Unit Cost Adjusted	Comparative Unit Cost Estimate	Variance
< = 33kV; 3ph current transformer	[redacted]	[redacted]	[redacted]	17.5%
> 33kV & < = 66kV; 3ph current transformer	[redacted]	[redacted]	[redacted]	13.2%
> 66kV & < = 132kV; 3ph current transformer	[redacted]	[redacted]	[redacted]	-1.7%
> 132kV & < = 275kV; 3ph current transformer	[redacted]	[redacted]	[redacted]	-0.5%
> 275kV & < = 330kV; 3ph current transformer	[redacted]	[redacted]	[redacted]	-12.3%

In almost each case, the variance is well within the nominal ±15% range we use for assessing reasonableness, and therefore we have concluded that the unit cost estimates for instrument transformers we have generated for Powerlink based on the standard building block definitions described in section 5.1 are reasonable in comparison to previous estimates for similar assets we have provided to other third parties. For two instances, the variance identified is at the upper end of the nominal range.

8.2 SCADA and network control and protection systems

For SCADA and network protection and control systems, as part of the unit rate estimation process, Jacobs relied on available market costs and associated costs from major suppliers, combined with knowledge and experience from peer providers in electricity and across the utilities sectors for similar installations.

The control system costs capture both current market conditions and also the full lifecycle and end project costs. Our assumptions have been outlined in section 5.4 .

9. Risk components

We have excluded any contingency allowances in the unit rate estimates.

10. Conclusions

Jacobs has developed the unit rate estimates using the most reliable market and publicly available data in accordance with the building block definitions detailed in section 5.

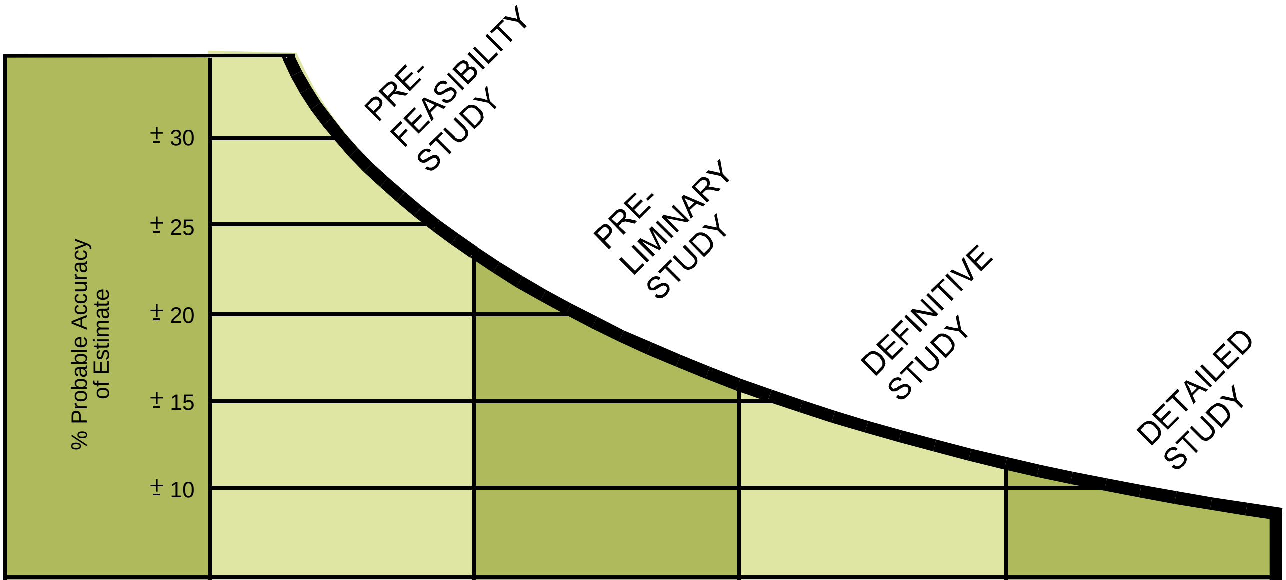
Jacobs compared wherever possible with unit rates for similar assets developed for other electricity utilities for other purposes and found the unit rate estimates developed for Powerlink are consistent.

Jacobs further included consideration of market-typical corporate overheads and stores on-costs included considerations raised by Powerlink, based on work in SE Queensland and the use Rawlinsons Construction Handbook for suggestion for regional factors.

Appendix A. Engineering estimates

A.1 Definition chart

Figure 1 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

A.2 Estimate classes

The various estimate classes are defined in AACE International Recommended Practice No. 17R-97 *COST ESTIMATE CLASSIFICATION SYSTEM TCM Framework: 7.3 – Cost Estimating and Budgeting*.

The purpose statement states that "*… as a recommended practice of AACE International, the Cost Estimate Classification System provides guidelines for applying the general principles of estimate classification to asset project cost estimates. Asset project cost estimates typically involve estimates for capital investment, and exclude operating and life-cycle evaluations. The Cost Estimate Classification System maps the phases and stages of asset cost estimating together with a generic maturity and quality matrix that can be applied across a wide variety of industries.*"[2]

The classification methodology notes that "*… there are numerous characteristics that can be used to categorize cost estimate types. The most significant of these are degree of project definition, end usage of the estimate, estimating methodology, and the effort and time needed to prepare the estimate. The "primary" characteristic used in this guideline to define the classification category is the degree of project definition. The other characteristics are "secondary."*

Categorizing cost estimates by degree of project definition is in keeping with the AACE International philosophy of Total Cost Management, which is a quality-driven process applied during the entire project life cycle. The discrete levels of project definition used for classifying estimates correspond to the typical phases and gates of evaluation, authorization, and execution often used by project stakeholders during a project life cycle.

Five cost estimate classes have been established. While the level of project definition is a continuous spectrum, it was determined from benchmarking industry practices that three to five discrete categories are commonly used. Five categories are established in this guideline as it is easier to simplify by combining categories than it is to arbitrarily split a standard.

The estimate class designations are labelled Class 1, 2, 3, 4, and 5 [refer Table 21]*. A Class 5 estimate is based upon the lowest level of project definition, and a Class 1 estimate is closest to full project definition and maturity. This arbitrary "countdown" approach considers that estimating is a process whereby successive estimates are prepared until a final estimate closes the process*."[3]

Table 21 IRP No. 17R-97 Generic cost estimate classification matrix

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

2 AACE International, *Recommended Practice No. 17R-97: Cost Estimating Classification System (TCM Framework: 7.3 – Cost Estimating and Budgeting)*, p 1, 12 August 1997

3 ibid., p 2

Notes:

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

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

Appendix B. Jacobs unit rates estimates

B.1 Substation assets

The following table shows the breakdown of the unit rate estimates for the nominated substation assets and power transformers.

Table 22 Unit cost estimates for circuit breakers (values in AUD)

Asset	Engineering	Material	Installation	Plant	Operations (1)	Other (2)	Corp OH	Total
33kV AIS CB	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]
66kV AIS CB	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]
132kV AIS CB	[redacted] [redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]
275kV AIS CB	[redacted] [redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]
330kV AIS CB	[redacted] [redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]

1. Network switching, testing and commissioning
2. Removal and disposal, delivery/transport, mobilisation/demobilisation

Table 23 Unit cost estimates for isolator/earth switch (values in AUD)

Asset	Engineering	Material	Installation	Plant	Operations (1)	Other (2)	Corp OH	Total
33kV AIS isolator/ES	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
66kV AIS isolator/ES	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
132kV AIS isolator/ES	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]
275kV AIS isolator/ES	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]
330kV AIS isolator/ES	[redacted] [redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]

1. Network switching, testing and commissioning
2. Removal and disposal, delivery/transport, mobilisation/demobilisation

Table 24 Unit cost estimates for cap voltage transformers (values in AUD)

Asset	Engineering	Material	Installation	Plant	Operations (1)	Other (2)	Corp OH	Total
33kV VT	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
66kV VT	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
132kV VT	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]
275kV VT	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]
330kV VT	[redacted] [redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]

1. Network switching, testing and commissioning
2. Removal and disposal, delivery/transport, mobilisation/demobilisation

Table 25 Unit cost estimates for current transformers (values in AUD)

Asset	Engineering	Material	Installation	Plant	Operations (1)	Other (2)	Corp OH	Total
33kV CT	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
66kV CT	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
132kV CT	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
275kV CT	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
330kV CT	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

1. Network switching, testing and commissioning
2. Removal and disposal, delivery/transport, mobilisation/demobilisation

Table 26 Unit cost estimates for power transformers (values in AUD)

Asset	Engineering	Material	Installation	Plant	Operations (1)	Other (2)	Corp OH	Total
132/33kV 25MVA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
132/33kV 60MVA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
132/33kV 125MVA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
275/110kV 100MVA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
275/132kV 375MVA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
330/132kV 100MVA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
330/132kV 250MVA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
330/275kV 1500MVA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

1. Network switching, testing and commissioning
2. Removal and disposal, delivery/transport, mobilisation/demobilisation

Table 27 Unit cost estimates for asset site infrastructure (values in AUD)

Asset	Engineering	Material	Installation	Plant	Operations (1)	Other (2)	Corp OH	Total
33kV AIS site infrastructure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
66kV AIS site infrastructure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
132kV AIS site infrastructure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
275kV AIS site infrastructure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
330kV AIS site infrastructure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

1. Network switching, testing and commissioning
2. Removal and disposal, delivery/transport, mobilisation/demobilisation

Table 28 Unit cost estimates for substation control buildings (values in AUD)

Asset	Engineering	Material	Installation	Plant	Operations (1)	Other (2)	Corp OH	Total
33kV AIS Control Building	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Asset	Engineering	Material	Installation	Plant	Operations (1)	Other (2)	Corp OH	Total
66kV AIS Control Building	[redacted] [redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]
132kV AIS Control Building	[redacted] [redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]
275kV AIS Control Building	[redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]
330kV AIS Control Building	[redacted]	[redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted]

1. Network switching, testing and commissioning
2. Removal and disposal, delivery/transport, mobilisation/demobilisation

Table 29 Unit cost estimates for communication network assets (values in AUD)

Asset	Engineering	Material	Installation	Plant	Operations (1)	Other (2)	Corp OH	Total
33kV AIS Communication network assets	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
66kV AIS Communication network assets	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
132kV AIS Communication network assets	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
275kV AIS Communication network assets	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
330kV AIS Communication network assets	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

1. Network switching, testing and commissioning
2. Removal and disposal, delivery/transport, mobilisation/demobilisation

B.2 Substation reactive plant

The following tables show a detailed breakdown of the building block unit cost estimates for the nominated substation reactive plant.

Table 30 Unit cost estimates for SVCs (all values in $k AUD)

Description	Equipment (1)	EPM (2)	CIC (3)	Total
33kV +50 MVAr to -10 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
66kV +50 MVAr to -10 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
132kV +100 MVAr to -50 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
275kV +250 MVAr to -50 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
330kV +250 MVAr to -50 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
500kV +250 MVAr to -50 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

1. Equipment: Transformer, filters, TCR, Valve and cooling, protection and control, auxiliary equipment
2. EPM: Engineering and project management
3. Civil, installation and commissioning

Table 31 Unit cost estimates for Statcoms (all values in $k AUD)

Description	Equipment (1)	EPM	CIC	Total
33kV +50 MVAr to -50 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
66kV +50 MVAr to -50 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
132kV +100 MVAr to -100 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
275kV +250 MVAr to -250 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
330kV +250 MVAr to -250 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
500kV +250 MVAr to -250 MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

1. Transformer, power modules, smoothing reactors, protection and control and auxiliary equipment

Table 32 Unit cost estimates for shunt capacitors (all values in $k AUD)

Description	Equipment (1)	Preparation	ED (3)	CIC (2)	Total
24kV 6MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
66kV 15MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
145kV 50MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
300kV 120MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
362kV 120MVAr	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

1. Capacitor bank, reactor, auxiliary equipment
2. Civil, Installation and pre-commissioning
3. Engineering and design (civil works)

Table 33 Unit cost estimates for shunt reactors (all values in $k AUD)

Description	Equipment (1)	ED (2)	Transport	C+Prep+IC(3)	Total
66kV 12MVAr	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
145kV 18MVAr	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Description	Equipment (1)	ED (2)	Transport	C+Prep+IC(3)	Total
300kV 30MVAr	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
362kV 120MVAr	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
500kV 1000MVAr	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

1. Material, fabrication and auxiliary equipment
2. Engineering and design
3. Civil, Installation and pre-commissioning

B.3 Transmission lines

The following illustrates the breakdown of the estimates for the building blocks.

A) Asset Group: Conductors by Voltage

- Maximum Continuous Rating
- Conductor replacement works only

Assumptions:

- The conductor replacement works costings will be presented in accordance with the table submitted in the "Addendum to Request for Quote" dated 18/8/2015
- The costings will be derived by assuming there will be no requirements for structure and/or foundation modifications or strengthening
- Costing will assume that insulation will be retained
- Costing will include the provision and fitting of new vibration dampers
- Costings will assume that any existing overhead earthwire or OPGW will not be replaced
- The replacement methodology would be as follows:
  - De-energise and apply running earths/working earths to the conductors
  - Remove spacers (if multi bundled) and dampers from the conductors
  - Remove jumpers and insulator sets at tension towers and join the existing conductor ends to short lengths of conductor to compensate for removal of the insulator sets from the circuit
  - Place the conductors in running-out sheaves
  - Set up the replacement conductor on drum stands and through a braking machine
  - Attach the new conductor to the end of the old conductor utilising a wire stocking
  - Install the old conductor at the far end of the pulling section into a winch and then to conductor recovery drums
  - Haul in the new conductor with the old conductor placing the old conductor onto conductor drums for salvage
  - Tension and clip in new conductor
  - Install new dampers and spacers (if multi bundled)
  - Install new jumpers
  - Remove earths
- Conductor lengths will include a 5% allowance for sag, jumpers and wastage

Table 34 Conductor selection

Asset category	Conductor	Approx rating at highest voltage[4]	Comments
> 33kV & < = 66kV ; < 400MVA	Single " Sulphur" 61/3.75 AAAC/1120	128 MVA	Largest standard AAAC/1120 conductor available
> 66kV & < = 132kV ; < 100MVA	Single "Krypton" 19/3.75 AAAC/1120	108 MVA	Meets required thermal rating at 132kV

[4] Olex Cables Bare Conductor catalog

Asset category	Conductor	Approx rating at highest voltage[4]	Comments
> 66 kV & < = 132kV ; > 100MVA & < = 400MVA	Twin "Phosphorus" 37/3.75 AAAC/1120	306 MVA	Meets mid-range thermal rating at 132kV
> 66kV & < = 132kV ; > 400MVA	Twin "Sulphur" 61/3.75 AAAC/1120	410 MVA	Largest standard AAAC/1120 conductor available
> 132kV & < = 275kV ; > 200MVA & < = 600MVA	Single "Sulphur" 61/3.75 AAAC/1120	534 MVA	Meets mid-range thermal rating at 275kV

The ratings have been based on the following conditions:

- Conductor temperature rises above ambient of 40 degrees C
- Rural weathered condition
- Ambient air temperature of 35 degrees for summer noon
- Wind velocity of 1 metre/second
- De-rating factor of 0.8 for multi conductor arrangements

A.1) FOR SINGLE CONDUCTOR ARRANGEMENT FOR VOLTAGES > 66kV & < = 275kV ON TOWERS

- "Krypton" 19/3.25 AAAC/1120 Conductor: Cost $2.20 /metre
- Based on 50 km of line with 400 metre spans (125 towers) = 2.5 towers/km.
- Assume 10% tension towers (0.25 tension towers/km)
- Assumes existing conductor will be used as a draw wire.
- Assumes new conductor will be on 6.3 km drums and 2 drum pulls
- Assumes labour rate= $150/hr for 10hr day ($1,500/man day)
- GST has not been added.

Table 35 Conductor cost calculation

Item No	Task	Cost for total line	Cost for 1km of line (1/50)	Remarks	Cost for total line	Cost for 1km of line (1/50)
Labour and Material Resources					**Equipment Resources**	
1	Mobilisation	[redacted]	[redacted]			
2	Isolate and earth line	[redacted]	[redacted]	2 person/ 1day	[redacted]	[redacted]
3	Remove dampers	[redacted]	[redacted]	2 person 15 towers/day	[redacted]	[redacted]
4	Remove spacers (if required)	N/A		4 person 10 spans/day		
5	Remove jumpers and install short lengths of conductor to join two ends of existing cond.	[redacted]	[redacted]	3 person 2 towers /day	[redacted]	[redacted]
6	Place conductors in running out sheaves	[redacted]	[redacted]	4 person 5 towers/day	[redacted]	[redacted]

Item No	Task	Cost for total line	Cost for 1km of line (1/50)	Remarks	Cost for total line	Cost for 1km of line (1/50)
Labour and Material Resources					**Equipment Resources**	
7	Set up tension stringing equipment	[redacted]	[redacted]	4 person 2days x 4 pulls		
8	Haul in new conductor	[redacted]	[redacted]	8 person 4 days x4 pulls	[redacted]	[redacted]
9	Tension new conductor	[redacted]	[redacted]	5 person 4 days/ tower x12.5 towers	[redacted]	[redacted]
10	Clip in conductor	[redacted]	[redacted]	3 person 8 towers/day x 112.5 towers	[redacted]	[redacted]
11	Install new dampers	[redacted]	[redacted]0	2 person 15 towers/day	[redacted]	[redacted]
12	Install new spacers (if required)	N/A				
13	Install new jumpers	[redacted]	[redacted]	3 person 3 towers/day	[redacted]	[redacted]
14	Remove earths	[redacted]	[redacted]	2 person /1day	[redacted]	[redacted]
15	Demobilise	[redacted]	[redacted]			
16	Purchase new conductor	[redacted]	[redacted]			
17	Purchase new conductor fittings Compression D/E & AGSU.	[redacted]	[redacted]	[redacted]		
18	Purchase new dampers	[redacted]	[redacted]	[redacted]		
19	Purchase new spacers (if required)	N/A				
20	Accommodation and meals	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Total1		[redacted]	Total2		[redacted]
	Grand Total		[redacted]			

A.2) Base cost for "Krypton" conductor supplied on 6.3 km drums= $2.20/metre

Adjustments as follows;

[redacted]

Table 36 Conductor cost calculation

Item	Base cost	Cost for “Sulphur”	Cost for “Phosphorus”

Item	Base cost	Cost for “Sulphur”	Cost for “Phosphorus”
Set up tension stringing equipment	[redacted]	[redacted]	[redacted]
Haul in conductor	[redacted]	[redacted]	[redacted]
Purchase new conductor	[redacted]	[redacted]	[redacted]
Purchase new conductor fittings	[redacted]	[redacted]	[redacted]
Total3	[redacted]	[redacted]	[redacted]

Hence Cost/km for Range of Conductors is as per below

- [redacted]
- [redacted]
- [redacted]

A.3) FOR TWIN CONDUCTOR ARRANGEMENT FOR VOLTAGES > 66kV & < = 132kV ON TOWERS

- Phosphorus 37/3.75 AAAC/1120 conductor: Cost $4.60/metre
- Based on 50 km of line with 400 metre spans (125 towers) = 2.5 towers/km.
- Assume 10% tension towers (0.25 tension towers/km)
- Assumes existing conductor will be used as a draw wire.
- Assumes new conductor will be on 3.3 km drums and 3 drum pulls
- Assumes labour rate= $150/hr for 10hr day ($1,500/man day)
- GST has not been added.

Table 37 Conductor cost calculation

Item No	Task	Cost for total line	Cost for 1km of line (1/50)	Remarks	Cost for total line	Cost for 1km of line (1/50)
Labour and Material Resources					**Equipment Resources**	
1	Mobilisation	[redacted]	[redacted]			
2	Isolate and earth line	[redacted]	[redacted]	2 men/ 1day	[redacted]	[redacted]
3	Remove dampers	[redacted]	[redacted]	2 men 8 towers/day	[redacted]	[redacted]
4	Remove spacers (if required)	[redacted]	[redacted]	4 men 8 spans/day	[redacted]	[redacted]
5	Remove jumpers and install short lengths of conductor to join two ends of existing cond.	[redacted]	[redacted]	3 men 1.5 towers /day	[redacted]	[redacted]
6	Place conductors in running out sheaves	[redacted]	[redacted]	4 men 3 towers/day	[redacted]	[redacted]

Item No	Task	Cost for total line	Cost for 1km of line (1/50)	Remarks	Cost for total line	Cost for 1km of line (1/50)
Labour and Material Resources					**Equipment Resources**	
7	Set up tension stringing equipment	[redacted]	[redacted]	4 men 3days x 5 pulls		
8	Haul in new conductor	[redacted]	[redacted]	8 men 10 days x 5 pulls	[redacted]	[redacted]
9	Tension new conductor	[redacted]	[redacted]	5 men 6 days/ tower x12.5 towers	[redacted]	[redacted]
10	Clip in conductor	[redacted]	[redacted]	3 men 5 towers/day x 112.5 towers	[redacted]	[redacted]
11	Install new dampers	[redacted]	[redacted]	2 men 8 towers/day	[redacted]	[redacted]
12	Install new spacers (if required)	[redacted]	[redacted]	4 men 8 spans/day	[redacted]	[redacted]
13	Install new jumpers	[redacted]	[redacted]	3 men 2 towers/day	[redacted]	[redacted]
14	Remove earths	[redacted]	[redacted]	2 men /1day	[redacted]	[redacted]
15	Demobilise	[redacted]	[redacted]			
16	Purchase new conductor	[redacted]	[redacted]			
17	Purchase new conductor fittings Compression D/E & AGSU.	[redacted]	[redacted]			
18	Purchase new dampers	[redacted]	[redacted]	[redacted]		
19	Purchase new spacers (if required)	[redacted]	[redacted]	15 spacers/ span = 9/ tension twr jumper		
20	Accommodation and meals	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		Total4	[redacted]		Total5	[redacted]
		Grand Total	[redacted]			

A.4) [redacted]

Adjustments as follows;

[redacted]

Table 38 Conductor cost calculation

Item	Base cost	Cost for "Sulphur"	Cost for "Krypton"
Set up tension stringing equipment	[redacted]	[redacted]	[redacted]
Haul in conductor	[redacted]	[redacted]	[redacted]
Purchase new conductor	[redacted]	[redacted]	[redacted]
Purchase new conductor fittings	[redacted]	[redacted]	[redacted]
Total6	[redacted]	[redacted]	[redacted]

Hence Cost/km for Range of Conductors is as per below

[redacted]

A.5) FOR SINGLE CONDUCTOR ARRANGEMENT FOR VOLTAGES > 33kV <= 66kV ON POLES

- Sulphur 61/3.75 AAAC/1120 conductor: Cost $7.50/metre
- Based on 50 km of line with 150 metre spans (333 poles) =6.66 poles/km.
- Assume 10% tension poles (0.67 tension poles/km)
- Assumes existing conductor will be used as a draw wire.
- Assumes new conductor will be on 2.0 km drums and 4 drum pulls
- Assumes labour rate= $150/hr for 10hr day ($1,500/man day)
- GST has not been added.

Table 39 Conductor cost calculation

Item No	Task	Cost for total line	Cost for 1km of line (1/50)	Remarks	Cost for total line	Cost for 1km of line (1/50)
Labour and Material Resources					Equipment Resources	
1	Mobilisation	[redacted]	[redacted]			
2	Isolate and earth line	[redacted]	[redacted]	2 men/ 1day	[redacted]	[redacted]
3	Remove dampers	N/A				
4	Remove spacers (if required)	N/A				
5	Remove jumpers and install short lengths of conductor to join two ends of existing cond.	[redacted]	[redacted]	3 men 8 poles/day	[redacted]	[redacted]
6	Place conductors in running out sheaves	[redacted]	[redacted]	3 men 10 poles/day	[redacted]	[redacted]
7	Set up tension stringing equipment	[redacted]	[redacted]	4 men 2 days x 6		

Item No	Task	Cost for total line	Cost for 1km of line (1/50)	Remarks	Cost for total line	Cost for 1km of line (1/50)
Labour and Material Resources					**Equipment Resources**	
				pulls		
8	Haul in new conductor	[redacted]	[redacted]	8 men 6 days x 6 pulls	[redacted]	[redacted]
9	Tension new conductor	[redacted]	[redacted]	4 men 1.5 days/pole x 33.3 poles	[redacted]	[redacted]
10	Clip in conductor	[redacted]	[redacted]	3 men 15poles/day x 330 poles	[redacted]	[redacted]
11	Install new dampers	[redacted]	[redacted]	2 men 20 poles/day	[redacted]	[redacted]
12	Install new spacers (if required)	N/A				
13	Install new jumpers	Included in Item 9				
14	Remove earths	[redacted]	[redacted]	2 men /1day	[redacted]	[redacted]
15	Demobilise	[redacted]	[redacted]			
16	Purchase new conductor	[redacted]	[redacted]			
17	Purchase new conductor fittings Compression D/E & AGSU.	[redacted]	[redacted]			
18	Purchase new dampers	[redacted]	[redacted]	[redacted]		
19	Purchase new spacers (if required)	[redacted]	[redacted]			
20	Accommodation and meals	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		Total4	[redacted]		Total5	[redacted]
		Grand Total	[redacted]			

A.6) [redacted]

Adjustments as follows;

[redacted]

Table 40 Conductor cost calculation

Item	Base cost	Cost for “Sulphur”	Cost for “Phosphorus”
Set up tension stringing equipment	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
Haul in conductor	[redacted] [redacted]	[redacted] [redacted]	[redacted]
Purchase new conductor	[redacted]	[redacted]	[redacted]
Purchase new conductor fittings	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
Total	[redacted]	[redacted]	[redacted]

Hence Cost/km for Range of Conductors is as per below

[redacted] [redacted]

[redacted] [redacted]

[redacted] [redacted]

A.7) FOR TWIN CONDUCTOR ARRANGEMENT FOR VOLTAGES >132kV & < = 330kV ON TOWERS

- Sulphur 61/3.75 AAAC/1120 conductor: Cost $7.50/metre
- Based on 50 km of line with 400 metre spans (125 towers) = 2.5 towers/km.
- Assume 10% tension towers (0.25 tension towers/km)
- Assumes existing conductor will be used as a draw wire.
- Assumes new conductor will be on 2.0km drums and 4 drum pulls
- Assumes labour rate= $150/hr for 10hr day ($1,500/man day)
- GST has not been added.

Table 41 Conductor cost calculation

Item No	Task	Cost for total line	Cost for 1km of line (1/50)	Remarks	Cost for total line	Cost for 1km of line (1/50)
Labour and Material Resources					**Equipment Resources**	
1	Mobilisation	[redacted] [redacted]	[redacted] [redacted]			
2	Isolate and earth line	[redacted] [redacted]	[redacted] [redacted]	2 men/ 1day	[redacted]	[redacted] [redacted]
3	Remove dampers	[redacted] [redacted]	[redacted] [redacted]	2 men 7 towers/day	[redacted]	[redacted] [redacted]
4	Remove spacers (if required)	[redacted] [redacted]	[redacted] [redacted]	4 men 7 spans/day	[redacted]	[redacted] [redacted]
5	Remove jumpers and install short lengths of conductor to join two ends of existing cond.	[redacted] [redacted]	[redacted] [redacted]	3 men 1.5 towers	[redacted]	[redacted] [redacted]

Item No	Task	Cost for total line	Cost for 1km of line (1/50)	Remarks	Cost for total line	Cost for 1km of line (1/50)
Labour and Material Resources					**Equipment Resources**	
				/day	=$33,200	
6	Place conductors in running out sheaves	[redacted]	[redacted]	4 men 2.75 towers/day	[redacted]	[redacted]
7	Set up tension stringing equipment	[redacted]	[redacted]	4 men 3.5days x 6 pulls		
8	Haul in new conductor	[redacted]	[redacted]	8 men 13.0 days x 6 pulls	[redacted]	[redacted]
9	Tension new conductor	[redacted]	[redacted]	5 men 6 days/ tower x12.5 towers	[redacted]	[redacted]
10	Clip in conductor	[redacted]	[redacted]	3 men 5 towers/day x 112.5 towers	[redacted]	[redacted]
11	Install new dampers	[redacted]	[redacted]	2 men 7towers/day	[redacted]	[redacted]
12	Install new spacers (if required)	[redacted]	[redacted]	4 men 7spans/day	[redacted]	[redacted]
13	Install new jumpers	[redacted]	[redacted]	3 men 2 towers/day	[redacted]	[redacted]
14	Remove earths	[redacted]	[redacted]	2 men /1day	[redacted]	[redacted]
15	Demobilise	[redacted]	[redacted]			
16	Purchase new conductor	[redacted]	[redacted]			
17	Purchase new conductor fittings Compression D/E & AGSU.	[redacted]	[redacted]			
18	Purchase new dampers	[redacted]	[redacted]	[redacted]		
19	Purchase new spacers (if required)	[redacted]	[redacted]	15 spacers/ span = 9/ tension twr jumper		
20	Accommodation and meals	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Total4		[redacted]		Total5	[redacted]
	Grand Total		[redacted]			

B) Asset Group A - Total cost per tower replacement

- assuming whole line to be replaced
- old tower decommissioning
- new tower costs: materials, construction
- conductors: typical span length for voltage
- average 400m of conductor, OPGW, OHEW

Assumptions:

- Estimated line costs are based historical data and current material and service provider's quotations for the provision of 132kV and 330kV self-supporting galvanised lattice steel tower lines constructed in Region A wind areas. Base costs have been adjusted for the remaining voltage levels.
- Single circuit towers are provided with a single OPGW earthwire. Double circuit towers are fitted with dual earthwires, one OPGW and one SC/GZ OHEW.
- Single phase conductors have been used for voltages from 33kV to 275kV. For acceptable corona performance twin bundled phase conductors have been selected for voltages greater than 275kV.
- Tower design is not included.
- Prototype assembly and testing of towers are not included.
- Access facilities are not included
- Foundation testing is not included.
- The transmission lines are assumed to be designed and constructed in accordance with the provisions provided in AS 7000 and AS/NZS 1170.2 "Structural design actions Part 2: Wind actions
- Redundant foundations are not completely removed - only removed to 1 metre below ground level
- No value given to scrap tower steelwork and conductor
- Typical foundation cost allowed for appropriate tower type based on normal dry soil conditions
- For the tower rate, the total cost of the line replacement has been divided by the total number of towers
- No allowance included for road/rail and overhead line crossings
- Existing access tracks are in good condition

EXPLANATION ON HOW THE ESTIMATES FOR ASSET GROUP "A" WAS DERIVED

Background

To estimate the cost of a unit tower in transmission lines of various voltages is a challenging task due to a number of unstipulated variables including:

- In-situ ground conditions for foundation construction, access, earthing etc.
- Type of tower ie. Intermediate, Strain, Terminal
- Topography of line corridor
- Distance from a major town to service consumable items

Approach to prepare the estimate

- The approach adopted by Jacobs was to refer to a +/- 15% estimate for a 330kV single circuit transmission line prepared for Western Power approximately 3 years ago.
- Details of the reference transmission line are as follows:
- Location: Muja Power Station – Township of Kojonup. (South West WA)- Wind Region "A"

- Corridor conditions: New line to replace existing 132kV line on Wood "Pi" structures. Located mainly in state forest and farmland in an existing easement.
- Voltage: 330kV
- Configuration: Single Circuit
- Conductors: Twin "Selenium" 61/3.25 AAAC/1120
- Earthwire: 48 core OPGW
- Line Length: 99.8km
- No of Structures: 220
- Average Span Length: 453m
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- To take into consideration the voltage changes and the subsequent reduction in the tower dimensions we have allocated a 7.5% discount for voltages from 330kV to 275kV and a further 12.5% for voltages from 275kV to 132kV.
- [redacted]
- [redacted]
- [redacted]

C) Asset Group D - Total cost per tower for tower refit/refurbishment

- existing tower retained
- for each structure
  - 1% of members, 5% of bolts plus painting
- insulator (suspension & tension) retained
- OHEW & OPGW retained

Assumptions:

Tower painting is done on a per square metre basis. The price is dependent on factors such as:

- The % level of surface corrosion on the steel,
- The % level of Zinc Corrosion Product (ZCP)
- The specifications for the coating and preparation,
- The amount of containment required. Are we talking towers built in a World Heritage Park, adjacent to homes, wet areas or a polluted industrial waste land.
- The configuration of the insulation that needs covering.

- Access to the towers.
- Is the earthing left on overnight or is access returned and the line put back into service.

On a sample project in Cairns the towers need 40% abrasive blasting with the remaining requiring a high pressure wash. There is vehicular access to most towers and Cairns is a good support town.

The overall rate for the works is $480 /m2 and this includes:

- Management
- Insurance and bonds
- Earth application
- Circuit access management
- All blasting and Coating
- Removal and dumping of environmental matting.

The preparation and coating aspect of the works is $360 per m2 and this included:

- Insulator covering
- Installation of containment blinds
- Laying of Environmental matting
- Measuring residual galvanising
- Abrasive blasting areas of corrosion and ZCP
- Washing down the steel
- Testing for surface contaminates and blast profile
- Provision of the coating, abrasive media and blast machinery.
- Application of coat No 1
- QA coating check
- Dry Film testing
- Wash down of steel
- Application of coat No 2
- QA coating check
- Dry Film testing

The voltage or tower size do not affect the price to a great extent. The numbers of towers to spread the overheads over, access and circuit availability are main factors that affect the price.

D) Asset Group C - Total cost per tower for tower refit/refurbishment

- existing tower retained
- for each structure
  - 1% of members, 5% of bolts plus painting
- insulator (suspension & tension) replaced
- OHEW & OPGW replaced

Assumptions:

- Estimated line costs are based historical data and current material and service provider's quotations for the provision of materials and services required for the replacement of electrical equipment.
- Single circuit towers are assumed to be fitted with one OPGW earthwire. Double circuit towers are assumed to be fitted with dual earthwires, one OPGW and one SC/GZ OHEW.
- Single phase conductors have been used for voltages from 33kV to 132kV. For acceptable corona performance twin bundled phase conductors have been selected for of 275kV and above.
- [redacted]
  - [redacted]
  - [redacted]
- Assumed 1 nos of Crane Operator and 3 nos of Labour required per tower
- Engineering design assessment of replacement members including integrity assessment - 35% of total price including site visit by Engineering.

Table 42 Suspension insulator sets - single conductor (all values in $ AUD)

Voltage	Insulators	Insulator fittings	Erection (3 men + EPV – 1 hr)	Total cost / tower (x3) SC	Total cost / tower (x6) DC
33kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
66kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
132kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
275kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

Table 43 Suspension insulator sets - twin conductor (all values in $ AUD)

Voltage	Insulators	Insulator fittings	Erection (3 men + EPV – 1.6 hr)	Total cost / tower (x3) SC	Total cost / tower (x6) DC
33kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
66kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
132kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
275kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
330kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

Table 44 Tension insulator sets - single conductor (all values in $ AUD)

Voltage	Insulators	Insulator fittings	Erection (3 men + EPV – 3 hr)	Total cost / tower (x6) SC	Total cost / tower (x12) DC
33kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
66kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
132kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
275kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

Table 45 Tension insulator sets - twin conductor (all values in $ AUD)

Voltage	Insulators	Insulator fittings	Erection (3 men + EPV – 4 hr)	Total cost / tower (x6) SC	Total cost / tower (x12) DC
33kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
66kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

Voltage	Insulators	Insulator fittings	Erection (3 men + EPV – 4 hr)	Total cost / tower (x6) SC	Total cost / tower (x12) DC
132kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
275kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]
330kV	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]	[redacted] [redacted]

Table 46 OPGW & OHEW unit costs (all values in $ AUD)

Category	Voltage	Material	Erection		Total
OPGW suspension sets	All voltages	[redacted] [redacted]	[redacted] [redacted]	(3 men + EPV – 1.0hr)	$ [redacted]
OPGW tension sets	All voltages	[redacted] [redacted]	[redacted] [redacted]	(3 men + EPV - 1.5 hr)	$ [redacted]
OHEW suspension sets	All voltages	[redacted] [redacted]	[redacted] [redacted]	(3 men + EPV - 0.75hr)	$ [redacted]
OHEW tension sets	All voltages	[redacted] [redacted]	[redacted] [redacted]	(3 men + EPV - 1.0 hr)	$ [redacted]
Replacement of 400 metres OPGW	All voltages	[redacted] [redacted]	[redacted] [redacted]	(3 men + EPV - 8.0 hr)	$ [redacted]
Replacement of 400 metres OHEW	All voltages	[redacted] [redacted]	[redacted] [redacted]	(3 men + EPV - 8.0 hr)	$ [redacted]

Table 47 Painting Costs – Suspension Towers

Category (Suspension Towers)	Estimated Weight (tonnes)	Estimated Height (m)	Estimated Surface Area (m^2)	Total
> 66kV & < = 132kV; Single Circuit	10	25	197.42	[redacted]
> 132kV & < = 275kV; Single Circuit	17	30	268.00	[redacted]
> 275kV & < = 330kV; Single Circuit	20	45	363.94	[redacted]
> 33kV & < = 66kV; Multiple Circuit	8	18	234.08	[redacted]
> 66kV & < = 132kV; Multiple Circuit	12	28	317.88	[redacted]
> 132kV & < = 275kV; Multiple Circuit	20	35	431.68	[redacted]
> 275kV & < = 330kV; Multiple Circuit	25	50	623.79	[redacted]

Table 48 Painting Costs – Strain Towers

Category (Strain Towers)	Estimated Weight (tonnes)	Estimated Height (m)	Estimated Surface Area (m^2)	Total
> 66kV & < = 132kV; Single Circuit	15	24	219.51	[redacted]
> 132kV & < = 275kV; Single Circuit	22	28	298.09	[redacted]
> 275kV & < = 330kV; Single Circuit	25	43	404.81	[redacted]
> 33kV & < = 66kV; Multiple Circuit	12	16	609.23	[redacted]
> 66kV & < = 132kV; Multiple Circuit	16	26	645.78	[redacted]
> 132kV & < = 275kV; Multiple Circuit	28	33	684.53	[redacted]
> 275kV & < = 330kV; Multiple Circuit	35	48	725.83	[redacted]

Table 49 Replacement of steel members – Suspension Towers

Category (Suspension Towers)	Estimated Replacement Length per Tower (m)	# Work days	Labour	Materials, Crane Costs inclusive	Engineering	Total
> 66kV & < = 132kV; Single Circuit	6.18	2	[redacted]	[redacted]	[redacted]	[redacted]
> 132kV & < = 275kV; Single Circuit	9.76	2	[redacted]	[redacted]	[redacted]	[redacted]
> 275kV & < = 330kV; Single Circuit	13.25	4	[redacted]	[redacted]	[redacted]	[redacted]
> 33kV & < = 66kV; Multiple Circuit	6.77	2	[redacted]	[redacted]	[redacted]	[redacted]
> 66kV & < = 132kV; Multiple Circuit	9.19	2	[redacted]	[redacted]	[redacted]	[redacted]
> 132kV & < = 275kV; Multiple Circuit	12.48	4	[redacted]	[redacted]	[redacted]	[redacted]
> 275kV & < = 330kV; Multiple Circuit	17.75	4	[redacted]	[redacted]	[redacted]	[redacted]

Table 50 Replacement of steel members – Strain Towers

Category (Suspension Towers)	Estimated Replacement Length per Tower (m)	# Work days	Labour	Materials, Crane Costs inclusive	Engineering	Total
> 66kV & < = 132kV; Single Circuit	8.34	2	[redacted]	[redacted]	[redacted]	[redacted]
> 132kV & < = 275kV; Single Circuit	11.33	2	[redacted]	[redacted]	[redacted]	[redacted]
> 275kV & < = 330kV; Single Circuit	15.39	4	[redacted]	[redacted]	[redacted]	[redacted]
> 33kV & < = 66kV; Multiple Circuit	14.82	4	[redacted]	[redacted]	[redacted]	[redacted]
> 66kV & < = 132kV; Multiple Circuit	15.71	4	[redacted]	[redacted]	[redacted]	[redacted]
> 132kV & < = 275kV; Multiple Circuit	16.65	4	[redacted]	[redacted]	[redacted]	[redacted]
> 275kV & < = 330kV; Multiple Circuit	20.81	5	[redacted]	[redacted]	[redacted]	[redacted]

B.4 SCADA and network control and protection systems

The following table illustrates the breakdown of the derivation of the unit rates for the SCADA and network control and protection systems.

Table 51 SCADA & network control and protection systems (all values in AUD)

Asset group	Asset includes	Cost
Communications Network Assets: • Equipment Cost • Labour Cost	2 x Network Switches	$ [redacted]
	1 x Firewall	$ [redacted]
	2 x UPS	$ [redacted]
	Cabling	$ [redacted]
	Installation, testing and commissioning	$ [redacted]
	Total Cost:	**$** [redacted]
Master Station Assets • Equipment Cost (Hardware & Software) • Labour Cost	5 x Servers	$ [redacted]
	2 x UPS	$ [redacted]
	Software Licensing Fee	$ [redacted]
	3 x User Station Software	$ [redacted]
	SQL Database	$ [redacted]
	Installation, testing and commissioning	$ [redacted]
	Total Cost:	**$** [redacted]

Asset group	Asset includes	Cost
Control equipment/systems • Equipment Cost • Labour Cost	30 x RTU with I/O	$ [redacted]
	HV Control System Equipment	$ [redacted]
	Installation	$ [redacted]
	Testing and commissioning	$ [redacted]
	Total Cost:	**$** [redacted]
Infrastructure: protection and control • Equipment Cost • Labour Cost	Design	$ [redacted]
	equipment supply and installation including FAT and SAT	$ [redacted]
	Total Cost:	**$** [redacted]
Metering • Equipment Cost • Labour Cost	Design	$ [redacted]
	equipment supply and installation including FAT and SAT	$ [redacted]
	Total Cost:	**$** [redacted]
Protection scheme/systems • Equipment Cost • Labour Cost	Design	$ [redacted]
	equipment supply and installation including FAT and SAT	$ [redacted]
	Total Cost:	**$** [redacted]
Site establishment • Equipment Cost • Labour Cost	Design	$ [redacted]
	equipment supply and installation including FAT and SAT	$ [redacted]
	• Total Cost:	• $ [redacted]