Specialist Consultants
to the Electricity Industry

ElectraNet Project Cost Estimates

Comparison Report

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For	**ElectraNet**
Reference	**JA6237**
Date	**13 December 2016**

Revision Table

Revision	Issue Date	Description
0	23/11/2016	First Draft
1	07/12/2016	Final
2	13/12/2016	For Submission

Reviewers

Name	Interest	Signature	Date
Andrew Robbie	Principal Electrical Engineer		07/12/2016
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Approval

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1. Introduction

PSC Australia was engaged by ElectraNet to develop independent cost estimates for a representative selection of network projects proposed in their capital project forecast for the next regulatory period (Reset Period 4, 2018-2023).

The purpose of the engagement was to demonstrate whether the cost estimates developed by ElectraNet are prudent and efficient, and within the range of accuracy expected.

This report is provided to summarise the methodology, source of costs/prices, key costing assumptions and results of the independent cost estimates.

Following completion of the independent cost estimates, PSC undertook a comparison with the estimates developed by ElectraNet, to analyse key differences. The cost estimate comparison is also provided in this report.

Information on PSC and the CV's for the PSC Australia team for this project can be found in Appendix 1.

1.1 Scope of Services

PSC's cost estimating scope of services for the selected projects, listed in Table 1, was as follows:

- Review the project scope documents provided by ElectraNet;
- Breakdown the scope for each project into building blocks for cost estimating purposes; and
- Prepare a cost estimate to the accuracy level of Class 4 in accordance with AACE[1] classification;

Table 1 - Final List of Selected Projects

ElectraNet Project Number	Project Name
14056	Para-Davenport Additional 275kV System Reactor
14077	Mannum Transformer 1 and 2 Replacement
14081	Line Insulator Systems Refurbishment 2018-23
14084	Line Insulator Systems Refurbishment 2018-23

The final stage of PSC's engagement was to compare the cost estimates developed independently by PSC against those developed by ElectraNet, provide an analysis of cost variations and reasons for the differences.

1.2 Accuracy and Limitations

The cost estimates developed by PSC Australia are high level estimates based on a level of scope definition in the order of 1% to 15%, for a Class 4 estimate in accordance with AACE[2]estimate classification. The estimates were developed as a desktop exercise. No site visits or detailed engineering was undertaken, nor was it in

[1] AACE – http://web.aacei.org/home - AACE International is a recognised body providing guidelines for cost engineering and total cost management
[2] AACE International Recommended Practice No. 56R-08

PSC Australia's scope to develop an independent scope or detailed work breakdown structure for any of the selected projects.

In accordance with the AACE guidelines the expected capital cost accuracy of the estimates developed by PSC is ±30%.

Specifically excluded from the PSC Australia cost estimates are:

- Development application, cultural heritage, environmental, and permitting costs.
- Costs associated with the alteration of easements, or acquisition of easements.
- Purchase of additional land and landowner liaison
- Allowances for annual movement in foreign exchange
- ElectraNet internal costs.

PSC notes that reasonable costs associated with these activities would be incurred in the efficient delivery of network projects.

2. Methodology

The overall process followed by PSC Australia for independent cost estimate development and comparison was as follows:

Step 1 - *Initial Cost Estimate* - PSC were provided with a project scope of work, from which PSC developed independent cost estimates in the format of cost building blocks.

Step 2 - *Scope Clarification* - PSC met with ElectraNet to review the detail of the scope and cost building blocks developed by PSC during Step 1.

Step 3 - *Final Cost Estimate* - PSC refined the independent cost estimates to account for any differences in scope as identified in Step 2.

Step 4 - *Cost Comparison* – PSC received a cost estimate comparison table from ElectraNet providing a high level comparison of the differences between the PSC and ElectraNet costs.

2.1 Initial Cost Estimate

PSC's methodology for reviewing and preparing estimates for each of the selected projects was as follows:

1. The project scope document, provided by ElectraNet, was reviewed to confirm the level of scope definition was sufficient for a Class 4 estimate.
2. ElectraNet's design standards and other relevant standards were reviewed to define estimate building blocks and develop equipment specifications for obtaining budget estimates from suppliers of major equipment.
3. The initial cost estimates were developed with the following approach:

a. PSC's existing "building block" cost estimation database was utilised, and modified where required, for current equipment prices, labour rates, material costs, allowances and other relevant assumptions.

b. Suppliers were contacted for budgetary pricing and lead times for major items of plant and equipment.

c. Contractors and suppliers of construction plant were contacted for labour hire rates, equipment hire rates and construction duration estimates.

4. Cost assumptions and allowances were made based on the level of scope definition, as well as site specific and geographic conditions.

No site visits were undertaken by PSC staff. The cost estimate was based on the project scopes provided and with reference to ElectraNet design standards.

On completion of this step, PSC issued the cost estimates to ElectraNet for review.

2.2 Scope Clarification

Following submission of PSC's initial cost estimates a meeting was held with ElectraNet to clarify the estimate scope, building blocks, assumptions and to identify any areas of difference.

During scope clarifications PSC did not receive or review ElectraNet's detailed cost estimates.

To ensure consistency between the scope and assumptions, the following items were discussed:

- Scope of work documents and design details that were used to develop each estimate;
- Materials or quantities used;
- Project delivery methodologies;
- Assumptions and allowances estimated that may not have been provided in detail within the scope of work documents.

Key issues discussed or identified during the meeting included:

- PSC's estimates include a contingency allowance, as a separate line item, to account for cost-risks that are known to occur but cannot be accurately predicted. PSC consider the contingency allowance as an integral part of the high level estimate. Following clarification PSC understands that ElectraNet do not include a contingency for the items identified by PSC. ElectraNet has included allowances for known contingency items based on ElectraNet's historical records and experience of delivering similar projects. Also the ElectraNet estimates are developed to a higher level of detail and scope definition than the PSC estimates.
- PSC's estimates include a percentage based allowance for project management. [redacted] However, [redacted]

[redacted]

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

2.3 Final Cost Estimate

For each project, the cost estimate developed by PSC in Step 1 was reviewed in light of any scope differences identified in Step 2. Any significant scope differences were addressed and the estimates were adjusted accordingly.

On completion of this step, PSC issued final cost estimates to ElectraNet for review.

One further revision of PSC's cost estimate was requested by ElectraNet [redacted]

2.4 Cost Comparison

ElectraNet's final cost estimates for the selected projects were then provided to PSC, with a high level breakdown and comparison with PSC's costs.

Areas of differences were reviewed at a high level. Based on this analysis, PSC has provided an assessment of reasons for and possible causes of cost difference. The results of this analysis are provided in Section 5.

A comparison of PSC and ElectraNet cost estimates is provided in Table 4.

3. Source of Costs and Prices

The sources of the cost assumptions adopted by PSC for major items of primary plant are summarised in Table 2. The original equipment manufacturer (OEM) pricing information typically has a degree of confidentiality associated with it. The names of OEMs and suppliers used can be provided on request.

Table 2 - Sources of Primary Plant Equipment Unit Prices

Cost Item	Source Description
CVT 275kV	Derived from prior experience
Circuit breaker 275 kV	Budget prices from OEM, 2016
Disconnector 275 kV	Budget prices from OEM, 2016
Earth Switch 275 kV	Budget Prices from OEM 2016
Post Insulator 275 kV	Derived from prior experience
Reactor, 50MVar, 275kV Oil type fitted with bushing CT's	Budget prices from OEM, 2016
Rigid Bus 275kV	Derived from prior experience
Surge Arrester 33 kV	Derived from prior experience
Surge arrester 132 kV	Derived from prior experience
Surge arrester 275 kV	Derived from prior experience
Transformer, 25 MVA, 132/33 kV	Budget prices from OEM, 2016

Sources for other major cost items are summarised in Table 3.

Table 3 - Sources of Other Cost Items

Cost Item	Source Description
Primary Construction/Installation	South Australian based electrical contractor estimates obtained for similar projects in 2016. PSC engineering experience from similar installations
Secondary design/construction /installation	Costs are based on a combination of 1. Engineering experience; 2. Electrical contractor time/cost estimates from 2016; 3. Relay equipment prices sourced from supplier budget prices; and/or 4. Publically published prices.
Site infrastructure and civil works, and foundations	Based on a combination of: 1. Engineering experience; and 2. Unit rates in Rawlinson's Australian Construction Handbook 2016.
Transmission Lines and structures	Tower basic parameters (e.g. steel tonnage) established from engineering experience. Steel supply/assembly/installation costs built up from units rates in Rawlinson's Australian Construction Handbook 2016, and engineering experience. Line stringing costs based on unit rates from engineering experience. Conductor cost based on previous prices from suppliers and adjusted for changes in raw materials prices
Communications	Based on a combination of: 1. Engineering experience; and 2. Budget prices obtained from suppliers.
Design	Based on the following allowances developed from experience: 1. Transmission line design – 5% of transmission line cost 2. Primary/civil design – 8% of total primary/civil cost
Project Management	Allowance of 8% of total project cost used in similar costing projects.
Site specific contingency allowance/project contingency allowance	A contingency allowance of 10% has been applied to high level estimates for projects with a significant number of assumptions/unknowns or unquantifiable requirements.
Remote location allowance	A percentage premium for construction in remote locations was obtained directly from Rawlinson's Australian Construction Handbook 2016 for the nearest reference location to site or the average if the project has multiple reference locations.

4. Key Costing Assumptions

Key costing assumptions used by PSC in the development of the cost estimates are listed below:

- A design allowance of [redacted] of the estimated project costs has been used for primary/site works and for transmission lines respectively. [redacted]
- A project management allowance of [redacted] has been applied to all works where project management is not already built into PSC's building block estimates.
- A site specific factor or [redacted] (e.g. geotechnical, earthing, weather), possible 24 hour shifts during critical outages, the staging and structuring of work or items that may be identified during a site visit/inspection.
- The average remote location indices were obtained from the Rawlinson's Construction Handbook 2016. These are detailed specifically in the list of costing assumptions applied to each individual project.
- Equipment unit prices which are more than one year old have been escalated by 2.5% per annum.
- No contractor margin (profit) has been added to any of the major procurement items. These have been assumed to be free issued by ElectraNet.
- A South Australian CITB levy has been applied to all construction contractor cost elements and project management costs that are directly applicable to the works. Design costs are excluded from the CITB levy.
- Prices for major items of equipment have been based on budget/unit prices, either obtained from OEM(s) or from PSC's existing cost estimation database. These estimates are based on one-off purchases and do not take advantage of any discounts or lower than market prices that may be negotiated by ElectraNet due to large quantity ordering.
- Certain assumptions have been made on base metal prices. These are detailed specifically in the list of costing assumptions applied to each individual project, as well as the validity of the price. These assumptions apply to the cost of copper, aluminium and steel. October 2016 rates have been used, obtained from http://www.lme.com/,
- Certain assumptions have been made on exchange rates where pricing information is provided in a currency other than AUD. These are detailed specifically in the list of costing assumptions applied to each individual project. Rates valid on 12 October 2016 have been used, obtained from http://www.x-rates.com.
- Other project specific assumptions have been detailed in the individual cost estimates.

5. Comparison with ElectraNet Prices -

An overall summary of the cost estimates is provided in Table 4.

Table 4 - Summary of PSC Cost Estimates Compared to ElectraNet's Cost Estimates

ElectraNet Project Number	Project Name	PSC Cost Estimate	ElectraNet Cost Estimate	Accuracy
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

5.1 Para-Davenport Additional 275kV System Reactors

[redacted]

5.2 Mannum Transformer 1 and 2 Replacement

[redacted]

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

5.3 Line Insulator Systems Refurbishment 2018-23

[redacted]

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

5.4 Line Conductor and Earthwire Refurbishment 2018-23

[redacted]

6. Conclusion

Based on the independent cost estimates performed by PSC, and within the limitations stated in Section 1.2, PSC finds that the network project cost estimates developed by ElectraNet for the representative selection of projects are within the range of accuracy expected for high level cost estimates of this nature.

Material variations observed in the cost estimates can be attributed to site specific factors, differences in cost estimate methodologies and allowances. PSC's independent cost estimates were performed as a desktop study, without the benefits of a site visit. The variations observed are to be expected for an independent review of this nature, considering the background knowledge and understanding of both parties.

Based on the information available, PSC concludes that the cost estimates produced by ElectraNet appear to be reasonable and provide a realistic indication of the costs required to undertake network projects of the types identified.

Appendix 1 – PSC Information and CV's

Power Systems Consultants was established in 1995 in New Zealand by two passionate electricity professionals. Now known as PSC, the company has rapidly grown into a multi-national organisation. PSC is now a team working across the globe from our bases in Australia, New Zealand, USA, Europe and Asia.

PSC is a niche provider of engineering services to clients within the electricity industry globally. Our clients include Market System Operators, Transmission Network Providers, Generation Companies and Distribution Network Providers. Our consultants work for clients in Australia, New Zealand, Singapore, the USA and Canada and have a good understanding of the business and our customer's needs.

PSC Australia has permanent offices established in Adelaide, Melbourne, Brisbane and Perth.

The professionals employed by PSC have real experience in one or more of our core business groups and in many cases have operated in significant roles within transmission utilities or significant transmission projects both in Australia and overseas.

The key team members for PSC Australia were:

- Mark Parker – Principal Electrical Engineer
- Andrew Robbie – Principal Electrical Engineer
- Ahsan Siddique – Manager Lines and Structures
- Kevin Box – Telecommunications Manager
- Alex McDonald – Senior Civil and Structural Engineer
- Keith Fisk – Engineer

Individual "pen portraits" of the team members are provided below.

Mark Parker – Principal Electrical Engineer – PSC Australia – Job Manager

Mark Parker is a chartered professional engineer with over 13 years of consulting experience including owners engineer, lenders engineer, detailed design engineer, site supervision and commissioning of electricity industry projects. He has worked on power projects from feasibility, planning and permitting, tendering and award, technical due diligence, construction, commissioning and asset management.

Mark is an experienced project manager for power generation, transmission and distribution projects. Mark is experienced in detailed design for transmission and distribution projects and industrial and commercial building services. Mark is also experienced in providing strategic advice, regulatory advice, cost estimation and business case planning for major electrical infrastructure projects.

Relevant cost estimating experience includes:

- SP AusNet, Primary Project Lead - Responsible for concept design & cost estimation, tendering, management of detailed design service providers and construction assistance for capital works projects both asset replacement and greenfields projects across the SP AusNet asset base from terminal stations up to 500kV and zone substations down to 22kV, plus auxiliaries.

- Ergon, Concept Manager, Major Projects – Responsible for the delivery of major distribution projects Customer and Network initiated through the concept and detailed design phases. Mark was responsible for key deliverables including, Gate 2 (±20%) and Gate 3 (±10%) business cases, capital cost estimates, scope statements, project scheduling and establishing project delivery methodologies.
- AECOM - Capital cost estimate component leader for a major multi-national 500kV HVDC project, Purari. Development of pre-feasibility level capital and operating cost estimates, construction and payment schedules. Estimate included risk based contingency and accuracy evaluation.
- AECOM - Lead Electrical Engineer for tender design, scoping, supplier engagement, cost estimation (±10%) and scheduling for traction power and traction SCADA systems – Adelaide to Gawler.

Andrew Robbie – Principal Electrical Engineer – PSC Australia

Andrew Robbie has 23 years of experience in the electrical power industry. After graduating with an ME from the University of Canterbury, Andrew joined Transpower New Zealand where he carried out system studies for generation connections, new capacitor banks, and the static var compensator at Islington substation. He then joined ESBI Engineering in the United Kingdom where he was responsible for the electrical design of 132 kV substations. Andrew returned to New Zealand and joined Meritec Ltd (now AECOM), primarily providing services to Transpower. He has been with PSC for eight years providing system study and electrical cost estimation services both within Australia and New Zealand.

Andrew has completed a number of studies for several clients including Western Power, Transend Networks and the Australian Energy Market Operator (AEMO) in Australia, and Transpower in New Zealand.

Relevant experience includes:

- ElectraNet – Independent scoping and cost estimation for substation projects for the ElectraNet Regulatory Reset Period 3.
- Powerlink – Independent scoping and cost estimation of 275 kV and 132 kV transmission lines and 275 kV substation projects. A detailed scope for each project was developed to obtain a cost estimate to within +/-30% accuracy, as an independent check for the client's own internal cost estimates.
- Western Power – A lead role in developing the justification and preparing the Project Planning Report for a new two zone substation (132/22kV) in Balcatta, including cost estimates and development of scope. Evaluation of reinforcement options in Rockingham City, including evaluation of substation reinforcement options.
- AEMO - Case study for transmission connection of large scale remote renewable generation up to 5000 MW to the National Electricity Market.
- Transend - Analysis and submission of projects through the New Small Network Transmission Assets arm for the Regulatory Process for the Tasmanian transmission network.

Ahsan Siddique – Manager Lines and Structures – PSC Australia

Ahsan has over 14 years' experience in the electricity industry, he has been responsible for designing and supporting the development of transmission lines and substations in Bangladesh, Nepal and Australia, and has often been the leader in civil and structural engineering on these projects. In 2010, Ahsan was awarded by his employer the "Quiet Achiever of 2010" award and had been regarded as the "Engineer of Choice" by the Project Portfolio Group.

In Bangladesh, Ahsan specifically designed river crossing towers with careful calculations, so as to reduce tower height along the coastal region of Bangladesh. He also has designed special foundations for towers on river banks which were in danger of erosion.

More recently, Ahsan has led the PSC's transmission line design team for a number of ElectraNet's line retrofit and augmentation projects, Origin's 132kV transmission line projects, Western Power's MWEP project. Notably, in Australia, Ahsan has designed cost effective retrofitting structures to support OPGW on existing towers, has represented Asset Owner's engineer for tower testing, pole strengthening testing and factory acceptance witnessing of transmission lines elements, has carried out training on transmission line design and PLS CADD/TOWER training. ElectraNet - Compiled delivery plan, scope and technical specification for the replacement of insulators and hardware on 5 transmission lines.

- ElectraNet - Concept Line design and scoping for a 220 kV, 65 km single circuit overhead power line to facilitate the connection at Chumvalle.
- Western Power – Detailed line design of 200km 330kV transmission line at Midwest Western Australia.
- Origin – Preliminary line engineering and project cost estimation of 34km double circuit 132 kV transmission line.

Kevin Box – Telecommunications Manager – PSC Australia

Kevin Box is the Telecommunications Manager for PSC Australia. Kevin's experience in the Electricity Industry has developed from being a Telecommunications Technician through to Project Management, Engineering and Commissioning for a wide variety of Telecommunications networks and Control Systems.

Kevin played several key roles in the design, installation, factory testing and commissioning of Transpower's FOTS / Microwave Radio Network and ECNZ's Communications Networks for Mighty River Power, Genesis Energy and Meridian Energy. The experience gained in these projects has enabled him to successfully handle a wide range of engineering and project management tasks.

Kevin's most recent experience has been assisting PSC's clients in Australia with the design, project management and technical support for several telecommunications projects.

Relevant experience includes:

- Tamworth Substation 132/66kV Switchyard upgrade New South Wales – detailed design for the communications equipment, procurement, installation and commissioning at the Tamworth substation. This project included a new

132/66kV switchyard and new 132/66kV control building and services buildings.

- Network optimisation South Australia – migrate existing services on to new digital telecommunications bearers at three sites. PSC completed the detailed design, installation and commissioning for this project.
- Templers West substation project South Australia – design and project management for the reconfiguration of the existing teleprotection and new teleprotection systems, this included working with PLC and optical fibre technologies.
- Genesis Energy - Communications & Systems Engineer - Overall responsibility for management and enhancement of a communications system to support Genesis Energy's remote control power stations and hydraulic control structures. This included an 18 month period of extensive involvement in the development of the Hydro Control System Upgrade Project.
- Transpower (New Zealand) - Kevin worked on several upgrade projects at including:
    - Dunedin Area Microwave Radio Communications Network Upgrade (Engineer to Contract)
    - Upper Clutha Communications Network Upgrade (Engineer to Contract)
    - North Canterbury Microwave Radio Communications Network Upgrade (Project Manager)
    - Waitaki Communications Network Upgrade (Project Manager)

Alex McDonald – Senior Civil and Structural Engineer – PSC Australia

Alex has been in the engineering and construction industry for over 15 years. His main area of expertise is industrial foundations. His most recent project has been the geotechnical investigation and design of 68 pole foundations for a 132kV Stobie pole line in the Clare region.

Prior to joining PSC, Alex worked as a transmission line engineer for Transpower New Zealand. His position at Transpower involved design/design review, and construction monitoring and quality control. One recent project was a 105 tower, 220kV line in the central North Island of New Zealand. Alex was part of the design review and project construction team. During construction, Alex was responsible for technical interpretation of the design for the construction team and helped provide feedback and on-going design optimisation as a result of specific geotechnical conditions, equipment and capabilities.

Alex has also carried out design and construction monitoring of substations including switch rooms, transformer foundations and bunds, oil separation and containment, cable pits and amenities buildings. His broader experience includes design work on seagoing barges, wineries, large pipeline projects and numerous industrial buildings.

Relevant experience includes:

- Murraylink HVDC VSC Converter Station 220kV Earth Switch Installation - Options assessment and ±30% cost evaluation for civil works associated with

the installation of nine 220kV earth switches within an operational HV facility, as well as detailed design and Contractor supervision during construction.

- Directlink HVDC VSC Converter Station Fire Services Retrofit– Options assessment and ±30% cost evaluation for civil works associated with the Directlink fire suppression retrofit within an operational HV facility, as well as Contractor supervision during construction.
- Stockyard Hill wind farm – Options assessment and ±30% cost evaluation for 30km of internal 132kV transmission lines with multiple foundation options.
- Transpower grillage foundation upgrade project – Most of Transpowers existing assets were originally designed and constructed on grillage foundations. This project included the review of design options and costings for encasement of existing grillage foundations

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Keith Fisk – Engineer – PSC New Zealand

Keith Fisk has wide experience in SCADA and automation systems for hydro power stations and electricity transmission networks.

During 8 years with the Electricity Division hydro power station design office, Keith specialised in the design of control, instrumentation, and telemetry equipment and systems required for the remote control and automation of power station and substation plant. During this time, Keith was fortunate to be part of the design team that was foremost in the introduction of modern SCADA and automation technology to the major hydro electric power stations in New Zealand. Later as a senior member of the DesignPower NZ Ltd's SCADA group, Keith's main responsibility was managing a small design team working on a number of work packages for the Transpower HVDC link upgrade project.

While with Transpower considerable experience was gained managing projects installing substation control systems and replacing RTUs and area SCADA systems. At present as a consultant with PSC, Keith is focused mainly on investigations to integrate the management of substation devices and data into the overall corporate Information Technology structure.

Relevant experience includes:

- Specification, design, estimation and implementation of the NSW fast runback scheme for TransÉnergie Australia's Murraylink project utilising a network of SEL-2100 logic processors.
- Specification, design and estimation works for the Basslink Special Protection Scheme implementation review for Transend Networks.
- Assisting power companies with investigations into ways of leveraging new technology to more efficiently manage substation and power system information.