



TransGrid

**TransGrid Revenue Proposal
2018/19 – 2022/23**

Appendix O

Aurecon:

**Assurance of maintenance and asset
management practices and strategy for 2016/17**



Asset Management Budget Review
16/17 Asset Maintenance OPEX
TransGrid

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This report has been prepared to assist TransGrid to determine the appropriateness and robustness of its proposed revenue to be sought in relation to its operational expenditure from 1st July 2018 to 30th June 2023. The review was conducted on the basis of compliance with the requirements under the National Electricity Rules (NER) definition of good electricity industry practice. This report covers a particular and limited scope as defined by TransGrid and should not be read as a comprehensive assessment of proposed expenditure.

This report relies on information provided to Aurecon by TransGrid. Aurecon is not liable for any errors or omissions in the information provided, nor for the use of any information in this report by any party other than TransGrid and / or for any purpose other than the intended purpose.

In particular, this report is not intended to be used to support business cases or business investment decisions nor is this report intended to be read as an interpretation of the application of the NER or other legal instruments.

Except where specifically noted, this report was prepared based on information provided by TransGrid prior to 16 December 2016 and any information provided subsequent to this time may not have been taken into account.

As far as it is practical to do so, Aurecon has read, understood and complied with Federal Court Practice Note CM7 in relation to the preparation of this report.



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Executive summary

Aurecon has conducted a review of TransGrid Asset management strategies, asset management plans and budget in order to assess whether these represent an appropriate basis on which to proceed to manage its assets.

In moving to a more managed process of asset management which is characterised by data driven approaches, TransGrid has recognised that the visibility and quality of data used to inform and run the system becomes very important. TransGrid has carried out a number of initiatives in this area to bring together data from across the organisation to enable the best asset management outcomes for the organisation as a whole. Whilst there are costs in changing systems the benefits from such approaches are significant and are greatly expected to exceed their costs.

Overall, Aurecon has determined that the actions taken by TransGrid to develop its plans and budgets are prudent and in line with sound asset management practices for a transmission utility. Reduction in maintenance frequencies have been made on the basis of technical reviews and opportunities to gain synergies with other works. The management of assets occurs in consideration of an equipment's specific requirements, resulting in changes not being universally applied but applied as warranted to particular types or individual equipment, which is expected to be the lowest cost approach.

Through taking these actions, TransGrid has indicated a 14.6% (\$6.133m) reduction in its OPEX expenditure for the 16/17 financial year. The saving has come about as a result of a substantial review of policies and frequencies applicable to asset management tasks.

The resulting asset management plans which have come through a process of review by various stakeholders meet the requirements of sound industry practice. These include identifying, monitoring, tracking, rectifying and reviewing the plant and its management, which is required to deal with varied infrastructure of different makes, ages and states of degradation.



1 Introduction

Aurecon was requested to review TransGrid's 16/17 OPEX budget drivers for three categories of maintenance expenditure; namely, preventative, corrective and condition based, and to provide an expert view on the following, with consideration against Good Electricity Industry Practice¹:

- the appropriateness of TransGrid's asset management processes associated with its preventative maintenance program scope and frequency of work
- the appropriateness of TransGrid's controls around the scope and delivery of the corrective maintenance work program
- the appropriateness of TransGrid's controls around the delivery of the condition based maintenance program
- the appropriateness of the proposed program for these areas of maintenance OPEX

Aurecon spent two days at TransGrid's Wallgrove offices gathering documentation for review and to discuss various aspects of the documents and the processes within TransGrid.

In general based on Aurecon's desktop review, TransGrid has been able to show an overall reduction in OPEX of ~\$6.133m (14.6%) resulting in a budget of ~\$35.986m. The reduction has mainly been achieved through the adoption of a more risk based asset management process and the reassessment of inspection and maintenance intervals for many routines consistent with their determined need. The increase in the time between inspections has also allowed some inspections to be combined hence generating further savings without compromising the overall maintenance requirements.

¹ NER Rules Ch 10



2 Asset Management Strategy & Objectives

The OPEX budget results from a framework that is set out in the Asset Management Strategy and Objectives document. This document sets out how the management of TransGrid's assets meets its various obligations to external and internal stakeholders and minimises the costs of meeting its business objectives. The document is aligned with TransGrid's ISO 55001 accreditation and covers the relevant elements of the rationale behind the asset management strategy and is also subject to continuous improvement.

Given that TransGrid has a long history in managing its assets, the document is well informed and forms a good basis for the more specific strategy, renewal and asset management plans.

In general TransGrid has good visibility of its plant and has a system of maintenance and surveillance that ensures that issues are identified, registered, assessed and actioned.



3 Asset Management Plans

TransGrid's Maintenance OPEX program is defined by its maintenance plans which are reviewed annually. In between cycles these can be varied through a change process involving Asset Management Instructions. Ahead of the 16/17 financial year significant changes to maintenance were made through Asset Management Instruction AS0001. This document outlines changes to the previous asset management practices to be used in the 16/17 financial year. It is closely aligned with the matrix in Appendix B, Asset Management Plan Changes, which was provided during the initial data gathering meetings and summarises the changes to maintenance frequencies.

These documents together show that there has been a considerable reassessment in relation to the frequency of inspections and maintenance, pushing these out and in some instances eliminating them. Elimination has often been the result of the installation of remotely accessible metering or monitoring equipment, or through alignment of multiple work packages; which results in greater efficiency whilst maintaining overall reliability of the network.

Aurecon has carried out spot checking and verified that the recommendations have been incorporated into asset management plans.



4 Review of Budget Category Variances

This section contains a review of the 15/16 and 16/17 budgets and their variances in order to demonstrate the savings made in relation to the last budget. Appendix C contains the 15/16 and 16/17 OPEX Budgets.

The budgets contain the following subcategories:

- Planned Corrective Maintenance
- Condition Based Preventive Maintenance
- Routine Preventative Maintenance
- Inspections - Prescribed Services

In general there is the expectation that an organisation running on modern principles of asset management will be preferentially performing more of its work in categories that relate to condition assessment and inspection. This has to be understood in the context that there may be significant expenditure involved in rectification works that fall into the Planned Corrective Maintenance subcategory which could equally be considered as condition based (particularly when issues are identified such as type defects) and the budgets are skewed due to the relative costs associated with performing inspections as opposed to carrying out rectification works.

Overall the 16/17 OPEX budget has been reduced by \$6.133m (14.6%) over the previous year, resulting in an overall budget of \$35.986m.

In general, and as much as the categories align with the previous year's budgets:

- Substation Maintenance expenditure has reduced by \$3.369m. All subcategories have reduced budgets except for Condition Based Preventive Maintenance which has nearly doubled, which reflects the increased emphasis on a condition based approach.
- Substation Property has a 16.5% increase in budgets totalling \$493k and an increase in each subcategory, mainly as a result of the inclusion of buildings in the asset management program which were previously not covered by programmed maintenance.
- Transmission Line Equipment is down \$742k with all subcategories reducing except for Inspections -Prescribed Services, which has increased by approximately 20%.
- Easements expenditure reduced \$3.246m (20.8%) with the only subcategory to increase slightly being Inspections - Prescribed Services
- Cables has increased overall \$551k and has overall increases in each subcategory

- 
- Protection metering category has only marginally increased its budget by \$33k.
 - Communications and Controls category has had its budget increased by \$281k, on the back of a \$386k increase in Planned Corrective Maintenance.
 - Repeater Site property has had an overall reduction of \$81k, on the back of \$54k reduction in Condition Based Preventive Maintenance.
 - Depots and Facilities Maintenance is reduced by \$52k overall.

Aurecon has not performed a detailed audit of these budgets but has carried out spot checks on the categories that relate to plans and programmed works and has found that the plans have been translated down to the works order level, which provides support for TransGrid's estimates.



5 Review of Documents

5.1 Easements

The proposed Easement OPEX of \$12,328,144 for 16/17 is some 21% less than the budget for 15/16. The subcategories reflect more variation against the previous year's budget.

The Easements & Access Track Maintenance Process Guide describes the entire process for vegetation clearance and access track maintenance. The document clearly documents TransGrid's processes to facilitate efficiency, manage risk and achieve service performance outcomes. Compliance with the process is expected to drive a suite of improvements and associated reduction in OPEX in 16/17, while still achieving legal compliance, and maintaining stakeholder relationships. This should drive value for money from the vegetation maintenance contractors, which amounts to some \$9 million, or 73%, of the Easement budget. This gives some confidence that the reduction in the 16/17 budget is realistic.

The Easements & Access Track Maintenance - Process Guide document which was recently issued, acknowledges the need for feedback and continuous improvement. The document acknowledges that the Vegetation Risk Framework and Model is currently under development. This should be finalised and implemented to achieve best industry practice.

The process documents the full suite of activities from planning and inspections through rating of defects, environmental approvals, work scope, contractor management, reporting, performance/feedback, and auditing. In this regard, the Process Guide represents good industry practice. As the document has only recently been issued it is anticipated that it will be used to drive performance and accountability from the TransGrid teams and also importantly the vegetation maintenance Contractors.

It is likely that future savings associated with easements and access tracks will be more modest on a year to year basis than the \$3 million savings projected for 16/17, as the opportunities to drive further efficiency become limited. In conclusion, based on a review of the several documents provided, it is clear that TransGrid has documented systems and processes that represent good industry practise.

5.2 Transmission Lines

After reviewing the transmission line strategy, maintenance plan and the changes to the maintenance plan, the following observations are made.



Aerial inspections are currently carried out separately to LIDAR. This makes sense as the flight pattern and proximity of aircraft is different. Where flight restrictions apply it has been confirmed that ground based inspections are substituted so as to adequately cover the assets. Aerial inspections are considered very cost effective and are being used by TransGrid to cover its most distributed and diverse asset class. These inspections provide information on encroachments, vegetation growth and condition of its assets. The aerial inspections are being performed using contracted aircraft with two TransGrid staff on board performing the assessments and reporting by exception.

It has been confirmed that scheduled maintenances are covering the assets and are integrated across inspection periods.

TransGrid has removed ground inspections of its wooden poles and these are now only covered by aerial and climbing inspections which makes good sense as does the removal of detailed aerial inspections of assets covered with climbing assessments. For wood pole inspections it also makes sense to perform ground interface inspections so that the condition of underground wood is adequately accessed. TransGrid has maintained awareness of developments on wood pole inspection technology and methods but has determined that to date there is no reliable and practical technology to automate this element of their inspections.

In relation to cost reductions a high level comparison shows the typical step changes in efficiency that you would expect from a more focussed risk management approach.

Aurecon has spot checked that transmission maintenance tasks in accordance with the plan have been budgeted and are on the program of maintenance works.

5.3 Substation Building and Infrastructure

The documents indicating strategies and frequency in relation to buildings and infrastructure, appear very reasonable for the buildings, depots/properties and security, and are in line with good practice.

The asset management plans are formulated by focussing on assets and not locations, with specific requirements for locations being driven by work orders, which is good practice.

Vermin control and fire protection are well covered in the requirements for maintenance.

Many other elements of substation infrastructure are covered in the Substation Assets Maintenance Plan although some elements of general civil infrastructure like cable pits, ducts and conduits appear not to be covered by specific maintenance inspections.

5.4 Cables

Long high voltage cables are a recognised difficult asset class in relation to their management as most of the asset is hidden and not economically or readily accessible. Much of the HV cable management in relation to general aging is not able to be assessed for long buried cables as small weak spots are masked by the averaging nature of the rest of the cables indications. For cables with route



temperature measurement capability there is a much enhanced ability to predict thermal degradation of the cables which helps with assessing the risk of these assets.

Overall TransGrid has brought in its maintenance works under budget by better than 10% in each of the listed financial years from 11/12 to 13/14, suggesting that project costs have been reasonably estimated and controlled. Some of this has come about from the deferral of elements of works that were not deemed urgent and have been left to be completed in combination with other works.

The two indicated major renewal works in the last financial period MetroGrid Tunnel Life Extension and Sydney Park Ground Water Treatment Plant have been brought in under budget with tunnel life extension works being deferred and resulting in savings. The tunnel works have been identified as still required but will be performed as part of the MetroGrid Tunnel Accessories project.

Overall cable maintenance works are being determined through engineering assessment, which is well aligned to the condition based principles of asset management.

There are two forecast changes to routines of the Maintenance Plan as indicated in AS0001, one for Cable 41, through removing manual monthly oil readings by replacing these with a remote oil monitoring system. The second is the removal of 3 monthly inspections of the MetroGrid cable tunnel steel water piping, due to its replacement. These changes are as would be expected of an organisation that is driving costs reductions.

Aurecon questioned the need for yearly magnetic field measurements on Cable 43 and 44, which were not indicated by engineering requirements and TransGrid was able to demonstrate that these were required to meet a deed agreement with Sydney Water for the use of the corridor. It was further indicated that as soon as was allowed by the agreement (after 5 years) the measurements would revert to being performed once every 5 years instead of annually.

TransGrid has good visibility of the condition of its cable assets across all its major installations as well as those within substations. The nature of modern cable management systems is such that they require relatively frequent repair and the replacement of their elements, which is due to the relatively short life span of their electronic components as compared to the long lived cables that they monitor. This cost has been rightfully identified as a significant recurring asset management expenditure and is common in relation to the application of modern continuous condition monitoring technologies, which are used to identify and monitor risks associated with critical assets.

The 16/17 budget has been built in a bottom up manner and reflects the additional costs associated with two new major cable assets being commissioned. Even though there were some savings in AS0001 with reductions in some inspections, these were offset by the general increases that result from the bottom up process which has captured costs associated with inspections that were missed in the 15/16 budget and reflects incurring of non-annual tasks in the 16/17 budget such as end of defects period inspections for cables 43 and 44.



5.5 Substations

Substations contain many concentrated assets and thus have a significant inspection and maintenance input. The inspection frequencies for many assets have been reduced which yields direct financial benefits in the 16/17 budget.

For substation sites, TransGrid is adopting a more risk based approach to the monitoring of its security fencing. This is based on the reasonable notion that defect maintenance of security fencing is appropriate.

The Maintenance Plan indicates that a thermographic survey to locate any hot joints is to be undertaken annually on all current carrying substation plant, i.e. all high voltage connections, disconnectors, transformer bushings and oil filled CTs. This is prudent given that some circuits may not be highly loaded during the inspection and therefore are not adequately assessed. In general, joints and connections, unless subject to a gross maintenance induced fault, should only be deteriorating slowly. TransGrid's thermographic intervals are determined using a risk based approach.

In relation to overall site inspection frequencies of plant, these have been influenced by age of the site and equipment type with newer sites being inspected less frequently than older sites. Inspection intervals also factor in the need for ensuring warranties are properly exercised, which is good asset management.

TransGrid has also shown it has adjusted maintenance requirements for items where the inherent operation of the equipment proves the functionality of that asset, such as operational checks of circuit breakers. Circuit breaker timing check frequency aligns with other maintenance intervals which is economic and a good risk mitigation given the importance of circuit breakers in the transmission system.

Earthing systems checks that are vital to the safe operation of the network are well covered through a 10 yearly routine maintenance and then a 30 year major review.

The requirements for monitoring of steel gantries are being reviewed but there is a general requirement to check these 5 yearly which adequately covers normal expected form of degradation. Even these inspections are somewhat risk based with the first being after 15 years, which is good management.

TransGrid advises that after extreme weather events that they perform ad hoc inspections of substations and assets. This is augmented by the good coverage of substation sites by a network of security cameras, which enables TransGrid to remotely determine gross environmental impacts. It makes sense though to formalise this and make it a part of asset management guidelines or plans so that it is systematically performed.

TransGrid has good visibility of the condition of its assets which supports an informed engineering decision making process and facilitates the monitoring of the degradation mechanisms associated with its assets. Overall asset condition has recently been reviewed through the development of an Asset Health Index associated with assets and through elements of the Substation Condition Monitoring Manual which indicates TransGrid's action criteria.



5.6 Automation and Metering

The Maintenance Plan proposes a change in the frequency of routine maintenance checks for self-checking protection assets from 6 yearly to 8 yearly, is in line with current protection practice for micro-processor based systems. This is facilitated by the relays' self-checking functions initiating remote alarms if a malfunction is detected.

The proposed change in frequency of routine maintenance checks of non-self-checking protection assets from 3 yearly to 4 yearly, is not expected to materially increase risk as modern relays do not require many auxiliary components.

The statistical metering routine checks have been removed from the maintenance plan as they are not a requirement under current regulations. This demonstrates a willingness of TransGrid to remove low value or unrequired routines.

It is noted that it is justified to reduce the frequency of inspection of communication structures from 5 yearly to 6 yearly as the tower loads do not change over time.

TransGrid has recognised their reliance on batteries for backup and the emergency support of their network and has modified maintenance requirements on their batteries and chargers to ensure that these assets are maintained whilst taking advantage of the improved reliability of newer batteries and technology to reduce their maintenance frequency.

5.7 Non-Routine Maintenance Works

TransGrid has a robust process for dealing with non-routine works. Aurecon has reviewed a copy of the Non-Routine Maintenance Process Ver 0.10. This document covers the process which sets financial limits on certain types of works and sets in place an approval process to ensure that the works are properly assessed and controlled.

Non-routine work may also represent an opportunity to reduce the cost of some routine works if bundled with those non-routine works. TransGrid assess these opportunities as they arise and then modifies work schedules to reflect that the work was carried out during the non-routine works so as to not inadvertently redo these works under a routine.



6 Warranty Tests

The reviewed documents show that TransGrid rightly maintains a high visibility of warranty expiry dates and seeks to test equipment prior to the expiry of warranties to enable it to exercise its rights under warranties. This is a valuable part of asset and vendor management.



7 Conclusion

TransGrid's OPEX has been driven by a considered and reviewed process based on its long experience of maintaining these assets and making rational improvements whilst still meeting its internal and external stakeholder's requirements. The process is well aligned with ISO 55001 requirements and shows that TransGrid has a commitment to ensuring that its processes are robust and consistent.

In forming the OPEX budget for 16/17, TransGrid has determined improvements to its previous maintenance routines through making alterations where it considers that the changes will not materially impact on its operation, reliability and safety. These changes as indicated in Asset Management Instruction AS0001 have been reviewed by Aurecon, and are considered consistent with both good industry practice and in alignment with TransGrid's ISO 55001 accreditation. It is Aurecon's opinion that the strategies and plans, used in generating the 16/17 OPEX budget, prudently represent the assets and work required to adequately maintain the transmission network.

TransGrid's document chain comprehensively presents a structured process for forming, administering, controlling and reviewing its maintenance and thus is a solid basis on which to control its maintenance system. Given the extent of signoff on these documents all the necessary stakeholders have had adequate opportunity to provide guidance in relation to their content. Whilst some minor improvements have been identified in relation to the documents, Aurecon is of the view that the process is appropriate and robust.

TransGrid is moving towards becoming a more data driven asset manager which is reflected in the improvement projects that have been identified in relation to data, its integrity and availability. This thrust is in line with modern asset management practice.



8 Document Sign-Off

Aurecon declares that it has made all the inquiries that it believes are desirable and appropriate and that no matters of significance that Aurecon regards as relevant have, to its knowledge, been withheld from the Court.

Appendices





Appendix A

Reviewed Documents

1. Routine Maintenance Proposed Changes.docx
2. Expected maintenance cost 15-16 and 16-17.xlsx
3. Asset Information Strategy Rev1.pdf
4. AMI_AS0001_Maintenance Plan Amendments.docx
5. Environmental Assessment Framework Rev1.pdf
6. Maintenance of Easements and Access Tracks Policy Rev6.pdf
7. Easements and Access Tracks Process Guide Rev0.pdf
8. Network Asset Health Framework rev0
9. Substations Condition Monitoring Manual Rev 8.pdf
10. NACA-SSAP - Assessment - Condition - Substation Automation Systems – Protection Rev3.pdf
11. Asset Management Strategy and Objectives Rev2.pdf
12. SSA Plan - Maintenance - Routine and Non-routine – Telecommunications Rev2.pdf
13. SSA Strategy - Renewal and Maintenance - Telecommunications Infrastructure Rev0.pdf
14. SSA Strategy - Renewal and Maintenance - Metering Systems Rev1.pdf
15. SSA Strategy - Renewal and Maintenance - Automation Systems Rev1.pdf
16. Underground Cables Renewal and Maintenance Strategy Rev2.pdf
17. Transmission Line Renewal and Maintenance Strategy Rev2.pdf
18. Substations Renewal and Maintenance Strategy Rev2.pdf
19. Telecommunications Terminal Equipment Renewal and Maintenance Rev0.pdf
20. Renewal and Maintenance Strategy - Substation Security Assets Rev2.pdf
21. Renewal and Maintenance Strategy - Office and Depot Facilities Rev0.pdf
22. Maintenance Plan - Transmission Lines Rev1.pdf
23. Maintenance Plan - Underground Cable Assets Rev1.pdf
24. Maintenance Plan – Telecommunications Systems Rev2.pdf
25. Maintenance Plan - Substation Security Assets Rev1.pdf
26. Maintenance Plan - Automation Systems Rev3.pdf
27. Maintenance Plan - Substation Assets Rev4.pdf
28. Maintenance Plan - Office and Depot Facility Assets Rev1.pdf

Appendix B

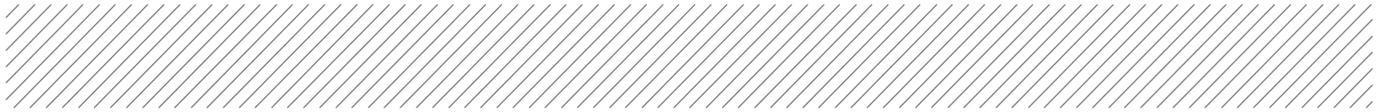
Asset Management Plan Changes

Asset Class	Maintenance Task	Current Freq	Proposed Freq	Reason for Change	Risk
Substations	Site Inspections	1 – 6 Monthly	6 Monthly	Align with peers.	Increase risk of plant failure due to leaks, (e.g. oil leaks with no alarm), flashover of grass, or intrusion.
	New Site Inspections	6 Monthly	1 Yearly for first 10 years	Sites should have limited issues, no grass and new plant. Assume good camera coverage and some amount of on line monitoring equipment.	Increase risk of undetected defects leading to failure or additional cost.
	Fire hydrant maintenance, incl. fire pumps and water valves	1 Yearly	Removed (hydrants to be decommissioned)	These assets are planned to be decommissioned and so the associated maintenance is not required.	No change in risk profile.
	SF6 and Mitsubishi DTCB Circuit Breaker Inspection	4 Yearly	6 Yearly Removed for 123 Circuit Breakers with OLCM installed	Low number of defects and issues experienced (qualitative review only) on this CB type. OLCM can be relied upon to indicate defects.	Increase in forced outages due to defects and potentially overall CB failure.
	SF6 and DTCB Circuit Breaker Minor Maint.	8 Yearly	12 Yearly	Low number of defects and issues experienced (qualitative review only) on these CB types.	Increase in forced outages due to defects and potentially overall CB failure.
	Oil Circuit Breaker Minor Maintenance	4 Yearly	6 Yearly Removed for 132kV from 2024 onwards as replacement with SF6 expected in RP2	Increase interval to align with peers and reduce cost. Generally reliable plant type.	Increase in forced outages due to defects and potentially overall CB failure. Will require monitoring of fault operations and cyclo readings and this may trigger additional maintenance.
	Vacuum Circuit Breaker Minor Maintenance	4 yearly	6 yearly	Increase interval to align with peers and reduce cost. Generally reliable plant type.	Increase in forced outages due to defects and potentially overall CB failure.
	Current Transformer IR, DDF & Oil Samples	4 Yearly	6 Yearly (in line with circuit breaker maintenance) Exceptions for higher risk hairpin oil CTs. Three yearly oil samples on these types with low voltage access only.	Align with CB maintenance to ensure efficiencies. Additional oil samples could be taken later in life if required on more specific basis.	Increase risk of not detecting aging/defect which leads to equipment fault and higher failure impact.
	Isolator Minor Maintenance	4 Yearly	6 Yearly	Align with CB maintenance to ensure efficiencies.	Increase risk of issue encountered during bay outage or project work (e.g. injury due to difficulty in operation) or unable to return to service.

Asset Class	Maintenance Task	Current Freq	Proposed Freq	Reason for Change	Risk
	Switchbay Inspections	4 Yearly	6 Yearly	Align with CB maintenance to ensure efficiencies.	Increase risk of not detecting aging/defect which leads to equipment fault and higher failure impact.
	Power Transformer Major Service	4 Yearly	6 Yearly for RIP bushings (26 TX's) 6 Yearly for OIP bushings with OLCM (59 TX's)	Significant number of transformers failures attributable to bushings. Lower failure probability and consequence associated with RIP bushings compared with OIP. Rely upon OLCM to detect bushing faults and act accordingly.	Increase risk of not detecting aging/defect which leads to equipment fault and higher failure impact. Tapchanger operation count to be monitored and may cause additional maintenance to be required.
	Non HV Network Property Costs	1 Yearly	Removed (part of Property)	Not part of substation maintenance	No change to risk
Security	Site Inspections	6 Monthly	Removed	To be managed on a defect basis	Increased risk of undetected defects, and undetected intrusion (resulting in increased financial and safety risk)
	Security System Maintenance	1 Yearly	Removed	To be managed on a defect basis	Increased risk of undetected defects, and undetected intrusion (resulting in increased financial and safety risk)
	Substation Perimeter Fence Inspection	4 Monthly	Combined with substation inspection (assumed half of cost)	Combined with sub inspection	No change
Secondary Systems	Protection (assets others) routine check	6 Yearly	8 Yearly	The change brings these into line with all other microprocessor based relay systems.	Minimal increase in risk expected as per other Protection assets currently set to 4 years
	Protection (assets others) performance check	3 Yearly	4 Yearly	This applies to a very limited number of systems that have no history of incorrect operation.	Minimal increase in risk expected as this change applies to only a very small population of assets
	Distance protection routine check (electromechanical relays)	6 Yearly	8 Yearly from 2024 onwards as replacement with microprocessor expected in RP2	Asset replacement strategy	No change to risk
	Distance protection performance check (electromechanical relays)	4 Yearly	Removed from 2024 onwards as replacement with microprocessor expected in RP2	Asset replacement strategy	No change to risk
	Statistical Metering routine checks	5 Yearly	Removed	Statistical metering is not registered in the market and therefore does not need to be maintained in accordance with the rules.	No increase in risk
	Communication structure inspections	5 Yearly	6 Yearly	It is appropriate to extend the interval between inspections as typically the towers are lightly loaded or are analysed/expected as part of customer works	Minimal increase in risk expected if current level of customer additions to towers continues.
	Communication power supplies	2 Yearly	4 Yearly	This routine only serves to confirm the current state of the asset and does not contribute to the capability or longevity of the asset.	No increase in risk

Asset Class	Maintenance Task	Current Freq	Proposed Freq	Reason for Change	Risk
	Battery Minor Maintenance	1 Yearly	2 Yearly (newer batteries)	Minor maintenance only serves to confirm the current state of the asset and does not contribute to the capability or longevity of the asset.	Moderate increase in rate of asset failure expected due to inspection frequency moving past manufacturer recommendations. Battery Systems are fully duplicated at most sites, therefore the overall risk should be tolerable. Change in policy will be monitored to confirm the appropriateness of these settings.
Transmission Lines	Ground Inspection	1 – 4 Years	Removed (Annual aerial/compliance inspection still undertaken)	Inspection redundant if detailed climbing inspections performed. Annual aerial and easement inspections still occur to identify immediate defects.	Minimal increase in risk expected if detailed condition assessment inspections are undertaken.
	Climbing Inspection (All Lines)	3 – 6 Years	5 Years (detailed Condition Assessment inspection)	Detail asset condition information required to support asset strategy. Wood pole line UGI will still occur in between climbing inspections.	Reduction in risk as more comprehensive asset data collected
	Detailed Aerial Photographic Inspection	5 – 10 Years	Removed	Not required once detailed climbing inspections are performed regularly	No increase in risk
	Cable 41 Oil Pressure Readings	1 Monthly	Removed (on-line oil monitoring system to be installed RP1)	Online oil monitoring system will make manual readings redundant	No increase in risk
	Cable Tunnel Water Main Inspection	3 Monthly	Removed (main to be replaced RP1)	Replacement main will not require inspection as superior construction	No increase in risk
Property (substations)	Annual Building Inspection (all substations)	Previous Property maintenance budget was a 'bucket' based on top down historical expenditure. Existing maintenance tasks rationalised into new tasks.	1 Yearly	Approx. 33% compliance requirements, remainder to provide information on current health of building.	No increase in risk
	Building Maintenance (all substations) Includes – A/C Maintenance, Annual clean of building exterior.		1 Yearly	Annual thorough clean of buildings will improve life of various areas of building structure. E.g. Powder coating life is extended when dust build-up is removed, window seals life expectancy is improved when build-up is removed.	Risk that A/C will have a shorter life.
	Ground Maintenance (Subs – High growth areas). Includes bush fire buffer maintenance, herbicide and pesticide applications, general lawn mowing inside and outside the switchyard.	Bottom-up budget estimated.	Maximum 20 times per year. Increased during the high growth seasons.	Bushfire buffer maintenance which includes compliance requirements and risk reduction, Pest/vermin baiting is for risk reduction to prevent damage to network equipment, ground maintenance internally to switchyard is as a WHS issue to prevent slip trip and falls in long grass.	Increase in risk of damage from bushfire, damage by rodents and slip trip and falls.
	Ground Maintenance (Subs - Low growth areas) Includes bush fire buffer maintenance, herbicide and pesticide applications, general lawn		Maximum 12 times per year. Increased during the high growth seasons.	Bushfire buffer maintenance which includes compliance requirements and risk reduction, Pest/vermin baiting is for risk reduction to prevent damage to network equipment, ground maintenance internally to switchyard is as a WHS issue to prevent slip trip and falls in long grass.	Increase in risk of damage from bushfire, damage by rodents and slip trip and falls.

Asset Class	Maintenance Task	Current Freq	Proposed Freq	Reason for Change	Risk
	mowing inside and outside the switchyard.				
	Cleaning & Waste Removal (Subs – Manned sites) Includes cleaning of bathrooms, meals areas and common areas.		Weekly	Ensure minimum standards for workplace accommodation	No increase in risk
	Cleaning & Waste Removal (Subs – Unmanned/ low visitation sites) Includes cleaning of bathrooms, meals areas and common areas.		Annual	Ensure minimum standards for workplace accommodation	No increase in risk
	Cleaning & Waste Removal (Subs – Unmanned/ high visitation sites) Includes cleaning of bathrooms, meals areas and common areas.		6 monthly	Ensure minimum standards for workplace accommodation	No increase in risk
Property (Depots)	Annual Building Inspection (Depots)		Annual	Approx. 33% compliance requirements, remainder to provide information on current health of building essential for health monitoring.	No increase in risk
	Building Maintenance (Depots) - annual		Annual	Preventative maintenance to ensure maximum life of building. Each depot has specific requirements.	Shorter life expectancy, higher defect rates, Possible WHS issues. Staff morale.
	Building Maintenance (Depots) – 6 monthly		6 monthly	Preventative maintenance to ensure maximum life of building. Each depot has specific requirements.	Shorter life expectancy, higher defect rates, Possible WHS issues. Staff morale.
	Air Condition Maintenance (Depots)		Maximum 3 monthly	Larger ducted units can require additional service requirements. In particular older units. Each depot has specific requirements.	Risk that A/C will have a shorter life without minimal maintenance.
	Ground Maintenance (Depots)		Maximum 20 times per year. More during the high growth seasons.		
	Cleaning & Waste Removal (Depots)		Daily		
Property (Radio Repeater Sites)	Bushfire hazard reduction (RRS – High growth areas).		Maximum 6 times per year (Site specific)		Higher risk of damage from bushfire.
	bushfire hazard reduction (RRS - Low growth areas)		Maximum 2 times per year (Site specific)		Higher risk of damage from bushfire.



Appendix C

15/16 and 16/17 OPEX Budget

	2015/16				2016/17				Category Variance
	Total	Labour	Material	Operating Expenses (IFRS Excl 332)	Total	Labour	Material	Operating Expenses (IFRS Excl 332)	
910 - Substation Maintenance									
Substation Equipment									
P0004529	11,671,913	10,347,738	1,220,706	3,081,389	8,302,523				3,369,390
P0004527	5,979,911				4,627,743	3,331,193	1,074,625	221,925	1,352,168
P0004525	559,142				974,435	855,832	100,219	16,383	413,293
P0004523	3,911,673				2,373,134	2,182,095	143,172	47,867	1,538,540
P0004521	1,221,187				329,212	317,295	11,615	302	891,975
Substations Property									
P0008248	2,977,919				3,470,867	674,130	81,696	420,741	492,948
P0008247	1,008,467				1,176,568	456,149	-	493,658	167,102
P0008246	814,911				949,807	376,271	-	827,576	134,896
P0008245	1,032,872				1,203,847	103,042	-	37,602	170,976
P0008245	120,669				140,644				19,975
911 - Transmission Line Maintenance									
Transmission Line Equipment									
P0004550	5,425,828	6,594,750	622,680	14,087,733	4,683,454				742,373
P0004546	3,425,830				2,587,245	1,875,814	279,592	431,840	838,585
P0004542	314,381				167,647	131,502	3,206	32,938	146,735
P0004538	623,897				580,834	493,734	52,600	34,500	43,063
P0004539	1,061,720				1,347,729	896,529	10,200	441,000	286,009
Easements									
P0004551	15,574,632				12,328,144				3,246,488
P0004547	826,195				633,440	318,090	36,600	278,750	192,755
P0004543	13,420,136				10,234,448	1,109,700	113,737	9,011,011	3,185,688
P0004539	118,699				14,530	11,030	3,000	500	104,169
P0004539	1,209,602				1,445,727	373,427	20,300	1,052,000	236,125
Cables									
P0004552	304,704				855,471				550,767
P0004548	46,482				224,137	141,150	12,991	177,654	12,179
P0004544	258,221				324,273	299,062	527	24,684	66,052
P0004540					294,882	288,982	186	5,714	294,882
912 - Secondary System Maintenance									
Protection Metering									
P0004575	2,051,579	3,426,284	221,553	119,793	2,084,557				32,978
P0004571	531,414				831,503	619,778	211,460	265	300,088
P0004568	32,218				-	-	-	-	32,218
P0004565	1,475,882				1,232,670	1,136,974	3,220	92,476	243,213
P0004566	1,205				20,385	19,738	647	-	8,320
Comms and Control									
P0004576	1,511,260				1,792,351				281,091
P0004572	798,442				1,184,494	809,886	359,533	15,075	386,053
P0004569	110,869				97,509	77,016	19,426	1,067	13,360
P0004566	601,949				510,348	508,305	2,043	-	91,602
Repeater Site Property									
P0008252	204,792				124,255				80,537
P0008251	50,433				30,600	18,550	2,507	9,543	19,884
P0008249	137,877				83,655	68,775	-	14,880	54,222
P0008249	16,482				10,000	-	-	10,000	6,482
913 - Property Maintenance									
Depots and Facilities									
P0008250	2,396,809	554,419	105,779	1,736,611	2,344,436				52,374
P0008258	534,692				523,008	291,472	66,669	164,866	11,684
P0008256	231,533				226,474	42,674	-	183,800	5,059
P0008254	1,606,097				1,571,001	54,401	-	1,516,600	35,085
P0008254	24,488				23,953	12,903	-	11,050	535
	42,119,435				35,986,058				6,133,378



Appendix D

Expert Witness Report Requirements

Federal Court Practice Note CM7

EXPERT WITNESSES IN PROCEEDINGS IN THE FEDERAL COURT OF AUSTRALIA

Commencement

1. This Practice Note commences on 4 June 2013.

Introduction

2. Rule 23.12 of the Federal Court Rules 2011 requires a party to give a copy of the following guidelines to any witness they propose to retain for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based on the specialised knowledge of the witness (see Part 3.3 - Opinion of the Evidence Act 1995 (Cth)).
3. The guidelines are not intended to address all aspects of an expert witness's duties, but are intended to facilitate the admission of opinion evidence² and to assist experts to understand in general terms what the Court expects of them. Additionally, it is hoped that the guidelines will assist individual expert witnesses to avoid the criticism that is sometimes made (whether rightly or wrongly) that expert witnesses lack objectivity, or have coloured their evidence in favour of the party calling them.

Guidelines³

1. General Duty to the Court

- 1.1. An expert witness has an overriding duty to assist the Court on matters relevant to the expert's area of expertise.
- 1.2. An expert witness is not an advocate for a party even when giving testimony that is necessarily evaluative rather than inferential.
- 1.3. An expert witness's paramount duty is to the Court and not to the person retaining the expert.

² As to the distinction between expert opinion evidence and expert assistance see *Evans Deakin Pty Ltd v Sebel Furniture Ltd* [2003] FCA 171 per Allsop J at [676]

³ The "*Ikarian Reefer*" (1993) 20 FSR 563 at 565-566.



2. The Form of the Expert's Report⁴

2.1 An expert's written report must comply with Rule 23.13 and therefore must

- (a) be signed by the expert who prepared the report; and
- (b) contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the Practice Note; and
- (c) contain particulars of the training, study or experience by which the expert has acquired specialised knowledge; and
- (d) identify the questions that the expert was asked to address; and
- (e) set out separately each of the factual findings or assumptions on which the expert's opinion is based; and
- (f) set out separately from the factual findings or assumptions each of the expert's opinions; and
- (g) set out the reasons for each of the expert's opinions; and
- (ga) contain an acknowledgement that the expert's opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (c) above⁵; and
- (h) comply with the Practice Note.

2.2 At the end of the report the expert should declare that "[the expert] has made all the inquiries that [the expert] believes are desirable and appropriate and that no matters of significance that [the expert] regards as relevant have, to [the expert's] knowledge, been withheld from the Court."

2.3 There should be included in or attached to the report the documents and other materials that the expert has been instructed to consider.

2.4 If, after exchange of reports or at any other stage, an expert witness changes the expert's opinion, having read another expert's report or for any other reason, the change should be communicated as soon as practicable (through the party's lawyers) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court⁶.

2.5 If an expert's opinion is not fully researched because the expert considers that insufficient data are available, or for any other reason, this must be stated with an indication that the opinion is no more than a provisional one. Where an expert witness who has prepared a report believes that it

⁴ Rule 23.13.

⁵ See also *Dasreef Pty Limited v Nawaf Hawchar* [2011] HCA 21.

⁶ The *"Ikarian Reefer"* [1993] 20 FSR 453 at 565.



may be incomplete or inaccurate without some qualification, that qualification must be stated in the report.

- 2.6 The expert should make it clear if a particular question or issue falls outside the relevant field of expertise.
- 2.7 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the opposite party at the same time as the exchange of reports⁷.

3. Experts' Conference

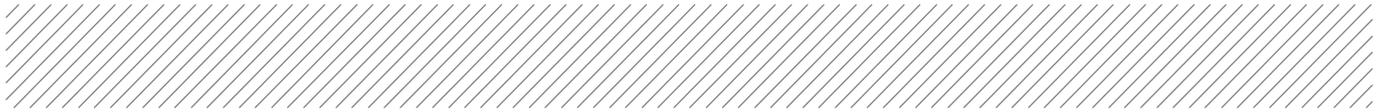
- 3.1 If experts retained by the parties meet at the direction of the Court, it would be improper for an expert to be given, or to accept, instructions not to reach agreement. If, at a meeting directed by the Court, the experts cannot reach agreement about matters of expert opinion, they should specify their reasons for being unable to do so.

J L B ALLSOP

Chief Justice

4 June 2013

⁷ The *"ikarian Reefer"* [1993] 20 FSR 563 at 565-566. See also Ormrod *"Scientific Evidence in Court"* [1968] Crim LR 240.



Appendix E

Engagement Scope

Expert Terms of Reference Review of 2016/17 Maintenance Program

**TransGrid
2014-19 Revenue Determination**

24 July 2016

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1. Background

TransGrid is the owner, operator and manager of the high voltage electricity network in New South Wales and the Australian Capital Territory. As such, TransGrid is a transmission network service provider (TNSP) regulated under the NEL and the NER.

Chapter 6A of the NER sets out rules for the economic regulation of prescribed transmission services and negotiated transmission services provided by TNSPs. This regime requires the AER to determine the revenue allowed to be earned by TransGrid for prescribed transmission services during each regulatory year, in accordance with the post tax revenue model, described in Chapter 6A of the NER for each regulatory control period. In addition, a pricing methodology, negotiating framework and negotiated transmission service criteria must also be determined by the AER. The process for making a transmission determination is set out in Part E of Chapter 6A of the NER.

TransGrid has a right to apply to the Australian Competition Tribunal (Tribunal) for merits review of a “reviewable regulatory decision” under section 71B of the NEL. The scope of and process for merits review of reviewable regulatory decision is set out in Division 3A of Part 6 of the NEL. The transmission determination that the AER is required to make in relation to TransGrid’s revenue is a “reviewable regulatory decision” amenable to review.

TransGrid is currently preparing its revenue reset proposal for the next regulatory period. TransGrid’s OPEX allowance is determined by the AER using a base step trend approach on an efficient year. Network maintenance is a large component of OPEX, and is comprised of three categories (preventative, corrective and condition based).

2. Scope of work

Aurecon is requested to review TransGrid’s 2016/17 OPEX budget drivers for preventative, corrective and condition based maintenance to provide an expert view on the following, with consideration against good industry practise ¹:

- the appropriateness of TransGrid’s asset management processes associated with the generation of the preventative maintenance program scope and frequency of work
- the appropriateness of TransGrid’s controls around the scope and delivery of the corrective maintenance work program
- the appropriateness of TransGrid’s controls around the delivery of the condition based maintenance program
- the appropriateness of the proposed program for these areas of maintenance OPEX.

1 Good Industry Practise

The exercise of that degree of skill, diligence, prudence and foresight that reasonably would be expected from a significant proportion of operators of facilities forming part of the power system for the generation, transmission or supply of electricity under conditions comparable to those applicable to the relevant facility consistent with applicable regulatory instruments, reliability, safety and environmental protection. The determination of comparable conditions is to take into account factors such as the relative size, duty, age and technological status of the relevant facility and the applicable regulatory instruments.

(Definition from National Electricity Rules Version 82, page 1157)

3. Information provided by TransGrid

The expert is encouraged to draw upon the following information which TransGrid will make available:

- Key asset management documents relevant to the maintenance OPEX program. These are the Asset Management Strategy and Objectives, Renewal and maintenance strategies, maintenance plans
- The 2016/17 maintenance OPEX budget for preventative, corrective and condition based maintenance

In addition use can be made of publically available Regulatory Information Notice (RIN) information.

4. Other information to be considered

The expert is also expected to consider the following additional information:

- Such information that, in expert's opinion, should be taken into account to address the questions outlined above;

5. Proposal requirements

The service provider is requested to provide a proposal addressing the project brief, including:

- Approach to the engagement, including any suggested changes to the brief or value-adds;
- High level project plan with milestone dates;
- Estimated effort and elapsed duration for the engagement;
- Proposed internal personnel, including CVs;
- Proposed subcontractors;
- Capped price.

6. Reports

Progress reports will nominally be fortnightly or as otherwise agreed.

7. Deliverables

At the completion of its review the Expert will provide an independent expert report which:

- is of a professional standard capable of being submitted to the AER and published in the public domain with no confidentiality provisions. It must also be prepared on the understanding that it may be referenced in an appeal under merits review, should this eventuate;
- in case where analysis is undertaken or models are used, sufficient detail of the analysis must be provided to meet the requirements of the National Electricity Rules Schedule S6.1.1 (2) and (4), Schedule S6.1.2 (2), (3) and (5), Schedule S6A.1.1 (2) and (4), and Schedule S6A.1.2 (2), (3) and (5). These schedules require a Revenue Proposal to include methods for developing forecasts, methods for developing forecasts of key variables and key assumptions that underlie forecasts. Specifically, the use of “black box” analysis is precluded.
- contains a section summarising the Expert’s experience and qualifications, and attaches the Expert’s curriculum vitae (preferably in a schedule or annexure);
- identifies any person and their qualifications, who assists the Expert in preparing the report or in carrying out any research or test for the purposes of the report;
- summarises TransGrid’s instructions and attaches these terms of reference;
- includes an executive summary which highlights key aspects of the Expert’s work and conclusions; and
- (without limiting the points above) carefully sets out the facts that the Expert has assumed in putting together his or her report, as well as identifying any other assumptions made, and the basis for those assumptions.

The Expert’s report will include the findings for each of the parts defined in the scope of works (section 2).

8. Timetable

The Expert’s report will deliver the draft final report to TransGrid by 5 August 2016 followed by the final report by 26 August 2016

9. Terms of engagement

The key terms of the engagement are as follows:

- a) You must not accept any other appointment or retainer to provide assistance or services to any other party in relation to this matter or the events surrounding this matter. You must at all times avoid any real or apparent conflict of interest between TransGrid’s interests in relation to this matter and the interests of any other person.
- b) You confirm that you have disclosed to us all information that is material to your engagement as an expert in this matter, including but not limited to:

- i. The nature of any services that Aurecon is currently providing, or may have previously provided, to TransGrid to the extent relevant to this engagement;
 - ii. Any holding of securities in TransGrid or any of its related bodies corporate that are held by your immediate family or any company in which you or a member of your immediate family has a material financial interest; and
 - iii. Your qualifications and experience, in so far as they are relevant to this matter.
- c) You will tell us about any matters of the sort listed above that arise, become known to you or significantly change after the date of this letter.

The terms on which the Expert will be engaged to provide the requested advice shall be as provided in accordance with the TransGrid's Q214/13 arrangements applicable to the Expert.

10. Remuneration

TransGrid will pay you for time spent on this matter in accordance with the instructions of TransGrid at the agreed rates in Q214/13.

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- (d) identify the questions that the expert was asked to address; and
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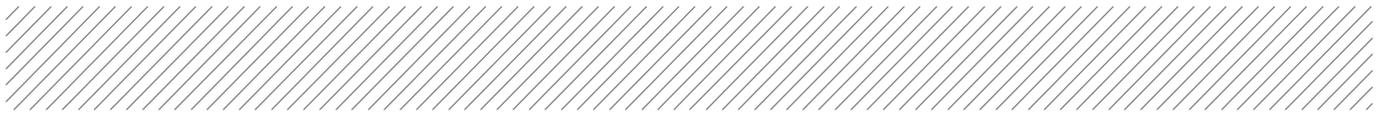
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J L B ALLSOP
Chief Justice
4 June 2013

⁴ See also *Dasreef Pty Limited v Nawaf Hawchar* [2011] HCA 21.

⁵ The *"Ikarian Reefer"* [1993] 20 FSR 453 at 565.

⁶ The *"Ikarian Reefer"* [1993] 20 FSR 563 at 565-566. See also Ormrod *"Scientific Evidence in Court"* [1968] Crim LR 240.



Appendix F

CV's of Report Contributors



Carl Badenhorst Technical Director Energy Services

Program and Project Director with over 20 years related experience, including significant international experience in South Africa, Canada and Australia. Excellent project management skills with extensive management, planning and financial experience. Strong background in power transmission and distribution projects, including advisory services. Registered Certified Practising Project Director (AIPM) and a Project Management Professional (PMI).

Qualifications

Executive MBA, Simon Fraser University
BSc, Electrical Engineering, University of Capetown
Advanced Diploma of Project Management, University of New England
Certified Practising Project Director (AIPM)
Project Management Professional (PMI)
Certified Practising Project Director (CPPD) - Certified Practising Project Director Project Management Professional (PMP)

Specialisation

Project and Program Management
Advisory Services

Years in industry

20+

Experience

2012 – present

Aurecon Australia Pty Ltd (Formerly Connell Wagner), Sydney

A global organisation offering engineering, management and specialist technical services to public and private sector clients)

Project Director, Transmission and Distribution

Responsible for the overall delivery of a program of transmission and distribution projects for various clients including TransGrid, Ausgrid, Endeavour Energy, Essential Energy, ActewAGL, and Zinfra.

Nov 2009 – 2012

Endeavour Energy, Sydney (One of three electricity distributors in New South Wales, providing transmission and distribution of power to over 2 million people)

Program Director, Major Projects

Responsible for managing a branch consisting of approximately 30 project management staff leading the delivery of \$0.8b of transmission and distribution capital works within the five year regulatory period.

- Ensured that the organisation's safety values were considered the highest priority in both project delivery and the operation of the branch
- Grew the branch from approximately 15 to 30 project management staff including senior PMs, PMs, schedulers, analysts and administrative staff
- Managed a portfolio of approximately 50 active major projects in various phases ranging from initial planning to final close-out. Individual projects ranged in value from \$1m to \$100m, and included zone and transmission substations plus the associated transmission and distribution feeders
- Managed compliance with Project Management Policies
- Assisted the Project Management Office (PMO) in the development of the Project Management Policies and Procedures.
- Managed a capital budget of approximately \$200m per financial year
- Identified and documented the key issues and risks present within the portfolio and ensured that adequate mitigation strategies and treatment plans were established
- Provided commercial and contract management support to Project Managers as required.



Carl Badenhorst Technical Director Energy Services

September 2008 – October 2009

ABB, Brisbane, Australia (Global organisation providing power and automation products and services)

Manager – Substation Services

- Responsible for developing the substation service business within the Power Systems group of ABB Australia.
- Worked with existing and potential clients to develop contracts for the provision of substation maintenance services.
- Formed a team to manage the ongoing implementation of these contracted services.
- Developed strategies to grow the service business in a sustainable manner.

August 2000 – April 2008

BC Hydro, Vancouver, Canada (Provides electricity to domestic, commercial and industrial customers in British Columbia including generation, transmission and distribution of power)

Substations Engineering Division Manager (Feb 2007 – Apr 2008)

Project Manager (Aug 2000-Jan 2007)

Responsible for managing the division consisting of approximately 90 professional, technical and administrative staff providing a variety of internal and external services on transmission substation capital and maintenance projects. Services include planning, design and maintenance engineering..

- Ensured that safety was considered and incorporated in all divisional activities and services
- Ensured adherence to applicable practices and standards, including project management practices
- Ensured successful delivery of the overall portfolio of work performed by the division
- Attracted, retained and developed critical staff to deliver services. Successfully retained 21 employees in order to deliver the significantly increased capital program
- Negotiated and recommended individual and long term strategic commercial agreements and contracts
- Successfully managed the organisation's \$2.8b per year Revenue Requirements Application to the BC Utilities Commission. Achieved a favourable negotiated settlement (the largest settlement achieved under the auspices of the BC Utilities Commission)
- Managing the Phase II BCTC Transition project (established the business relationship between BC Hydro and the newly formed BC Transmission Corporation)
- Provided leadership and mentoring in the development and ongoing activities of the Distribution Engineering Project Management Team
- Managed distribution electrical projects, typically ranging from \$300k to \$5m, from planning to commissioning and close-out, within time, cost, and performance constraints
- Managed the interconnection of Independent Power Producers to the distribution network



Joe Tusek Technical Director

Joe is a Technical Director spanning roles in Asset Management, High Voltage Testing and Advisory. He manages the Electrical Group in Newcastle and has over 35 years' experience in the power industry. Over this time he has worked in transmission, generation, power station construction and high voltage testing.

Qualifications

Bachelor of Engineering (Hons)
Master of Business Administration
CIGRE - Australian Panels Convenor of D1 and Member of the International Study Committee and Strategic Advisory Group - Materials and Emerging Test Techniques.
Member of A2-Transformers.
Member of Australian Standards Subcommittee EL_007_01 - High Voltage Testing Techniques

Specialisation

HV asset management, testing and condition assessment. Failure investigation. Technical data analysis and modelling. Electronic and electrical systems design, testing and fault finding.

Years in industry

Over 35

Project experience

2003 to present

Aurecon Australia, Technical Director

Joe is responsible for the management of the Electrical Services and Design groups at Newcastle which is Aurecon's centre of excellence in Asset Management. This centre provides specialised asset management services to the power industry and other heavy industries in Australia and Asia. He has provided consultancy and training within the power and mining industries on high voltage asset management, high voltage testing and measurements, insulating oil analysis, failure investigation, system identification of automatic excitation regulators and generator parameters.

Joe has consulted on various significant projects including most recently:

- Determination of 660MW generator and excitation system R2 parameters
- Member of the panel of enquiry into the failure of a generator at Liddell Power Station
- Owners engineer in generator core hotspot condition and risk assessment at Loy Yang A power station
- Technical advisor to Synergen Power, Snuggery Power Station generator failure and repair
- Technical advisor to Port Waratah Coal Services T1B1 transformer gassing investigation
- Technical advisor to Tomago Aluminium in instrument and rectifier failure investigation
- Technical advisor to Pacific Hydro on transformer FAT testing
- Technical advisor on rail insulating boot defect detection for Gold Coast Light Rail

Joe has lead and participated in significant reviews and audits of transmission assets including:

- SA Power Networks – Transformer, HV Cable and Transmission Lines Asset Management Plans.
- SAP Power Networks Maintenance Backlog Database review.
- Due diligence of TransGrid HV maintenance and assets.
- Technical review of reliability of Myki automated ticketing system.

Joe is the manager of the HV test group that provides routine and outage, high voltage motor, generator, cable, switchgear and transformer testing services across Australia and principally to Delta Electricity, Origin Eraring Energy and AGL Macquarie Generation. In the transmission sector the group provides field HV tests up to 720 kV AC. The group has been in existence since 1954 and in that time has performed over 20,000 high voltage plant test and condition assessments.

Joe has a high level of proficiency in the design, management and maintenance of electrical and measurement systems. He has designed and overseen the construction of many types of equipment and software for high voltage testing, test automation and data acquisition to support the HV testing and asset management requirements of the business.

Joe has authored and co-authored a number of technical presentations and papers, and has given a number of training courses in areas of High Voltage plant condition assessment.

Key achievements

- Developed testing systems and regimes for performing advanced generator and



Joe Tusek Technical Director

excitation system parameter measurements and modelling

- Developed various compliance monitoring tests and measurement systems
- Managing the Electrical Group at the Advanced Technology Centre since 2001, transitioning from public to private ownership
- Winner of the John Connell Award for innovation and technical excellence for work in the area of generator, governor and excitation system parameter determination - 2005
- Won and managed major HV testing contracts with all of NSW's main generating and transmission utilities
- Developed 120 cell, 1400A computer controlled battery discharge testing equipment
- Developed unique test equipment for the detection of traction rail insulating boot defects
- Developed various software packages, Universal Instrument Control Program, Frequency Response Analysis Program, Data File Structure Analysis Program, and aided in the development of the Recovery Voltage Analysis Program and Insulation Displacement Current Analysis Program
- Development of equipment and training of personnel in the use of Ultrasonic Partial Discharge location equipment, both in Australia and Malaysia
- Key developer in the Pacific Power INTELLINODE, remote condition monitoring system
- Developed a FM telemetered High Voltage disc voltmeter for condition monitoring of disc insulator strings
- Contributions to the field of electrical plant life management at the international level through CIGRE, Standards Australia and the University of Newcastle

Key expertise Management

- Management of multidisciplinary teams
- Business Management

- Development, implementation and operation of quality management systems
- Management of safety management systems

Technical

- Asset management systems development and implementation
- Development of asset health index measures
- Electrical plant testing, condition monitoring, condition and life assessment
- Power transformer, motor and generator life management, and insulation risk assessment
- Technical analysis of engineering systems
- Equipment failure investigations
- Power, energy and power quality measurement systems implementation and analysis
- Design of electrical and electronic systems and instruments
- Development and delivery of training programs in asset management
- Data analysis, modelling and simulation
- Scientific and engineering computing

Details of experience

Aurecon Australasia Pty Ltd (formerly Connell Wagner Pty Ltd)

2003 to present, Manager/Electrical

Responsible for the operations of Aurecon's HV Test group at the Newcastle Office. Providing specialised consulting and training in areas of electrical asset management, high voltage testing and condition assessment, engineering measurements, compliance testing, data acquisition and electronic systems design. Major consulting projects included 660MW generator and governor parameter identification as well as system identification of complete analogue automatic excitation regulators.



Joe Tusek Technical Director

1979 to 2003, Pacific Power

Pacific Power was the sole organisation responsible for the generation and transmission of electrical energy in New South Wales. Pacific Power International was the supplier of engineering and technical services to the power supply industry throughout Australia and South East Asia. Joe's experience has included roles in business management, project management, construction, maintenance, engineering, asset management, technical services and power system analysis.

2001 to 2003, Manager/Electrical Plant Investigations

Responsible for the operations of Pacific Power International's Electrical Plant Investigation Branch at the Advanced Technology Centre. Provided specialised consulting in areas of electrical asset management, training, high voltage testing and condition assessment, engineering measurements and data acquisition.

1993 to 2003, Senior Consultant/Electrical Plant Investigations

Provided expert consulting in ultrasonic partial discharge location, high voltage testing, electronic systems design, remote condition monitoring systems, thermal imaging, engineering and scientific software authoring, digital signal processing and system identification. Responsible for OH&S and NATA laboratory accreditation. Provided training in condition monitoring and assessment in Australia and in Malaysia.

1986 to 1993, Engineer (Grade 1, 2 and 3) - TransGrid

Held various positions in diverse areas of transient and harmonic analysis, operations, facilities management and gas turbine control systems maintenance. Was also involved in electronic hardware design, reverse and re-engineering projects. Design analysis and verification work on the Kemps Creek Static Var Compensators. Worked as a programmer performing software design and development for TransGrid's Energy Management System.

1979 to 1986, Engineer (Cadet and Grade 1) - Electricity Commission of NSW

Worked in power station construction at Bayswater Power Station, involved in contract administration and supervision of contractors and inspections at Bayswater Power Station of the cable supply and installation, turbine house overhead crane and circulation water pump electrical contracts. Worked in Operations at Tallawarra Power Station, and various other locations in junior positions associated with TransGrid field maintenance.

General

- Provided training in condition assessment methods for HV plant in Australia, Malaysia and Indonesia
- Aurecon's representative on Australian and International CIGRE D1 Committees (Materials and Emerging Test Techniques)
- Aurecon representative on CIGRE Australian Panel A2 (Transformers)
- Member of Australian Standards Committee EL-007-01 - High Voltage Testing Techniques

Papers

Joe has been an author of and co-authored numerous technical and conference papers.



Joe Tusek Technical Director

Tusek, J., Developments in sensitive measurement of traction insulated rail defects. Internal report, Aurecon, 2016.

Welsh, J., Wolinski, S., Tusek, J., Developments for Frequency Response Analysis Automation. CIGRE, Paris, France, 2016

Wolinski, S., Welsh, J., Tusek, J., Optimizing Basis Function Pole Locations for Transformer Frequency Response Identification. AUPEC, Hobart, TAS, Australia, 2013

Wolinski, S., Welsh, J., Basis Function Modelling of Transformer Frequency Response Analysis using PSO. Cigre Colloquium, Brisbane, Australia, 2013

Dawson, R., Naismith, N., Tusek, J., Optimise Power Plant Reliability With A Structured Plant Asset Management Approach. PowerGen Asia, Kuala Lumpur, Malaysia, 2008.

Tusek, J., Elliott, B., Standstill Frequency Response Measurement of Generator Parameters. AUPEC Perth, Australia, 2007.

Tusek, J., Bateman, G., Finlay, B., Australian Experience with the Periodic Condition Assessment of Power Station High Voltage Motors, CIGRE Colloquium, Gyeongju South Korea, 2007.

Tusek, J., High Voltage Plant Asset Management. Strategic Industry Research Fund Round Tables 9SIRF-RT), Queensland, Australia, 2007.

Finlay, B., Tusek, J., Transformer Condition Diagnosis Using Frequency Response Analysis, TechCon Sydney, Australia, 2006.

Tusek, J., Thiru Siva, Dynamic Torque Measurement, Austerque, Sydney, Australia. 2005.

Tusek, J., The Role of High Voltage Testing in Plant Risk Control, Austerque, Sydney, Australia, 2004.

Bateman, G., Tusek, J., Condition Monitoring of High Voltage Rotating Machines, Presentation, ESAA, 2004.

Tusek, J., Dissolved Gas Analysis, Presentation, ESAA, 2004.

Tusek, J., Frequency Response Analysis, Presentation, ESSS, 2004.

Cornforth, D., Middleton, R., Tusek, J. Visualisation of electrical transients using the Wavelet transform.

Tusek, J., Crash Course in Electrical Condition Monitoring for Mechanical Engineering Students, Newcastle University, Australia, 2002.

Conforth, D., Middleton, R., Tusek, J., Intellinode : A Distributed Condition Monitoring System for High Voltage Electrical Insulation. University of Newcastle Industry Research Report, 2000.

Tusek, J. & Walsh, G., Research into the Failure of 11kV Plugs and Adaptors Used in Underground Coal Mines, ACARP, 1997.



Loni Karabesinis Technical Director Energy Services

Loni has extensive experience as an engineering manager in the energy services industry. He has expertise in the overall management and implementation of energy and industrial infrastructure projects throughout Australia and Internationally including the design, technical direction, document preparation, contract and site management of these projects. He has managed the feasibility, development and the design delivery of the civil and structural components for several power station, substation and energy related projects, including the delivery of renewable energy projects. Loni also has extensive and specialist experience in the decommissioning of industrial facilities.

Qualifications

Master of Engineering
Science (Construction and
Management) UNSW
Bachelor of Engineering
(Civil), University of New
South Wales

Specialisation

Civil and Structural Energy
and Industrial Infrastructure
Engineering Projects
Project Management and
Decommissioning

Years in industry

36

Experience

February 2003 to Present

Principal Engineer

Aurecon Australia Pty Ltd, Sydney (formerly Connell Wagner)

- Leader of the Aurecon NSW Energy Civil and Renewables Group
- Project Director for the 20 MW PV Barcardine Solar project, North Queensland, providing detailed design and document preparation to Green Light Contractors (Elecnor)
- Due Diligence on a confidential wind farm in Victoria for a confidential client
- Project Director for the 3MW PV Solar project, providing project development assistance to the University of New England
- Project Lead for the provision of Owners Engineer development services for the Silverton 200 MW Wind Farm project, Broken Hill NSW for AGL
- Civil lead approver for the TfNSW traction Gosford Substation and Wyoming Sectioning Hut detailed design and document preparation for Zinfra Group
- Project Director for the provision of Owner's Engineer Services for the 56 MW Moree Solar Project (PV) in NSW for Fotowatio Renewable Ventures
- Project Director for the provision of Owner's Engineer Services for 20 MW Royalla Solar Project (PV) in ACT for Fotowatio Renewable Ventures
- Professional Head Track & Civil for the Novo Rail alliance. Responsible for the engineering capability and technical competence of track and civil engineers and engineering activities within Novo Rail. Novo Rail is an alliance of Transport for NSW with Aurecon, Lang O'Rourke and ODG Haden working together to deliver a substantial portfolio of infrastructure works across Sydney's local rail network.
- Professional Head Civil & Track for Novorail Projects, including new Canopies for 10 Railcorp stations, Wynyard Station upgrade, Newcastle Truncation Project, Westmead to Granville Resignalling Project and miscellaneous brownfield substation upgrade projects.
- Preparation of Decommissioning Strategy and Options for the Ron Goodin Power Station in Alice Springs for Territory Generation



Loni Karabesinis Technical Director Energy Services

- Project Director and Decommissioning lead for the Wallerawang Power Station Decommissioning, Demolition and Remediation Plan Preparation for Energy Australia
- Decommissioning lead on the Callide Oxyfuel Project Decommissioning and Asset Sale Technical Specification Preparation for CS Energy
- Project Director and Decommissioning lead for the Gladstone Power Station Closure Cost Estimate for NRG Gladstone Operating Services
- Project Director and Decommissioning lead for the Callide Power Station A, B and C and Ash Dams Demolition and Remediation Cost Estimate preparation for CS Energy
- Project Director and Decommissioning lead for the Kogan Power Station Demolition and Remediation Study preparation for CS Energy
- Project Director for technical and environmental due diligence assignment of Macquarie Generation's Generation Assets for potential buyer
- Civil lead for the technical due diligence of Delta Electricity's Western Generation Assets for Energy Australia
- Civil direction and technical assistance for the design and delivery of the Penrith Substation as part of the Novo Rail alliance for Transport for NSW
- Civil lead for tender design preparation for the Visy Clean Energy Power Project (45 MW Biomass Plant and Handling Facility) in Tumut NSW for Theiss
- Civil lead for tender design preparation for the Leichhardt (Diamantina D) Gas Power Station (60MW) project in Mt Isa, Queensland for Leighton Contractors
- Civil design and documentation for oil containment and upgrade works for Yanco, Tenterfield, Buronga and Deniliquin substations for Transgrid
- Project Director for design delivery of the Civil BOP and fuel delivery system for Solomon 4 x 15 MW diesel fuel mobile Power Station in the Pilbara region of Western Australia for Zinfra - FMG
- Civil Discipline lead for the civil engineering feasibility design and documentation of the Terminal 4 Coal Export Terminal at Kooragang Island, NSW for Port Waratah Coal Services
- Project Director for the engineering design and documentation preparation for the Balance of Plant for the Merriden Power Station (2x40 MW open cycle gas turbine distillate fuelled) in Western Australia for CTEC.
- Project Leader and Director for the civil and primary design engineering and documentation for Yanco Substation refurbishment and upgrade works in NSW for TransGrid.
- Civil Discipline lead for the civil engineering and documentation for the Murchison Radio-astronomy Observatory Power System (diesel and solar powered facility) which will host the Australian Square Kilometre Array Pathfinder Project.
- Civil Discipline lead for the civil, structural and building engineering and documentation preparation for the Merriden Power Station (2x40 MW open cycle gas turbine distillate fuelled) in Western Australia for CTEC.
- Project Director Nhon Trach 2 (750 MW) Combined Cycle Gas Turbine Project, Civil and Building works detailed design and project management in Vietnam for Petrovietnam Construction.
- Project Management, Owners Engineer services for Woodlawn Windfarm (48 MW), Tarago, NSW for Infigen
- Civil Discipline lead for the civil engineering prefeasibility design and documentation of the Terminal 4 Coal Export Terminal at Kooragang Island, NSW for Port Waratah Coal Services.
- Civil Discipline lead for the civil engineering, building design and document preparation of the NCIG Coal Export Terminal at Kooragang Island, NSW Stages 1, 2AA & 2F.



Loni Karabesinis Technical Director Energy Services

- Civil and structural design and drawing documentation preparation for Tomago, NSW Substation for Jemena
- Project Management, Owners Engineer services and Project Formulation for Capital Windfarm (132 MW) Bungendore, NSW for Infigen.
- Project Management, Owners Engineer services and Project Formulation for Lake Bonney 1 & 2 Windfarms (80 and 159 MW), Port Augusta, SA for Infigen.
- Civil and structural design and drawing documentation preparation for Wagga Wagga North, NSW and Quenbeyan, ACT Substations for Downers.
- Project Management, Owners Engineer services and Project Formulation for Alinta Windfarm (89MW), Geraldton, WA for RPV/Infigen.
- Concept design of transformer access, existing services relocation and protection for the Macarthur Substation for TransGrid, NSW.
- Civil and structural design, drawing and specification documentation preparation for the Bluewaters Power Station Units 1 & 2, Plant Civil Works for IHI, Collie, WA.
- Civil documentation preparation for the Tallawarra Power Station Connection Works for TRUenergy.
- Feasibility Study (civil engineering, earthworks, buildings, amenities and services) for the new Coal Export Terminal at Kooragang Island for NCIG, NSW.
- Civil design, drawings and specification documentation preparation for the Bluewaters Power Station Site Preparation Works for IHI, Collie, WA.
- Civil Owner's Engineering services to TRUenergy for Tallawarra CCGT 435 MW Power Station procurement and construction in NSW.
- Documentation preparation, tender management, analysis, award, site and contract management of Site Clearance Works for the Tallawarra CCGT 435 MW power station for TRUenergy, NSW.
- Tender analysis and negotiations of civil and structural aspects for the Tallawarra CCGT 435 MW Power Station EPC Contract for TRUenergy, NSW
- Civil and structural design documentation preparation for the Tallawarra CCGT 435 MW Power Station EPC Contract for TRUenergy, NSW
- Civil Prefeasibility Study for proposed new coal terminal at Kooragang Island for NCIG, NSW
- Concept Design and Cost Estimate for Horsley Park Brickworks expansion for CSR – PGH, NSW
- Engineering, design, documentation, site and contract management of the Plant Civil Works Stage 1 Tallawarra Energy Facility for TXU, NSW
- Civil and Structural Design Upgrade 14 Zone Substations for Country Energy, NSW
- Upgrade Works for Alstonville, Casino and South Lismore Substations
- Site Earthworks and Blower Room for Lime Plant at Galong, NSW for Blue Circle Southern Cement
- Civil Owner's Engineering support services for the Huntly Power Station CCGT 385 MW in New Zealand
- Gas Turbine Foundations for Huntly Power Station OC 40 MW in New Zealand
- Project Aqua Bid Proposal Coordinator, New Zealand
- Preliminary concept design for Scottish Canoe Course for Byzac, Glasgow, Scotland
- Provision of construction and design advise to Greek construction contractors for the Athens 2004 Whitewater Canoe Facility



Loni Karabesinis Technical Director Energy Services

- Led the Civil Engineering contribution to the winning bids for the Callide C and Tarong North Power Station Engineering, Procurement and Construction Projects (\$2 billion project value)
- Successfully delivered the civil and structural design and drawing requirements for the Callide C and Tarong North Power Station Projects, including the contract management of all the civil subcontracts (contract worth \$120 million)
- Delivered and managed the White Water Canoe Course from inception to commissioning well in time for the Sydney 2000 Olympic Games and provided technical advice to the constructor of the Athens Olympic White Water Course
- Successfully decommissioned and disposed of Pacific Power's redundant power stations and surplus sites throughout NSW (\$250 million total cost)
- Delivered the civil works for the Burrinjuck Hydro Project a logistically difficult project involving hard rock blasting adjacent to existing structures, deep under water construction and difficult construction access issues.

April 1996 to February 2003

Manager, Civil Engineering & Environment

Pacific Power International

- Led the civil and structural engineering contribution in the winning bids for the Callide C and Tarong North Power Station Engineering, Procurement and Construction Projects (\$2 billion project value)
- Successfully engineered and delivered the civil and structural design and drawing requirements for the Callide C and Tarong North Power Projects (a fast track project involving over 1,600 civil drawings)
- Managed the procurement and delivery of the site civil works for the Callide C and Tarong North Projects within allocated budget and very tight program schedule (\$120 million and 18 months per unit)
- Successfully project managed the document preparation, tender process and awarding of all contracts for the Burrinjuck Hydro Project including the design and delivery of the civil works. A logistically difficult project involving hard rock blasting adjacent existing structures, deep underwater construction and difficult construction access issues.
- Delivered and project managed the Penrith White Water Canoe Course from inception to commissioning well in time for the Sydney 2000 Olympic Games
- A key member of the team to receive a "highly commended" award in the 2000 Engineering Excellence Awards from the Institute of Engineers Australia, Sydney Division for the Penrith White Water Canoe Course
- Delivered and managed the civil design and contract works for Australia's first grid connected wind farm at Crookwell, NSW and for a larger wind farm at Blayney, NSW
- Developed and implemented a civil asset management strategy and methodology for power stations and similar complexes now widely used throughout power stations in NSW.

June 1990 to March 1996

Pacific Power

Manager, Decommissioned Sites

- Successfully decommissioned and disposed of Pacific Power's redundant power station and surplus sites throughout NSW
- Successfully managed a complex and hazardous decommissioning process, involving asbestos removal, dismantling and demolition of major structures and decontamination of ground surfaces within the Sydney inner city metropolitan area
- Developed procedures and methodology for decommissioning power station sites and related structures implemented by power authorities in Victoria and Western Australia



Loni Karabesinis Technical Director Energy Services

- Successfully managed and implemented large scale controlled explosive demolition techniques for large industrial structures within built-up areas
- Managed the Industrial and Community Relations including the Development Approval Process for the Decommissioning Works Program without any adverse impact or delay on the disposal program and overall budget.

Pre-1990

Project and Site Engineer

Pacific Power

- Site supervision and coordination of civil contracts on a variety of power station related projects covering large dams, pipelines, chimney stacks, hardrock tunnels, heavy foundations, pump stations, roadworks, bridges and building works for administration buildings, workshops and plant related buildings throughout NSW.



Mike Luger Technical Director Environment & Advisory Services

Mike is a Technical Director for environment in Sydney and was previously also Aurecon's Expertise Leader for Environmental Management for Australia New Zealand. He has almost 25 years' experience in environmental impact assessment and approvals, environmental management plans and compliance, and review of environmental reports. He has worked extensively in the water and energy sector in Australia and southern Africa. Mike chairs an international advisory panel on the environmental implications of South Africa's nuclear power plant program, and has led numerous major environmental projects.

Mike is familiar with NSW waste management assets, regulations and policy having undertaken a due diligence process for the acquisition of the WSN landfill, waste transfer and other assets. He is also familiar with noise, air, surface and groundwater monitoring and modelling. Mike was the environment lead assisting EnergyAustralia in their due diligence for the acquisition of the Wallerawang and Mt Piper powerstations as well as the environment lead for numerous other due diligence processes including TransGrid. Mike is familiar with the World Bank/ International Finance Corporation principles, performance standards and sector guidelines and has knowledge of the environmental issues associated with various types of industrial and waste disposal facilities, including ash dams and repositories, wastewater treatment works and sludge lagoons.

Qualifications

BSc (Zoology and Environmental & Geographical Science),
University of Cape Town
BSc (Hons) (Environmental & Geographical Science),
University of Cape Town
MPhil (Sci) (Environmental & Geographical Science),
University of Cape Town

Specialisation

Environmental planning
approvals and impact
assessment
Environmental management
Environmental compliance
and due diligence
Stakeholder consultation

Years in industry

20+

Project experience

February 2010 to present
AURECON Pty Ltd - Technical Director/
Expertise Leader for Environmental
Management

- **Confidential (2015-2016): Environmental due diligence for acquisition of the Transgrid transmission assets in NSW.**
- Confidential (2014-2015): Route selection, easement acquisition, biodiversity offsets for approximately 150km of powerline easement in NSW.
- **Taralga Wind Farm Nominees (2015): Taralga Wind Farm Environmental Compliance Report for lenders**
- Jemena (2014-2015): Panel manager for the provision of environmental services for electrical and gas assets in Victoria, NSW and Queensland.
- Sydney Water Corporation (2013 -): Project director and environment lead for a program of works for new and upgrades to existing wastewater and water infrastructure.
- Energy Australia Tallawara (2013-): Seagrass monitoring and licence reporting and various other investigations at Tallawara power station.

Mike Luger Technical Director

- Energy Australia NSW (2012-): Suite of investigations and reporting on surface and groundwater salinity potentially caused by Mt Piper power station ash repository and/or coal mining activities in the catchment.
 - Equinix datacentre (2015): Review of compliance with planning conditions of approval to secure construction certificate.
 - **Energy Australia due diligence (2012-2013): Environmental (water, air emissions, legal and licensing, contamination) due diligence of Delta Western NSW power station assets Wallerawang and Mt Piper.**
 - Tank farm planning approvals (2013-2014): Caltex: Managed development application for changes and additional petrol and diesel tanks near Newcastle.
 - Eraring Energy (2012-2014): Panel manager for the suite of environmental monitoring, management and reporting tasks associated with the power station.
 - Kandos future use investigation (2012): Investigated environmental opportunities and constraints associated with decommissioned cement factory.
 - Patrick Stevedores (2012-2013): Project Director for the stormwater quality improvement device section 75W modification for the expansion of the container facilities at Port Botany.
 - Camp Sapper (2012): Environmental assessment and contamination management associated with small boat harbour dredging and spoil disposal.
 - **Project Chester (2012): Environmental due diligence inputs for confidential major urban development in Sydney.**
 - North West Rail Link (2011-2012): Technical reviewer of the two Environmental Impact Statements for the 23km rail link from Epping to Rouse Hill.
 - Port Waratah Coal Services T4 (2011-2012): Technical review of environmental management process and environmental design reports during pre-feasibility stage.
 - Frederickton to Eungai (2011): Compiled environmental management plan and audited environmental compliance of the geotechnical investigations associated with the realignment of the Pacific Highway.
 - Newcastle Coal Infrastructure Group (2010-2011): Input into the environmental management of the construction of the terminal.
 - **WSN waste management (2010): Managed the environmental due diligence and review of assets and landfill closure provisions for a potential purchaser of WSN.**
 - Tintenbar to Ewingsdale (2010): Compiled surface water quality and groundwater monitoring plans for the NSW Roads and Traffic Authority.
- December 2008 to February 2010
November 1993 to November 2008
- NINHAM SHAND Pty Ltd (now Aurecon) -
Director and Environmental Discipline
Group Leader
- **Review of Nuclear Power Station (2008-current): Chairperson of the Advisory Panel appointed to advise the National Department of Environmental Affairs on the Environmental Impact Assessment for South African's conventional nuclear power station programme.**
 - Coal to liquids site selection (2007-2008): Undertook a confidential screening process to find the best location for a new plant for PetroSA.
 - Durbanville crematorium (2003-2004): Managed the suite of applications for environmental and air pollution approval for a crematorium, for Durbanville Memorial Park.
 - Potsdam Wastewater Treatment Works (2000-2002): Oversaw the EIA and dealt with the subsequent appeal process and environmental monitoring for the upgrade and extensions of the 47 Ml/day plant located in close proximity to a protected wetland system and residential area.
 - Wildevoelmei sludge rehabilitation (2001-2005): Investigated and assessed a range of options to remove and dispose of sludge from an ecologically important coastal lagoon in South Africa for the Cape Metropolitan Council.



Stephen Hodgkinson Technical Director Energy Services

Stephen has extensive experience in the electricity supply industry and has worked in both the transmission and distribution sectors. He has undertaken power system analysis studies for the South East Australian transmission system and had a lead role in the design of a number of overhead transmission lines, high voltage substations and underground cable projects with responsibility for both the broad design parameters and detailed design.

Qualifications

BE(Hons) UNSW 1982

Member IEEE

Member of the Institution of
Engineers Australia

Specialisation

Power Systems Analysis

Transmission Lines

High Voltage Substations

Years in industry

34

Project experience

Aurecon Australia Pty Ltd - Technical Director, Energy Services

July 2007 to November 2015

Projects include:

- Olympic Dam mine expansion project. Examined power transfer capacity for large mine project supplied by a 260 kilometre radial 275kV transmission line, including reactive plant support requirements, voltage stability, load rejection and line thermal rating.

Carried out power system loadflow and voltage stability studies to determine network concept for connection of proposed copper mine to South Australian 275kV transmission network via a 180 kilometre 275kV transmission line.
- Electromagnetic induction studies to assess earth potential rise and touch potentials for a water pipeline in close proximity to a 132kV overhead transmission line. Determined safety requirements for pipeline.
- Power system loadflow, fault level, equipment rating and transient stability studies for the 250MW Silverton wind farm project including scoping of reactive plant requirements, voltage control, wind farm transient stability and ride through response to fault conditions on the interconnected 500/330/220kV network. Developed wind generation runback scheme to enable wind farm to be connected to a long radial network.
- Network studies to assess equipment rating, transformer requirement, reactive plant and network fault levels for a 220kV high voltage transmission network to supply the Roy Hill mine from five unit gas turbine power station.
- EMTP electromagnetic transient analysis studies to assess performance of 330kV and 275kV overhead lines to evaluate line lightning performance when the lines are fitted with surge arresters.
- Carried out design reviews for 500kV insulation designs for new transmission line project. Developed high voltage testing specification and managed high voltage tests on 500kV insulator arrangements for Halys-Blackwall transmission line. Tests carried out included radio interference, lightning impulse, switching impulse and high current test.
- Modelling of 220kV fault levels for the redevelopment of the SP Ausnet West Melbourne substation using system data for the interconnected transmission network.
- Prepared electrical designs for planned 750kilometre 330kV and 220kV double circuit transmission line project in central Queensland including studies to determine conductor requirements, insulation design, electrical clearances and lightning performance and equipment specifications.
- Hobson St 220/110kV substation GIS substation concept design. Role included design of primary layout for 220kV and 110kV gas insulated switchgear, multi-level switchgear



Stephen Hodgkinson Technical Director Energy Services

building, transformer enclosures and cable tunnels to integrate onto a confined CBD site and 220kV and 110kV underground cables. Role also included EMF assessment and earth grid concept design.

- Managed studies to assess surface voltage gradient and corona performance for conversion of 220kV Broken Hill single circuit overhead line to 275kV operation for proposed wind farm
- Network load flow studies and equipment ratings assessment to determine transmission augmentations required to supply a major industrial load to be connected to the north west NSW 132kV transmission network.
- For Eastlake 132/11kV substation, undertook preliminary layout of gas insulated switchgear, substation layout and overhead and underground cable concepts.
- Managed cable loading, fault level, voltage unbalance and induced voltage studies on 275kV underground cable project in Adelaide to assess impact on underground gas pipelines and telecommunications facilities.
- Tomago 330/132kV substation. Role included primary layout design, earth grid, lightning protection, short circuit terminal loads, high voltage equipment selection, insulation coordination and review of secondary systems and protection design.
- Managed studies to assess network load flow and fault levels for the concept design for proposed Sydney Metro rail system
- Queanbeyan 132/66kV substation. Role included primary layout design, earth grid, lightning protection and insulation coordination and review of protection design
- Undertook EMTP insulation coordination studies for design of 275kV substation to connect North Brown Hill Wind Farm to transmission network
- Wagga North 132/66kV, Raleigh 132/33/11kV, Boambee 132/66/11kV and Macksville 132/11kV substations. Role included primary layout design review, earth grid and lightning protection and insulation coordination design review.
- Olympic Dam Expansion. Prepared concepts for new 275kV line connections including insulation, conductors and 275/132kV substation augmentations.
- Carlingford substation. Undertook thermal rating studies for 132/66kV transformers to assess transformer overload capacity for present day loading

TransGrid – High Voltage Design Manager

1995-July 2007

- Manage a team of professional engineers and engineering officers responsible for the electrical design of overhead transmission lines and high voltage substation switchyards.

This position was a technical specialist position that determined performance criteria for insulation coordination, electrical clearances, conductor selection, overhead line vibration design, corona performance, electrical safety, and coordination of power and telecommunications facilities. This position provided specialist advice to other groups within TransGrid as well as being responsible for development of substation and overhead line design standards and purchase specifications for insulators, conductor and optical fibre ground wires.

Experience includes a wide range of transmission line and substation projects, including development of Bayswater and Mt Piper 500 kV substation layouts, Coffs Harbour 330 kV substation augmentation, Yass substation reconstruction.

- Queensland-NSW interconnection 330kV transmission line. Role included selection of transmission line design parameters for towers and compact poles, insulation design, transmission line lightning performance, corona design, earthing.
- Queensland-NSW interconnection 330kV substations. Role included primary layout design of rebuild of Armidale 330/132kV substation and design review for static var



Stephen Hodgkinson Technical Director Energy Services

compensator. Undertook primary layout design and earth grid design of new substation at Dumaresq.

- Sydney CBD Haymarket 330/132kV substation. Role included primary layout design for gas insulated switchgear and gas insulated transformers and reactors, earth grid design, 330kV and 132kV underground cable layout, 330kV cable cross bonding and earthing; mitigation of 330kV cable earth potential rise and step and touch voltages.
- Lead role on TransGrid consultancy projects for the design of the Hadspen 220/110 kV substation in Tasmania, specialist corona studies for a proposed 330 kV compact pole line for Western Power and concept design studies for the proposed Transpower New Zealand 400 kV transmission lines and substations.
- Undertook insulation coordination studies for TNB (Malaysia) 275kV and 132kV substations.
- Managed an ARC Linkage research project with Queensland University of Technology to assess aging mechanisms for composite insulators.

ECNSW/Pacific Power - Transmission Line Electrical Design

1990-1995

- Responsible for the electrical design of overhead lines, technical investigations concerning transmission line insulation coordination and line design parameters and development of line design computer software.
- Transmission line design specialist member of PPI/SECVI consultancy team for Vietnam North-South 500 kV transmission line project. Involvement included verification of the overall line design, lightning performance and field investigations in Vietnam of transmission line tower earthing.
- Undertook specialist surface voltage gradient and radio interference studies for CSIRO for the proposed Narrabri-Wee Waa 132 kV transmission line.
- Under the electrical design of the Mt Piper to Marulan 500kV double circuit transmission line including insulation coordination studies and high voltage testing of 500kV insulator string assemblies.
- Performed specialist transmission line electric and magnetic field studies for Electricity Commission submission to the 1991 Gibbs Inquiry into Electricity Transmission in NSW.

ECNSW - System Planning

1988-1991

- Load flow and transient stability studies for the interconnected NSW-SECV-ETSA transmission system. Undertook load flow and transient stability feasibility studies into proposed Queensland-NSW 330kV AC interconnection; coordinated field commissioning and power system testing of Kemps Creek SVC. Performed transient stability studies to assess transmission line coordination of line protection clearing times with system stability.
- Undertook technical and economic evaluation of future transmission system needs for metropolitan Sydney. Duties includes liaison design, project and system operation groups and with external supply authorities for joint planning requirements and load flow and fault level analysis of ECNSW transmission network.

ECNSW - Transmission Line Design

1986-1988

- Technical investigations concerning design, construction and maintenance of high voltage transmission lines. Development of line design computer software.
- Carried out technical investigations for the performance of high voltage insulators and transmission insulation coordination.



Stephen Hodgkinson Technical Director Energy Services

Sydney County Council - Protection Design

1985-1986

- Carried out sub-transmission protection system designs, settings and fault calculations; relay purchasing and testing; investigations into abnormal protection operations. Examined operation of 11kV feeder Sensitive Earth Leakage protection relays and their interaction with delta-star 33/11kV transformers.

Sydney County Council - Eastern Area

1983-1984

- Supervision and coordination of distribution construction and maintenance staff. Carried out design and coordination of distribution mains and substation augmentations; distribution and sub-transmission protection designs, settings and maintenance.

Sydney County Council - Distribution System Planning

1982-1983

- System Planning studies for zone substation development plans, network load forecasts; 33 kV and 132 kV power system investigations.

Sydney County Council - Engineering Cadet

1977-1982

- Engineering cadet employed on a rotational training scheme, with experience in workshops, design, system planning and electrical testing



Steve Redhead Technical Director Energy Services

Steve has over 17 years experience in the electricity supply industry specialising in transmission design to 500kV. He has been involved with the whole of asset lifecycle including regulation, business case development, through design process to construction supervision and commissioning. In recent years Steve has been instrumental in developing key client relationships at all levels of organisations as Client Relations Executive for a number of energy companies to trusted advisor status. He has worked on projects throughout Europe, USA Australia and NZ and brings experience of international best practice. He is also a member of the Cigre AP B2 for overhead lines.

Qualifications

MENG (Hons) Materials
Design and Engineering
Chartered Engineer
Member of Institution of
Engineering and Technology

Specialisation

Client relationships
Transmission Lines

Years in industry

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Experience

Aurecon Australia Pty Ltd (Formerly Connell Wagner)

2007 - Present

Technical Director

- Failure analysis of 220kV tower
- Installation issues investigation with large AAAC stringing
- Detailed design of over 1000km of HV transmission line for Copperstring Project QLD
- Project manage 9000km of Overhead Line ALS data submissions on behalf of TransGrid
- Design 330kV transmission line Dumeresq - Lismore
- Design 132kV circuit turn-ins and reconfigurations for Orange North Switching station
- Design double circuit 132kV concrete pole transmission line Kempsey - Port Macquarie
- Design double circuit 132kV concrete pole transmission line Tamworth - Gunaddah
- Provide solutions to overcome clearance infringements using finite element methods for numerous TransGrid 300kV and 132kV lines
- Specification for 66kV transmission line at Daunia Mine
- Benchmark 500kV Transmission Line costing - Bannaby to Sydney 500kV Line Development
- Upgrading investigation for TransGrid 330 kV Tumut - Yass line
- Upgrading investigation for TransGrid 330 kV Tumut - Canberra

National Grid, Network Mapping – Design Project manager

2002 – October 2007

- Manage a team of engineers providing a complete OHL design service for existing and new build overhead lines, providing added value engineering solutions such as line analysis, line upgrading, re-routing and new build design. Based on data from ALS capture techniques and use of finite element method design software such as PLS-CADD.
- Managed ALS projects for international clients requiring financial control, specification interpretation and planning through to delivery.



Steve Redhead Technical Director Energy Services

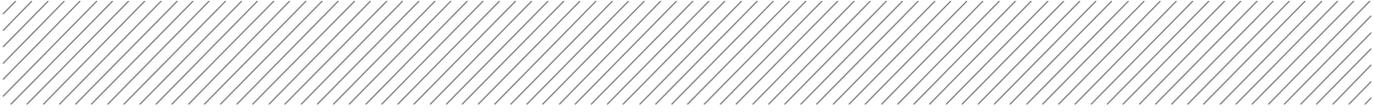
- Project Managed thermal uprating program for National Grid Company 400kV and 275kV system delivering on average 8% ratings enhancement for minimal work (zero outage requirements) and on average 15% ratings enhancement using re tensioning and suspension clamp displacement techniques.
- Managed incorporation of British line design standards into PLS-CADD line design software.
- Assisted in introducing Aerial Laser survey techniques to National Grid USA. Produced specifications for complete asset management solution for Overhead Line data for NG-USA network.
- Introduced replacement Geographical Information system within National Grid, introduced at minimal cost using data captured from the aerial laser survey projects. Combined Asset Management Information and Wayleave Information systems within a GIS environment.
- Specified, and managed the IS infrastructure for Network Mapping with particular focus on data security and worldwide communications.
- Responsible for seeking and implementing new applications for captured data and managing through to product deliverable.

National Grid – Overhead Line Policy Engineer 2001 – 2002

- Development of engineering documentation and drafting of technical specifications for OHLs to facilitate the design, supply, erect and maintain strategy for NGC.
- Work with transmission design to develop long term policy and strategies for application of new technologies.
- Project management of R&D projects.
- First line technical support to maintenance staff.
- Audible noise responsibilities, in a technical advisor role.
- Produce technical specifications for OHL transmission equipment
- Project managed R&D project Composite Insulator application for 400kV overhead lines

National Grid – Scheme Support Engineer 1998 – 2001

- Provided technical advice on all transmission plant items, with particular focus on overhead line issues, inputting to multi- million pound connection and infrastructure schemes, capital asset replacement schemes and overseas projects.
- Responsible for studying new capital delivery schemes to identify technological issues such as design, rating and environmental impact. Required to liaise with other technical experts within Engineering & Technology and other operating units to provide the scheme team with relevant information within tight timescales, to allow timely completion of feasibility in order to be presented to the board for project sanction. In the case of overseas work, technological solutions were required to assist NGC in winning contracts.
- Expanded audible noise responsibilities to attending public consultations.
- Responsibility for Type Approval of new insulators and conductor fittings for use on the NGC transmission system, from UK and overseas suppliers. The work encompassed many aspects including design review, type testing, and approval of drawings/designs and subsequent test documentation.
- Responsible for project managing R&D projects including Audible noise research, which involved full scale erection trials of a triple bundle (novel for use in the UK) and developing a strategy for prevention of birds roosting on overhead line lattice steel structures. These had a combined budget of £500k and involved managing various numbers of people and cross-functional working.



Steve Redhead Technical Director Energy Services

National Grid - Overhead Lines and Environmental Sciences Engineer 1996–1998

- Responsible for all aspect of overhead transmission line design, with a focus on investigation of public complaints, regarding environmental issues with Overhead Lines (OHL) and instigating remedial actions to alleviate problems.
- Responsible for audible noise surveys to specify noise specifications for new or uprated plant with the intention of minimising the impact on third parties and the public. Further responsibilities included providing technical advice on audible noise for inclusion in planning applications, Environmental Statements, consent reviews and public enquiries, (and also extended to external clients as a service).
- Natural pollution testing of polymeric overhead line insulation at testing station at Dungeness. This involved, collating test data, reporting and software development.



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Namibia, New Zealand, Nigeria,
Philippines, Qatar, Singapore, South Africa,
Swaziland, Tanzania, Thailand, Uganda,
United Arab Emirates, Vietnam.