Estimating Risk Assessment

TransGrid

Estimating Risk Assessment

2014/15 – 2018/19 Regulatory Submission

July 2013

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1 Summary

TransGrid has engaged Evans & Peck to assist with its 2014-19 revenue submission to the Australian Energy Regulator (AER). Evans & Peck's scope includes the following:

- Review TransGrid's estimating system in terms of good industry practice and the likelihood that it will deliver estimates of the order of P50 – that is, an equal likelihood of overruns and underruns. This is the subject of Appendix 1
- On a look back basis, review the performance of TransGrid's estimating and project delivery systems in terms of overall financial performance of the the projects that have progressed to completion over the 2009-14 regulatory period. This is the subject of this Appendix 2
- On the basis of the foregoing analysis, provide recommendations in relation to the inclusion of an estimating risk allowance in the forthcoming revenue submission to the AER.

Analysis of completed projects points to a slight bias towards underestimation in TransGrid's system, and the need for risk inclusion on Future Projects. In simple terms, after exclusions, the system (based on "Committed" projects that attract no risk) has an underestimation bias of approximately 3.16%, with "Future" projects 8.75% underestimated – implying a risk premium requirement of around 5.6% on "Future" projects to bring them in line with "Committed" projects. Analysis of completed projects would therefore, in the absence of corrections to the estimating system, point to the inclusion of a corporate risk allowance not dissimilar to that applied to the 2009-14 determination.

However, in addition to a number of salient "lessons learned" from the current program of work flowing back into the estimating system, TransGrid's "business as usual" estimating system has changed from that adopted in relation to the 2009-14 regulatory submission. Whereas risk was added at the end of the process based on workshop analysis of a sample of project types, greater focus is now placed on a more developed deterministic assessment of the costs likely to be incurred at a project level during the estimating process. This is in accordance with what Evans & Peck consider "best practice estimating".

Given this change in approach, and Evans & Peck's analysis indicating that current estimates are in fact delivering very close to a "P50" outcome in their own right, we can find no requirement for the addition of a "corporate" risk allowance to achieve an overall "p50" outcome across the project portfolio.

2 TransGrid's Approach & Good Estimating Practice

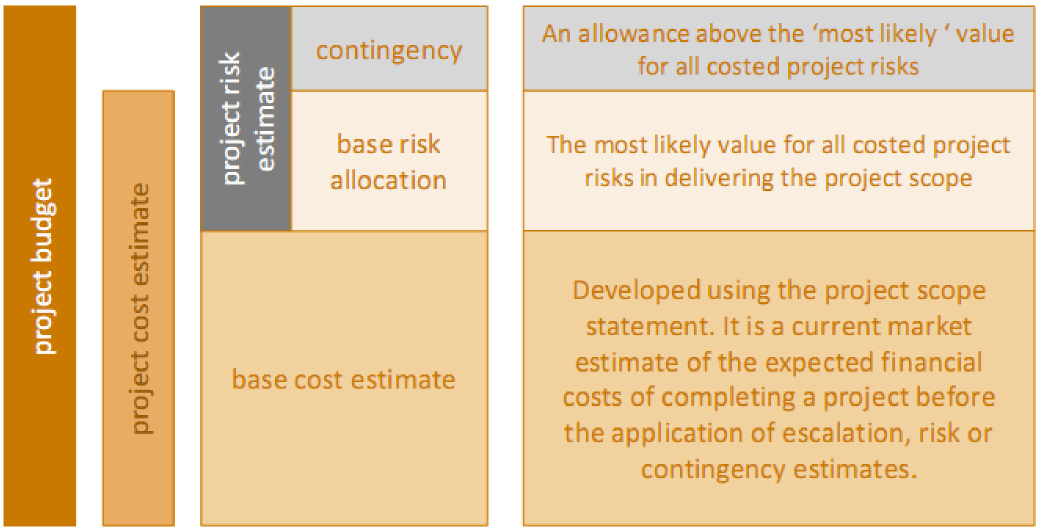
In August 2012, the Victorian Department of Treasury and Finance, (DTF) released a document:

> *Investment Lifecycle and High Value / High risk Guidelines – Preparing Project Budgets for Business Cases Technical Guide Draft"*[1]

This is one of a series of documents prepared by the DTF as the lead agency for State, Commonwealth and Territory Governments aimed at improving estimating, procurement and delivery standards for public sector infrastructure.

Figure 1[2], extracted from the DTF Draft, demonstrates the three levels that should make up an estimate.

Figure 1: Components of a Project Estimate



- The base estimate – includes direct, indirect costs, and external costs directly attributable to the project.
- *"The base risk allocation – "an allowance for the 'most likely value' of the increase in cost above the base estimate to accommodate uncertainties in the project …*
- *The contingency – an allowance above the 'most likely value' for all costed project risks"*.

Figure 2, also taken from the Draft Technical Guide, demonstrates the "cone of uncertainty" associated with the various phases of estimation. At the Concept stage, there is not only a high degree of uncertainty, but also a degree of asymmetry around the expected cost outcome. Both the level of uncertainty and the level of asymmetry decline as the project moves through the design / construction phase. For so called "Committed" projects, TransGrid's estimates are at the Design / Procurement phase, whereas "Future" projects" are at the Concept / Design phase.

[1] http://www.lifecycleguidance.dtf.vic.gov.au/admin/library/attachments/2012%20ILG%20-%20Stage%202%20Prove%20-%20Project%20Budget%20Technical%20Guideline.pdf

[2] Op cit, P5, Figure 1.

Figure 2: The "Cone of Uncertainty"

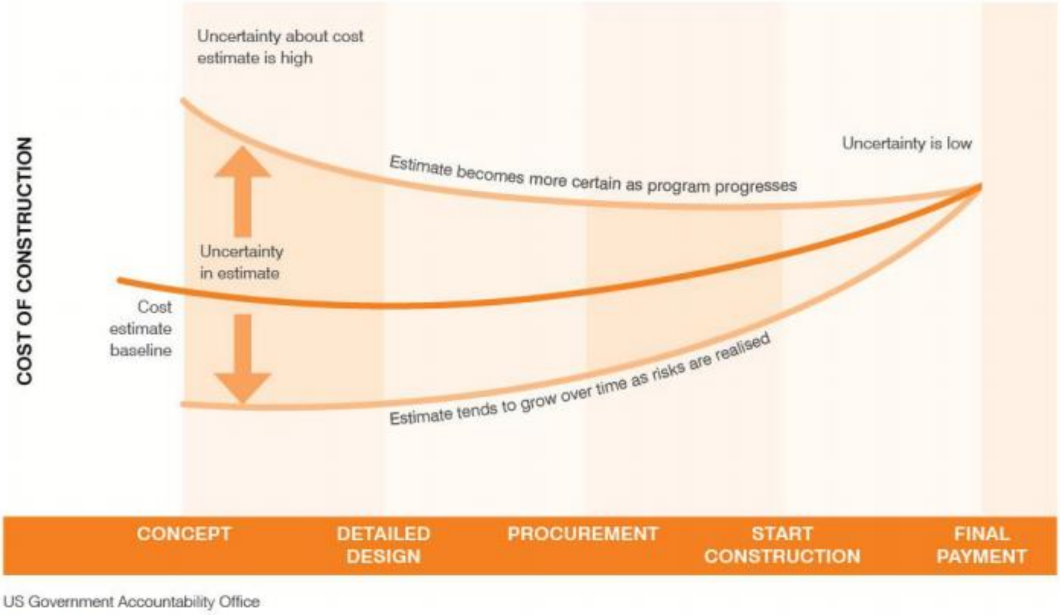


Figure 2 Cone of uncertainty

Evans & Peck understands that TransGrid's current approach to estimating for the 2014-19 submission will be consistent with the above principles:

- The establishment of a "base estimate"
- The determination of project specific "allowances" only to projects early in the "Cone of Uncertainty" -i.e "Future" projects , not "Committed" projects
- The inclusion of a global risk allowance to bring the overall portfolio estimate to the "P50" level should this be necessary. P50 should be seen in the context of a regulatory environment with an objective of equal sharing of risks between the TNSP and its customers. This is a slight change from the approach adopted for the 2009-14 period. In that case, base risk allowances were not calculated during the estimating process, but added at the end of the process based on selection of factors developed by TransGrid in conjunction with Evans & Peck following a series of workshops on "typical" projects. To this extent, Evans & Peck's role has changed from advising on project risk factors, to quantitatively reviewing the adequacy of TransGrid's base risk allowances in developing P50 project estimates.

3 Findings

3.1 Best Practice Estimating

As part of this review, TransGrid engaged Evans & Peck to qualitatively and quantitatively examine its DG1 (Decision Gate 1)[3] estimates (i.e. early estimates) in terms of implementing best practice in achieving the objectives for the "Base Cost Estimate" and the "Base Risk Allocation".

Whereas in preparation for the 2009–14 submission Evans & Peck performed "workshop" based analysis to develop a menu of risk factors that TransGrid could add to their projects in the Capital Accumulation model (CAM), consistent with the above approach TransGrid's estimating system has evolved to include "base risk allocation" assessment on every project. Base risks are set deterministically based on likelihood / consequence analysis.

On this occasion, rather than establishing the risk factors to apply, Evans & Peck has modelled a sample of the projects probabilistically to determine where the TransGrid's estimates, including base risk allocation, sit in relation to achieving a P50 outcome at the project level. This analysis points to:

- Whether a "corporate" allowance is required to achieve the overall "P50" budget outcome
- Conversely, whether the project estimates are in fact above P50 and some discount is warranted.

This review was conducted by a team within Evans & Peck with general estimating (rather than electricity only) estimating experience. Analysis and conclusions are documented in Appendix 1. Evans & Peck concludes:

- The DG1 estimating process is based on a deterministic estimating approach. Considering the early project phase at which DG1 estimates are prepared and the lack of scope and design detail available, this approach is reasonable
- The key strengths identified in the process include:
  - Evidence of historical actual data being used in preparing future estimates
  - Use of "assemblies" and templates for each project type, to take advantage of the comparatively repetitive nature of TransGrid projects
  - Takes into consideration that the construction environment or the assumptions relied upon during the base estimating process may vary in reality
- The DG1 estimates were within a range of ±1.5% of the median (P50) value calculated using a stochastic approach. The results from the sample indicated that the DG1 estimates were, on average, 0.2% (of the P50 value) higher than the P50 value
- The average difference for the entire TransGrid portfolio between the estimate generated by the DG1 process and the modelled median is between -0.38% and 0.66% (based on a 90% confidence interval)
- Overall, the process is more detailed and robust than the equivalent estimating processes observed in comparable (non-electricity) organisations.

[3] In terms of Figure 2, TransGrid's "Decision Gate 1" (DG1) estimates are prepared on the basis of an identified planning need and a concept design. They incorporate very limited detailed design work.

3.2 "Look Back" Analysis

As part of its revenue proposal to the Australian Energy Regulator in relation to its 2009-14 revenue determination, TransGrid engaged Evans & Peck to provide recommendations on risk factors that, in Evans & Peck's view, should apply to project cost estimates.

Following a series workshops with senior TransGrid estimating and project delivery staff, risk factors were determined for 11 different asset categories making up the 2009-14 regulatory submission. These risk factors only applied to "Future" projects:

- 500 kV line – new route (5.3%)
- 330kV line – new route (6.3%)
- 330kV line – existing route (3.9%)
- 132kV line – new route (1.7%)
- 123kV line – existing route (4%)
- Greenfields substation (5%)
- Brownfields substation (6.4%)
- Cable Project (3%)
- SCADA communications (3.3%)
- SCADA installation (3.6%)
- Property (4.9%).

These factors were integrated into TransGrid's Capital Accumulation model (CAM) at a project level, and an aggregate "estimation risk factor" calculated as an output of the CAM. Risk was only applied to "Future" projects. "Committed" projects and Programs were not risked. The resultant recommended aggregate portfolio risk adjustment was $77.1 million on a total capex estimate of $2,626.8 million (in $2008/09 including real price escalation and the risk allowance). In its Final Decision, the AER reduced the risk allowance by $6.5 million, but this also applied to a reduced capex base of $2405.1 million ($2008/09 including real price escalation and risk). In both cases, the effective risk allowance was 3.0% of the "pre- risk" capital base.

TransGrid has provided data on 42 projects completed during the current regulatory period. Data has been provided in a form that permits a comparison of outturn cost to regulatory budget in constant dollar ($2012/13) terms. Budget data has been provided both with and without the risk allowances that formed the overall risk allowance of approximately 3% that was approved in relation to the 2009/10 to 2013/14 revenue determination. In addition, data has been provided on a further 8 projects that are due for completion by the end of 2013, and are considered to be sufficiently developed for reliable cost to complete estimates to be made.

As part of its recent final decision in relation to ElectraNet's 2013-18 Determination the AER, acting on advice from its advisors EMCa Strata, used the "*non-parametric bootstrap*" methodology to statistically infer the likely mean outcome of a portfolio of projects based on a relatively small sample of completed projects. This methodology acts to increase the data "richness" of the sample set, and allows the likely variability in the portfolio outcome to be quantified. Evans & Peck has adopted this methodology in relation to this engagement. Details of this analysis and the conclusions drawn are contained in Appendix 2.

In order to infer the underlying reliability of TransGrid's estimating system in relation to projects in the future, a number of projects have been excluded from analysis. These include:

- 3 completed lines projects (systemic underestimation of structure cost)
- 1 completed transformer replacement project (dramatic scope change resulting in a statistical outlier)
- 1 to be completed 330kV cable project (technology and route change) resulting in a statistically dominant outlier.

Whilst individual projects have exhibited outturn to budget ratios in the range -80% to +100% (after exclusions), Evans & Peck's primary focus is on the portfolio as a whole. The portfolio has been analysed in total, and by breaking into "Committed" / "Future" projects and "Augmentation" / "Replacement" projects. The results are summarised in Table 1.

Before exclusions and incorporation of risk allowance, the expected overall portfolio outcome (using non-parametric bootstrap estimation on 39 completed projects) is a 10.8% overrun, with near certainty of an overrun of any size (98.4% probability). Inclusion of risk allowances marginally improved this to 9.72% / 97.5%

The "Future" project portfolio has an 80% chance of overrunning, with an expected mean overrun of 8.75%. Inclusion of risk allowances reduces this to 69% / 5.36%. The "Committed" portfolio has a 74% probability of overrun, with a mean expected overrun of 3.16%. After inclusion of risk allowances, the Augmentation portfolio still has an 80% probability of overrun, with a mean expectation of 4.2% overrun, but the Replacement portfolio has achieved a breakeven position, with essentially the same probability of an overrun as an underrun. This is the target outcome.

The projects to be completed in 2013 (excluding the 330kV cable) appear to be in line to achieve an overrun of less than 1.5% after inclusion of risk allowances, with near equal probability of an underrun or an overrun. Without risk allowances, this overrun would be 6.7%.

Table 1: Summary of Portfolio Outcomes – Bootstrap Methodology Applied to Completed / soon to be Completed Projects

		With Budget Risk Allocation		No Budget Risk Allocation	
		Expected Portfolio Outcome	**Probability of a Portfolio Overrun**	**Expected Portfolio Outcome**	**Probability of a Portfolio Overrun**
Completed by 30 June 2013	All Projects - No Exclusions	10.81% overrun	98.4%	9.72% overrun	97.5%
	All Projects – With Exclusions	4.8% overrun	85.4%	3.69% overrun	78.6%
	"Committed" Projects	3.16% overrun	73.9%	3.16% overrun (No risk allocated)	73.9%
	"Future" Projects	8.75% overrun	80.3%	5.36% overrun	69.1%

		With Budget Risk Allocation		No Budget Risk Allocation	
	Augmentation Projects	5.28% overrun	84.9%	4.2% overrun	79.7%
	Replacement Projects	1.72% overrun	56.9%	0.1% underrun	48%
Scheduled for Completion in 2013	All Projects – No Exclusions	14.71% underrun	23.7%	18.79% underrun	17.2%
	All Projects – With Exclusions	6.76% overrun	62.3%	1.37% overrun	50.9%

Based on this analysis, Evans & Peck's conclusions are:

- Of the projects completed, over half of the overrun is attributable to four projects – 3 lines projects where a systemic underestimation of the cost of structures occurred, and a transformer replacement project where scope change resulted in a circa 300% overrun. The lines issue is in part attributable to a lack of current project experience entering this regulatory period and should not re-occur. It is understood governance measures have been put in place to reduce the likelihood of a reoccurrence of a scope change of the magnitude of the transformer replacement project. Avoidance of these "big ticket" items must continue to be TransGrid's priority.
- "Future" projects, which utilise so called DG1 estimates made prior to completion of significant design activities, have a significantly higher probability of overrun than "Committed" projects that are based on an increased level of design. This is entirely consistent with the so called "Cone of Uncertainty" traditionally used to describe estimating uncertainty as projects progress through their design phases.
- Replacement projects have, from an outturn ratio point of view, performed better than Augmentation projects. This is not to say however that they do not have inherent risk.
- The risk approach adopted by TransGrid and approved by the AER in relation to the 2009-13 revenue determination has had a positive impact in achieving a balanced outcome for TransGrid and its customers – that is, in moving results towards a breakeven outcome and achieving a more balanced probability of an underrun / overrun.
- In the absence of other changes (discussed below), TransGrid should continue to apply risk factors of a similar (or slightly greater) magnitude to Future projects in the forthcoming regulatory submission.
- Overall, it is appropriate to conclude that TransGrid's underlying estimating and risk assessment system delivers balanced outcomes at a portfolio level, albeit with a slight bias towards overruns rather than underruns. On this basis, it is reasonable to conclude that the estimating system provides a sound basis on which to prepare estimates for the next regulatory period.

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TransGrid

Review of Estimates and Portfolio Risk Calculation

Appendix 1 Review of project estimating process to confirm establishment of "most likely" estimates

July 2013

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Version Control

Revision	Date	Author	Reviewed by	Comments
1	17/05/13	Andrew Nguyen	Michael Quinnell	Initial Draft for Comment
2	8/07/13	Brendan Jones	Michael Quinnell	Revision to address modifications
3	17/07	Andrew Nguyen	Michael Quinnell	Minor modifications

1 Executive Summary

Evans & Peck has been engaged by TransGrid to undertake a review of its project estimating process to confirm the establishment of "most likely" estimates and to determine whether there is a need for a Portfolio Risk Factor. This review is to support TransGrid in its preparation of its 2014-19 revenue proposal.

This report details only Evans & Peck's findings in relation to whether TransGrid's project estimating process produces estimates representative of the median project cost. Evans & Peck's findings in relation to the portfolio risk are addressed in a separate report.

Evans & Peck has taken both a qualitative and quantitative approach to this review. The qualitative approach involves a high-level assessment of the process steps and inputs, including comparison with other similar organisations. The quantitative approach involved a comparison between TransGrid's DG1 project cost estimates and a stochastic median value, being the value as likely to be exceeded as not.

The results of the review indicate that:

- The DG1 estimating process is based on a deterministic estimating approach. Considering the early project phase at which DG1 estimates are prepared and the lack of scope and design detail available, this approach is reasonable
- The key strengths identified in the process include:
  - Evidence of historical actual data being used in preparing future estimates
  - Use of "assemblies" and templates for each project type, to take advantage of the comparatively repetitive nature of TransGrid projects
  - Takes into consideration that the construction environment or the assumptions relied upon during the base estimating process may vary in reality
  - Overall, the process is more detailed and robust than the equivalent estimating processes observed in comparable organisations.
- The DG1 estimates were within a range of ±1.5% of the median (P50) value calculated using a stochastic approach. The results from the sample indicated that the DG1 estimates were, on average, 0.2% (of the P50 value) higher than the P50 value
- The average difference for the entire TransGrid portfolio between the estimate generated by the DG1 process and the modelled median is between -0.38% and 0.66% (based on a 90% confidence interval).

2 Introduction

Evans & Peck Pty Ltd (Evans & Peck) has been engaged by TransGrid to undertake a review of its project estimating process to confirm the establishment of "most likely" estimates and to determine whether there is a need for a Portfolio Risk Factor. This review is to support TransGrid in its preparation of its 2014-19 revenue proposal.

The determination of an estimating risk allowance by the AER is based on the following two pre-conditions:

1) That individual project estimates are based on a determination of the "most likely" cost (assumed to be the median[1] cost which, in a probabilistic terms, is the cost which is as likely to be exceeded as not)[2], including allowances specific to the project. However, no additional contingency should be included at a project level

2) When all projects are considered at a portfolio level, there is an asymmetric probability that out-turn costs will be greater than estimated costs, rather than less.

As part of this review, Evans & Peck will make an assessment on the validity of both these pre-conditions.

However, this report details only Evans & Peck's findings in relation to the first pre-condition that TransGrid's project estimating process produces estimates representative of the median project cost. Evans & Peck's findings in relation to the second pre-condition will be addressed in a separate report.

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[1] The median is often referred to as the P50.

[2] Note that while strictly the most likely outturn cost is that cost that occurs with the greatest frequency (the "mode"), it is often not a good measure of the centre of a cost distribution involving skewness (i.e. where the potential overrun is significantly greater than the potential underrun or vice versa). This is a particularly important consideration where a series of estimates are being summed to arrive at an estimate of the cost of a portfolio of projects.

Where the cost distributions being summed are positively skewed (potential overrun being greater than potential underrun), the addition of the mode costs will systemically underestimate the mode of the portfolio. This systemic underestimation when working with skewed distribution is reduced when considering the medians or the means of the distributions being summed.

3 Methodology

Evans & Peck has undertaken both a qualitative and quantitative assessment of TransGrid's project estimating process for the development of regulatory or strategic estimates, known under the TransGrid process of Decision Gate 1 (DG1).

The qualitative approach involves a high-level assessment of the process steps and inputs, including comparison with other similar organisations. The quantitative approach involved a comparison between TransGrid's deterministic estimate of the cost of each project and median values determined using a stochastic approach.

The results from both approaches were used by Evans & Peck to form an opinion as to whether TransGrid's estimating process produced estimates that are representative of the median project cost and whether any shortfalls exist in the process.

3.1 Qualitative Assessment Methodology

As part of its qualitative assessment of TransGrid's project estimating process, Evans & Peck has undertaken the following:

1) Performed a high-level review of TransGrid's DG1 project estimating process, including direct and indirect costs, factor allowances for Network, Engineering and Ancillary Costs, as well as allowances to address the expected variability in project cost outcomes deriving from site conditions, weather, productivity, design suitability and contractor performance
2) Provided commentary on the process steps and identified any shortcomings or areas of concern that may result in estimates that are not representative of a median project cost
3) Reviewed the estimated allowances for a sample of projects to assess whether:
   (a) All allowance items are relevant to the project only
   (b) The allowances for each item are based on reasonable assumptions (in terms of likelihood and consequence) to arrive at a value corresponding a median project cost outcome.
4) Compared TransGrid's DG1 project estimating process with other similar organisations and regulatory estimate preparation.

3.2 Quantitative Assessment Methodology

Evans & Peck has compared TransGrid's DG1 estimates (which represent TransGrid's deterministic assessment of the outcome) for the projects listed in Table 1 against modelled median values determined using a stochastic modelling approach.

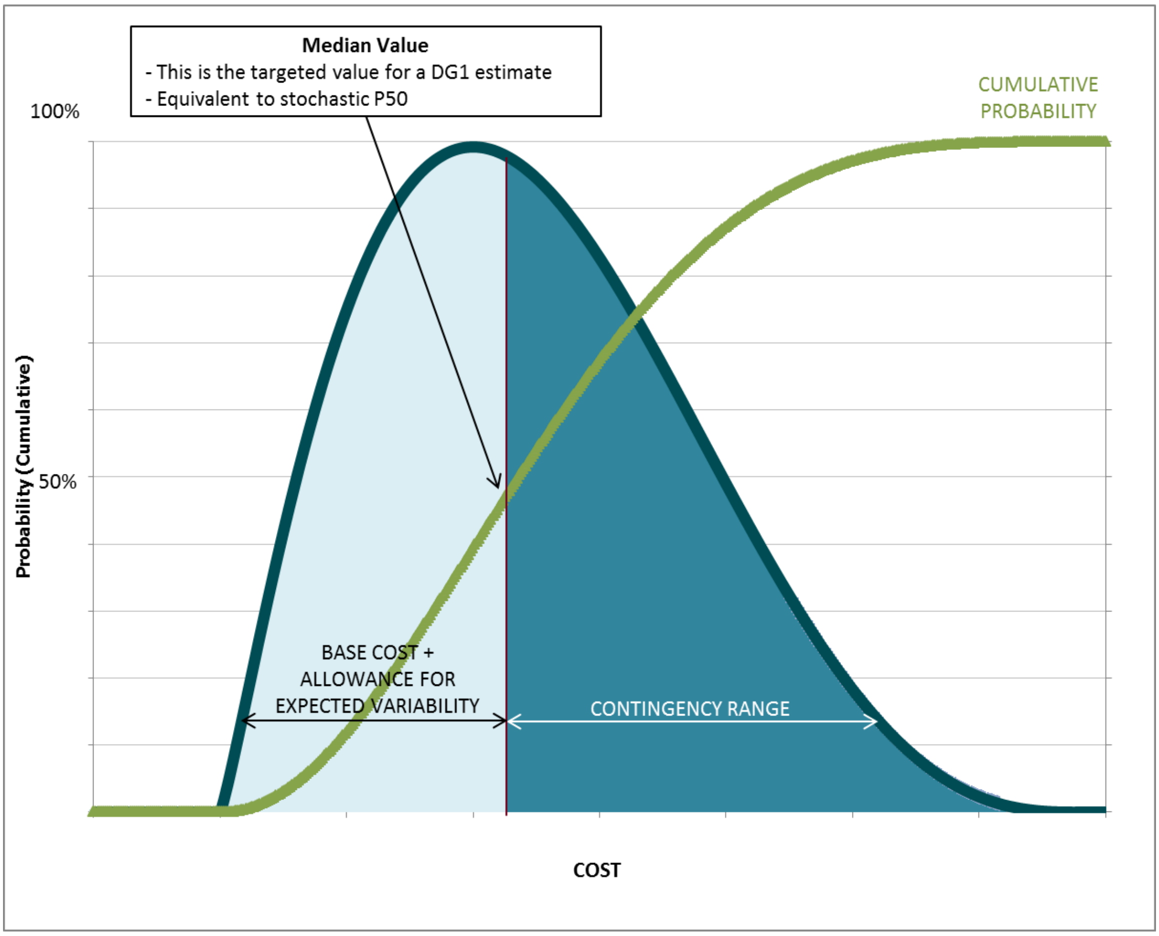
The purpose of this comparison is twofold:

1) Firstly, a stochastic approach to estimating can be considered leading practice in preparing cost estimates for infrastructure projects[3]
2) Secondly, the main output of the probabilistic approach is a range of potential outcomes with associated confidence levels, from which a forecasted median value can be selected. This enables a direct comparison between the DG1 estimates and the modelled median values, as represented by P50.

[3] Department of Infrastructure and Transport, Best Practice Cost Estimation Standard for Publicly Funded Road and Rail Construction (May 2011)

An illustrative example of the output from a stochastic model is provided in Figure 1 below. Typically, an estimate targeting a median value aims to achieve a P50 value. A cumulative probability curve (with left hand axis) has been overlaid on the probability density function in Figure 1 to clearly indicate the P50 value of the illustrative model output.

Figure 1: Illustrative Example of Stochastic Model Output



The selected projects used in the quantitative analysis have been judged by Evans & Peck, in consultation with TransGrid, as representative of the types of projects which make up TransGrid's capital portfolio.

Table 1: Projects included in quantitative assessment

No	Option No	Project Name	Project Type	Project Description
1	1030A	Tamworth 330kV Switchyard Replacement	Substation New	Construction of new 330kV substation on greenfield land
2	1031A	Installation of a series reactor on No.23 Line	Transformer/Reactor	Installation of a 330kV series reactor at Munmorah Substation
3	2014A	Sydney North - Replacement of No.1 and No.2 Capacitor Banks	Substation Capacitor	Replacement of No.1 and No.2 Capacitor Banks at Sydney North with units of similar rating.

No	Option No	Project Name	Project Type	Project Description
4	4058B	Rebuild of 9U3 Gunnedah - Narrabri Line	Transmission Line New	Construction of new 132kV transmission line adjacent to existing line and dismantling of old line
5	4061C	Replacement of Tamworth No.2 Transformer	Transformer/Reactor	Replacement of No.2 Transformer in Tamworth 330kV Substation
6	6007B	Provision of improved communication links at Beryl Substation	Communications Existing/New Sites	New microwave link involving a new m/w pole at Beryl substation and two new microwave tower sites (Mt Bodangora and Mt Misery)
7	8006A	Vales Point Substation Rebuild	Substation Augmentation – Large	Rebuild of Vales Point Substation in-situ within the existing site

For each project, a modelled median value was determined using a stochastic approach by adopting the following procedure:

1) The cost items (direct costs, indirect costs and network, engineering and ancillary factors) from TransGrid's DG1 estimate was used to derive the "base cost" estimate

2) For each cost item, an assessment was undertaken to capture the uncertainty (from both potential savings and additional cost) around the base quantities and rates. This uncertainty was captured in the most appropriate probability distribution and an estimate of the minimum, maximum and most likely (where required) value for the quantity and rate for each cost item based on the following:

   (a) Uncertainty on quantities was based on the confidence of the estimating team regarding the assumed scope and based on past experience regarding observed actual variability of quantities of certain cost items from the base assumption

   (b) Uncertainty on rates was based on an assessment of actual cost data i.e. an analysis of the observed deviations between the actual rates paid for cost items on recent TransGrid contracts against the cost rate in TransGrid's estimating database.

3) For allowances, the uncertainty was captured in terms of the potential range in treatment costs in the eventuality that the allowance is required to fund additional costs introduced by the variability in site conditions, weather, productivity, design suitability and contractor performance - i.e. what is the worst-case, best case and most likely (if known) treatment cost and the most appropriate probability distribution.

4) A Monte Carlo simulation (using 5,000 iterations) was performed to produce a distribution of potential outcomes from which the modelled median value could be selected.

Evans & Peck has compared modelled median values determined using a stochastic approach for each project to the TransGrid DG1 estimate. It was expected that if TransGrid's regulatory project estimating process established median estimates then the sample of DG1 estimates would be within a reasonable range of the modelled median values.

4 Findings

4.1 Qualitative Assessment Findings

4.1.1 Review of TransGrid Estimating Process

TransGrid prepare DG1 stage project estimates using the following approach:

	Process Description	Evans & Peck Commentary
Calculation of Base Costs		
1.	TransGrid utilises a database estimating system called "Success" to prepare DG1 cost estimates. Success incorporates: a) Individual resources with rates at an "all contractor cost" level (inclusive of direct and contractor's indirect costs); b) Cost items which are created using a mix of appropriate resources; and c) Assemblies which are a collection of relevant cost items.	• The majority of rates used in the Success system are based on actual rates obtained by TransGrid from actual past projects. These rates are updated in an annual review process that captures the most recent rates from actual projects. • The main exceptions to this are: • Rates related to concrete footings and steelwork, which are generally based on rates from Rawlinsons Australian Construction Handbook; and • Rates for major electrical equipment, which are generally based on established period orders. • Overall this appears to be a very good approach, however there are potential areas of concern regarding the reliance of historical rates • Historical rates are typically highly reliable for items which are not generally volatile (e.g. labour rates) or if the rates is very recent; • They can however, be misleading for more volatile items (e.g. cabling which may be highly correlated to fluctuating copper prices); and • Consideration should be given to the cyclical nature of the market e.g. were the rates achieved in a quieter market with generally lower rates or in a very busy market where rates are higher than normal. This can be particularly relevant if the rates are over a year old. • TransGrid addresses these areas of concern through an annual pricing review which escalates any rates over one year old and excludes any rates which appear to be unreliable or unlikely to be repeated.
2.	The estimator selects the relevant project type in Success and enters in the key project scope from the Option Feasibility Study (OFS). Success produces a standard estimate for the selected project type and inputted key scope. The estimate includes:	
	a) Project "Base Cost"	• The rates used in the Success system are inclusive of all contractor costs (i.e. they capture direct costs, indirect costs and

	Process Description	Evans & Peck Commentary
		margin). • From E&P's review, there did not appear to be a "double-up" on contractor's indirect or margin anywhere else in the estimate.
	b) Percentage "factor" mark-ups for the following: i) Network Costs for site management, testing and commissioning costs. ii) Engineering Costs for design costs. iii) Ancillary Costs for scope items not included in the base estimate.	• TransGrid advised that the percentages used for network, engineering and ancillary costs are based on actual project data, regularly updated as further projects are completed. • Evans & Peck did not review the historical data to assess the appropriateness of the actual percentages. • However, at this early phase and with little or no design available, a percentage mark-up approach based on past experience is an appropriate approach.
3.	The estimating team reviews the standard estimate produced by Success with particular consideration to site area and quantity of key equipment, which are both primary drivers of the base estimate. In addition, the percentage factor mark-ups for Network, Engineering and Ancillary costs may also be modified and lump sum items may be included for items not in the Success database.	• Although the estimates reviewed by Evans & Peck were based on the standard templates generated from Success, there was evidence of modification and adjustments to suit the circumstances specific to a particular project.
Calculation of Allowances		
4.	The sum of the individual allowances is a lump sum item and is determined separately by identifying where the construction environment or the assumptions relied upon during the base estimating process may vary in reality. Using a deterministic, approach, an assessment of likelihood and maximum consequence is made to calculate an individual value for each allowance, identified as relevant.	
	a) Allowance items are identified by the estimating team using a template with a list of typical sources of variability, for a particular project type.	• The list of typical items appears comprehensive and there was evidence that new items are captured based on project delivery experience.
	b) For each item, the maximum consequence is determined using a first principles estimate of the treatment costs.	• There is concern over the use of the label "maximum cost" to determine a consequence allowance in the DG1 context. • There is also some inconsistency with the interpretation of the term "maximum cost". Some items, particularly when any costs are constrained by physical limits, e.g. site area, represent a true maximum treatment cost, whereas other items appear to allow for an assessed "reasonable" upper value , with the true maximum cost lying between 10% to 50% higher. • However, the calculation of the treatment cost itself is transparent and is based on a first principle estimate of historic treatment methods.

	Process Description	Evans & Peck Commentary
	c) Likelihoods are determined using a qualitative approach i.e. each item is assessed to be “rare”, “unlikely”, “possible”, “likely” and “almost certain”. Each likelihood rating corresponds to a set probability percentage i.e. unlikely items are considered to have a probability of occurrence of 20%.	• The use of qualitative categories to derive an appropriate probability has some limitations in that it can be a crude approach. • However due to the early stage of the project when these estimates are prepared and with the limited information available, it is not an inappropriate approach.
	d) The allowance value is calculated as the maximum consequence multiplied by the assessed likelihood probability.	• The use of the maximum cost is only reasonable if an appropriate likelihood, corresponding to the lower probability of occurrence for an event requiring a maximum cost treatment, is used in the calculation of the expected value for that item. • E.g. wet weather may be almost certain to occur (i.e. >90% probability) however wet weather resulting in a delay in the projects by more than 50% may be considered rare (>5% probability). • Evans & Peck’s review did not identify any obvious issues with the likelihood being inappropriately matched with the maximum consequence.

4.1.2 Comparison between TransGrid Project Estimating Process with other Organisations

Evans & Peck has undertaken a high-level, comparison of TransGrid’s DG1 estimating process with the regulatory and strategic phase cost estimating process used by organisations in other industry sectors, particularly water and road sectors. .

Similar to TransGrid, these organisations adopt deterministic approaches to preparing strategic cost estimates. There is generally a component of the estimate that is reliant on actual costs incurred on previous projects, but it is not a universal practice.

The key differences between TransGrid’s DG1 estimating process and other organisation’s strategic phase estimating process are as follows:

- TransGrid’s projects are typically more “repetitive” in nature, i.e. there is less variance between scopes of work, when compared against the projects delivered by the water and roads organisations. TransGrid has been able to take advantage of this by developing and utilising work “assemblies” which enables the production of estimates that have a much greater level of detail when compared against similar organisation , despite the common issue of their being limited design available at the strategic phase
- The comparable organisations generally aim to determine strategic estimates which are more conservative than TransGrid’s DG1 estimates, typically aiming for the equivalent of a P80 to P90 confidence level rather than the median P50
- As such, these agencies typically add significant percentage mark-ups to capture the most likely outcome and further to capture a conservative outcome while the TransGrid process omits this second component.

Overall TransGrid’s DG1 estimate process appears to be more detailed and robust than equivalent regulatory and strategic estimating processes observed in comparable organisations.

4.2 Quantitative Assessment

4.2.1 Results

The results of the quantitative assessment are outlined in Table 2 below. The full outputs are provided in Appendix A.

Table 2: Summary of Stochastic Modelling Results & Comparison with DG1 Estimate

Project	DG1 Estimate	Stochastic Median P50	Difference ($)	Difference (%)	DG1 Equivalent P-Value
1030A	$50,404,881	$50,400,862	$4,019	0.01%	P50.0
1031A	$20,890,917	$20,605,881	$285,036	1.38%	P66.0
2014A	$5,168,494	$5,238,362	-$69,868	-1.33%	P38.0
4061C	$15,216,320	$15,296,913	-$80,593	-0.53%	P43.4
4058B	$48,465,271	$48,845,317	-$380,046	-0.78%	P44.2
6007B	$5,571,782	$5,507,737	$64,046	1.16%	P55.9
8006A	$47,776,918	$47,276,249	$500,669	1.06%	P57.8

The key observations from the stochastic modelling of the sample of TransGrid's projects indicated that:

- The DG1 estimates were within a range of ±1.5% of the stochastic median value with an average difference of 0.1% and a weighted average difference of 0.2% (in both cases with the DG1 estimate being, on average, slightly greater than the stochastic median value)
- The narrow range of the DG1 estimates around the stochastic median value suggests consistency between the DG1 estimating process and the stochastic estimate of the P50 value
- Had the strategic estimates been determined using a stochastic approach, the confidence level (P-Value) would have ranged from an equivalent P38to P66 confidence level
- Based on the investigation, the average difference for the entire TransGrid portfolio between the estimate generated by the DG1 process and the modelled median is between -0.38% and 0.66% (based on a 90% confidence interval).

These results suggest that TransGrid's DG1 estimating process is likely to produce estimates that have an equal likelihood of exceeding the stochastic modelled median value as not exceeding. Furthermore when uncertainty is considered in both "base" estimate and the allowance for expected variability, the results of the stochastic modelling, results in the median value of the sample of projects being, on average, closely approximate to the DG1 estimates.

5 Conclusion

Evans & Peck has undertaken a review of TransGrid's DG1 estimating process in order to make an assessment as to whether individual estimates are representative of a "most likely" cost.

The results of the review indicate that:

- The DG1 estimating process is based on a deterministic estimating approach. Considering the early project phase at which DG1 estimates are prepared and the lack of scope and design detail available, this approach is reasonable
- The key strengths identified in the process include:
  - Evidence of historical actual data being used in preparing estimates
  - Use of “assemblies” and templates for each project type, to take advantage of the comparatively repetitive nature of TransGrid projects and which allows for a relatively high degree of detail in the estimate given the limited design and scope information available
  - Takes into consideration that the construction environment or the assumptions relied upon during the base estimating process may vary in reality, through inclusion of allowances estimated using a first-principles approach
  - Overall, the process is more detailed and robust than the equivalent estimating processes observed in comparable organisations.
- The DG1 estimates were within a range of ±1.5% of the median (P50) value calculated using a stochastic approach. The results from the sample indicated that the DG1 estimates were, on average, 0.2% (of the P50 value) higher than the P50 value
- The average difference for the entire TransGrid portfolio between the estimate generated by the DG1 process and the modelled median is between -0.38% and 0.66% (based on a 90% confidence interval).

Appendix A

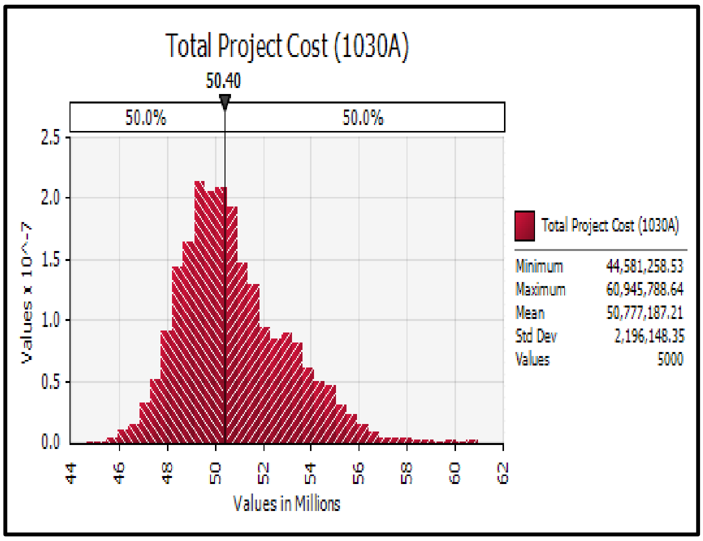
Stochastic Model – Outputs

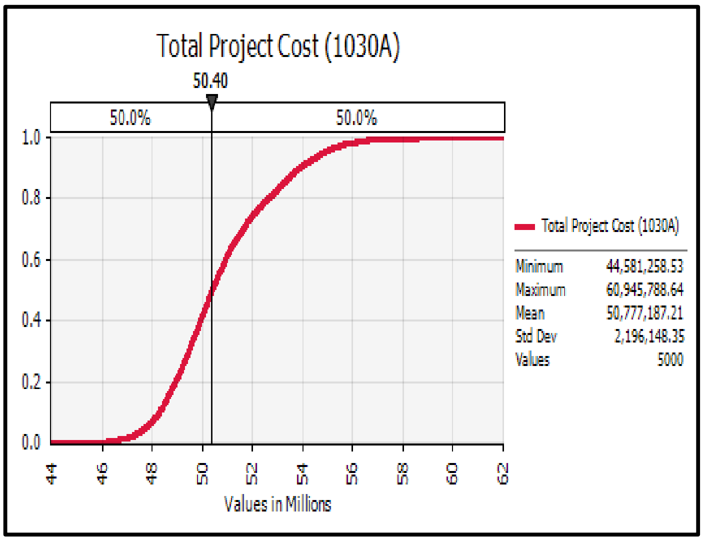
1. Tamworth 330kV Switchyard Replacement

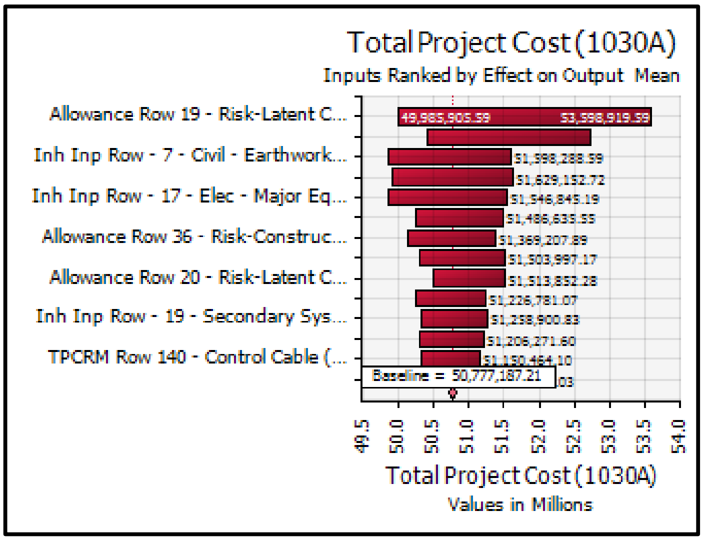
@RISK Output Report for Total Project Cost (1030A)

Performed By: Brendan Jones

Date: Monday, 1 July 2013 3:05:39 PM







Simulation Summary Information	
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Number of Simulations	1
Number of Iterations	5000
Number of Inputs	91
Number of Outputs	1
Sampling Type	Latin Hypercube
Simulation Start Time	1/07/2013 16:05
Simulation Duration	00:00:12
Random # Generator	Mersenne Twister
Random Seed	2999

Summary Statistics for Total Project Cost (1030A)

Statistics		**Percentile**	
Minimum	44,581,259	**5%**	47,770,212
Maximum	60,945,789	**10%**	48,296,865
Mean	50,777,187	**15%**	48,637,671
Std Dev	2,196,148	**20%**	48,946,628
Variance	4.82307E+12	**25%**	49,215,351
Skewness	0.716165017	**30%**	49,466,097
Kurtosis	3.55788058	**35%**	49,703,553
Median	50,400,862	**40%**	49,943,064
Mode	50,235,920	**45%**	50,170,138
Left X	47,770,212	**50%**	50,400,862
Left P	5%	**55%**	50,657,116
Right X	54,823,807	**60%**	50,928,985
Right P	95%	**65%**	51,255,453
Diff X	7,053,595	**70%**	51,622,294
Diff P	90%	**75%**	52,081,772
#Errors	0	**80%**	52,634,694
Filter Min	Off	**85%**	53,217,329
Filter Max	Off	**90%**	53,889,248
#Filtered	0	**95%**	54,823,807

Change in Output Statistic for Total Project Cost (10

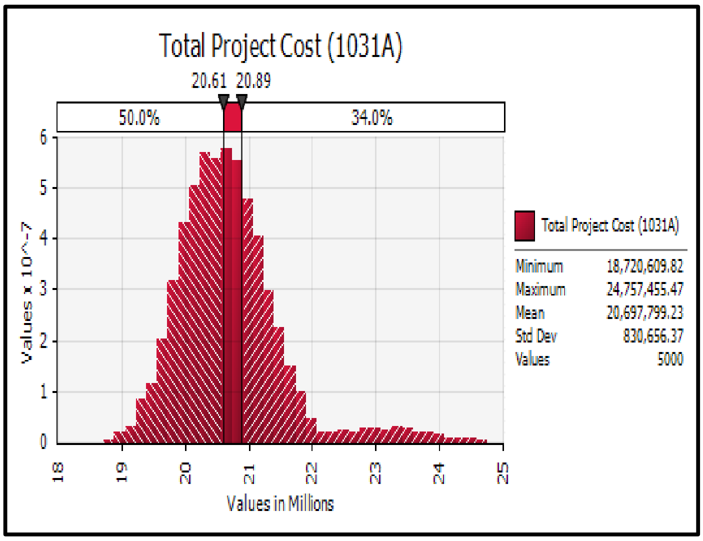
Rank	**Name**	**Lower**	**Upper**
1	Allowance Row 19 -	49,985,906	53,598,920
2	Allowance Row 23 -	50,419,134	52,735,199
3	Inh Inp Row - 7 - Civ	49,850,661	51,598,289
4	Inh Inp Row - 9 - Civ	49,910,625	51,629,153
5	Inh Inp Row - 17 - E	49,869,688	51,546,845
6	Allowance Row 21 -	50,241,511	51,486,636
7	Allowance Row 36 -	50,126,621	51,369,208
8	Inh Inp Row - 12 - C	50,309,433	51,503,997
9	Allowance Row 20 -	50,499,799	51,513,852
10	TPCRM Row 45 - Ca	50,248,764	51,226,781
11	Inh Inp Row - 19 - S	50,320,580	51,258,901
12	Inh Inp Row - 23 - T	50,289,754	51,206,272
13	TPCRM Row 140 - C	50,340,385	51,150,464
14	Inh Inp Row - 13 - C	50,496,205	51,179,567

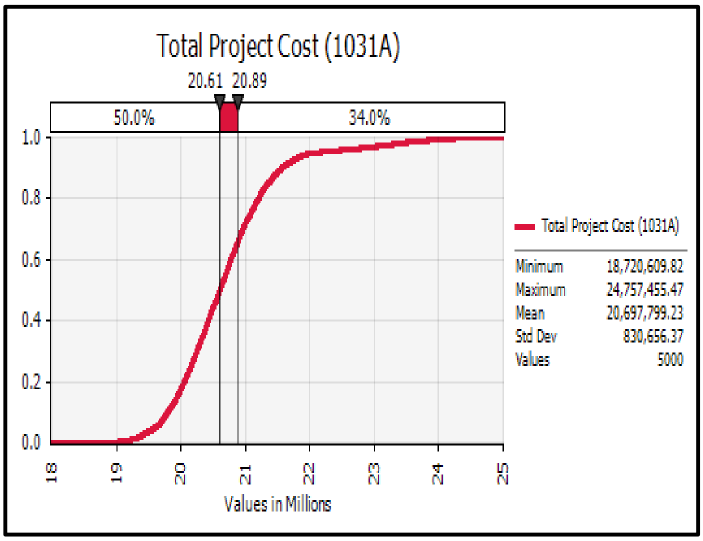
2. Installation of a Series Reactor on No. 23 line at Vales Point

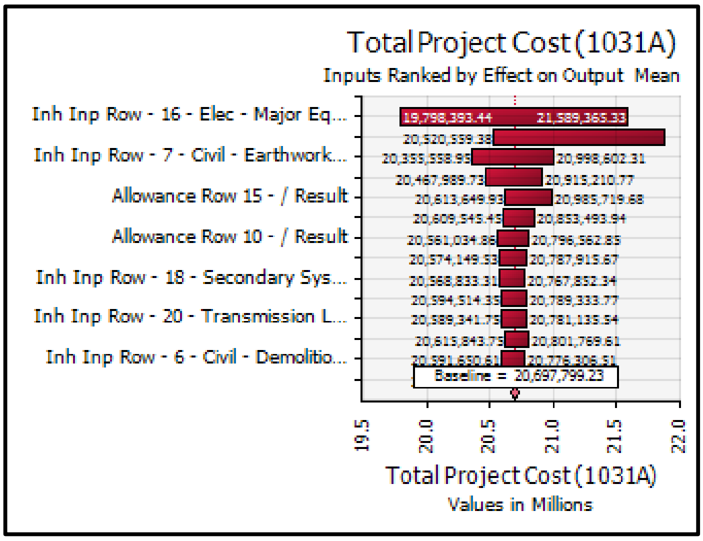
@RISK Output Report for Total Project Cost (1031A)

Performed By: Brendan Jones

Date: Monday, 1 July 2013 2:56:45 PM







Simulation Summary Information	
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Number of Simulations	1
Number of Iterations	5000
Number of Inputs	68
Number of Outputs	1
Sampling Type	Latin Hypercube
Simulation Start Time	1/07/2013 15:55
Simulation Duration	00:00:10
Random # Generator	Mersenne Twister
Random Seed	2999

Summary Statistics for Total Project Cost (1031A)

Statistics		**Percentile**	
Minimum	18,720,610	**5%**	19,609,152
Maximum	24,757,455	**10%**	19,805,185
Mean	20,697,799	**15%**	19,946,004
Std Dev	830,656	**20%**	20,057,577
Variance	6.8999E+11	**25%**	20,156,977
Skewness	1.364535537	**30%**	20,252,551
Kurtosis	6.440507202	**35%**	20,346,139
Median	20,605,881	**40%**	20,426,883
Mode	20,388,760	**45%**	20,516,606
Left X	19,609,152	**50%**	20,605,881
Left P	5%	**55%**	20,695,601
Right X	22,059,043	**60%**	20,776,956
Right P	95%	**65%**	20,868,693
Diff X	2,449,891	**70%**	20,967,034
Diff P	90%	**75%**	21,079,200
#Errors	0	**80%**	21,201,724
Filter Min	Off	**85%**	21,355,945
Filter Max	Off	**90%**	21,567,958
#Filtered	0	**95%**	22,059,043

Change in Output Statistic for Total Project Cost (10

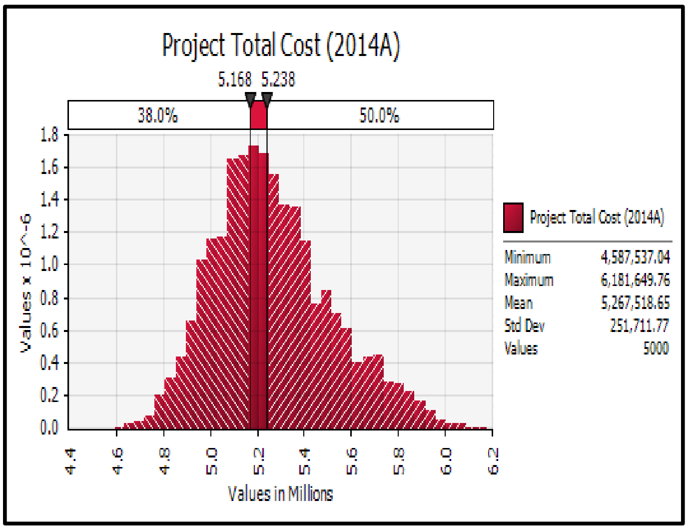
Rank	**Name**	**Lower**	**Upper**
1	Inh Inp Row - 16 - E	19,798,393	21,589,365
2	Allowance Row 18 -	20,520,559	21,880,008
3	Inh Inp Row - 7 - Civ	20,355,559	20,998,602
4	Inh Inp Row - 9 - Civ	20,467,990	20,915,211
5	Allowance Row 15 -	20,613,650	20,985,720
6	Inh Inp Row - 23 - T	20,609,545	20,853,494
7	Allowance Row 10 -	20,561,035	20,796,563
8	Allowance Row 19 -	20,574,150	20,787,916
9	Inh Inp Row - 18 - S	20,568,833	20,767,852
10	TPCRM Row 87 - Co	20,594,514	20,789,334
11	Inh Inp Row - 20 - T	20,589,342	20,781,136
12	Allowance Row 9 - /	20,615,844	20,801,770
13	Inh Inp Row - 6 - Civ	20,591,651	20,776,307
14	Inh Inp Row - 13 - C	20,592,998	20,776,558

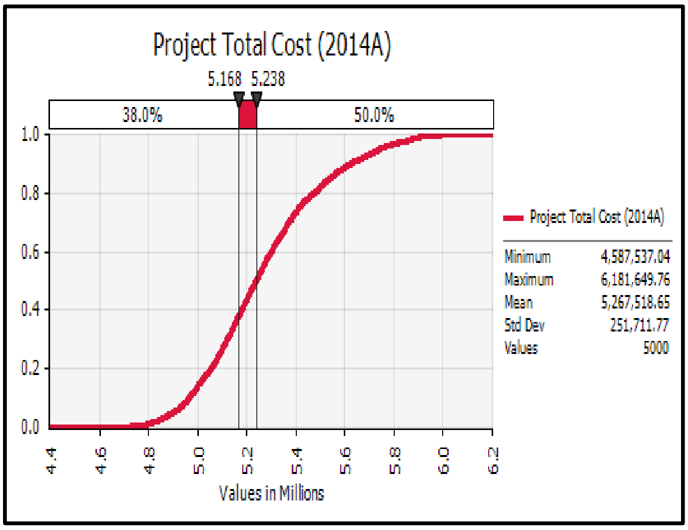
3. Sydney North – Replacement of No.1 and No.2 132 kV Capacitor Banks

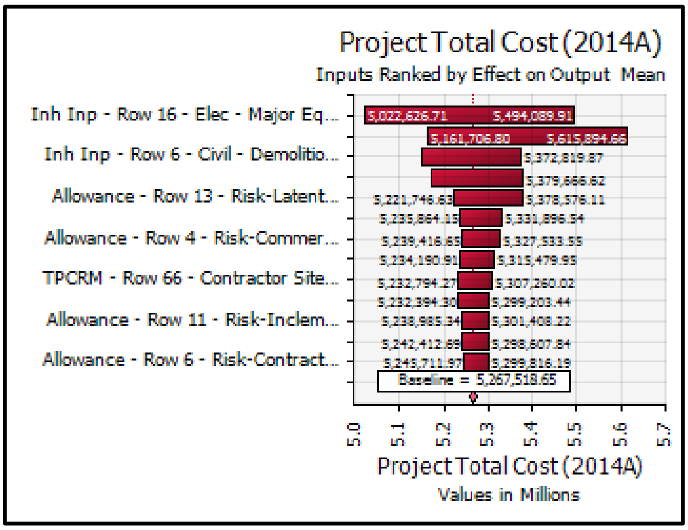
@RISK Output Report for Project Total Cost (2014A)

Performed By: Brendan Jones

Date: Monday, 1 July 2013 2:41:54 PM







Simulation Summary Information	
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Number of Iterations	5000
Number of Inputs	50
Number of Outputs	1
Sampling Type	Latin Hypercube
Simulation Start Time	1/07/2013 15:41
Simulation Duration	00:00:05
Random # Generator	Mersenne Twister
Random Seed	2999

Summary Statistics for Project Total Cost (2014A)

Statistics		Percentile	
Minimum	4,587,537	**5%**	4,903,058
Maximum	6,181,650	**10%**	4,964,963
Mean	5,267,519	**15%**	5,007,005
Std Dev	251,712	**20%**	5,054,734
Variance	63358815158	**25%**	5,089,097
Skewness	0.502574239	**30%**	5,119,821
Kurtosis	2.968592098	**35%**	5,150,122
Median	5,238,362	**40%**	5,179,836
Mode	5,199,741	**45%**	5,207,827
Left X	4,903,058	**50%**	5,238,362
Left P	5%	**55%**	5,268,647
Right X	5,740,289	**60%**	5,300,532
Right P	95%	**65%**	5,337,015
Diff X	837,231	**70%**	5,372,572
Diff P	90%	**75%**	5,413,322
#Errors	0	**80%**	5,475,980
Filter Min	Off	**85%**	5,538,386
Filter Max	Off	**90%**	5,623,228
#Filtered	0	**95%**	5,740,289

Change in Output Statistic for Project Total Cost (2014A

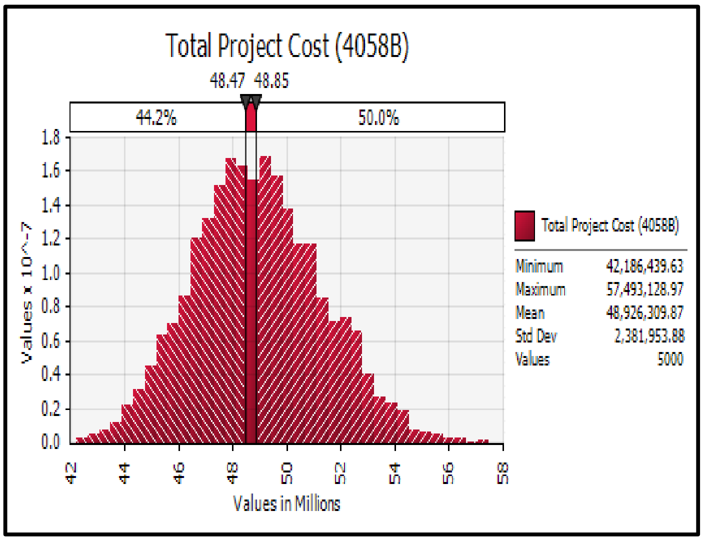
Rank	Name	Lower	Upper
1	Inh Inp - Row 16 - Elec -	5,022,627	5,494,090
2	Allowance - Row 10 - Ris	5,161,707	5,615,895
3	Inh Inp - Row 6 - Civil - D	5,150,316	5,372,820
4	Inh Inp - Row 13 - Contra	5,172,302	5,379,667
5	Allowance - Row 13 - Ris	5,221,747	5,378,576
6	Allowance - Row 8 - Risk	5,235,864	5,331,897
7	Allowance - Row 4 - Risk	5,239,417	5,327,534
8	Inh Inp - Row 18 - Secon	5,234,191	5,315,480
9	TPCRM - Row 66 - Contr	5,232,794	5,307,260
10	Allowance - Row 6 - Risk	5,232,394	5,299,203
11	Allowance - Row 11 - Ris	5,238,985	5,301,408
12	Allowance - Row 14 - Ris	5,242,413	5,298,608
13	Allowance - Row 6 - Risk	5,245,712	5,299,816
14	Allowance - Row 8 - Risk	5,244,756	5,296,486

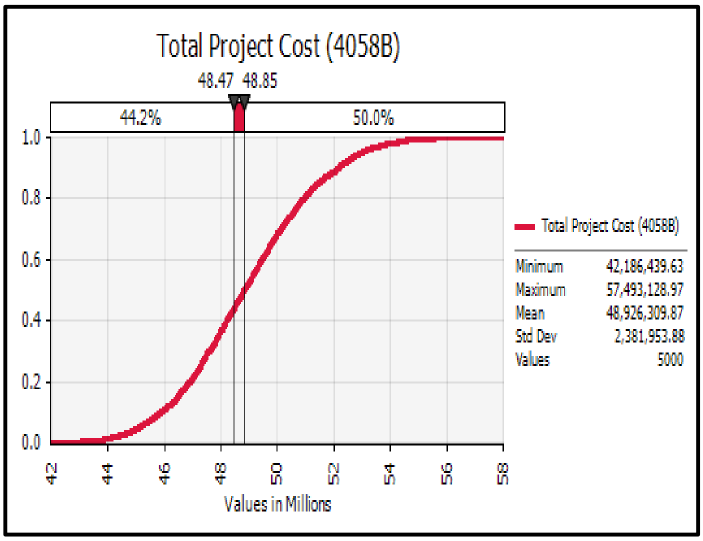
4. Rebuild of 9U3 Gunnedah – Narrabri Line

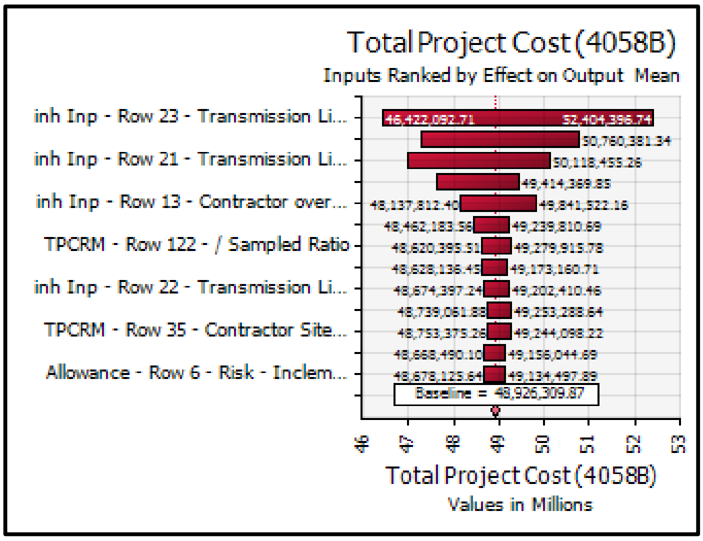
@RISK Output Report for Total Project Cost (4058B)

Performed By: Brendan Jones

Date: Monday, 1 July 2013 2:28:27 PM







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Number of Inputs	35
Number of Outputs	1
Sampling Type	Latin Hypercube
Simulation Start Time	1/07/2013 15:27
Simulation Duration	00:00:06
Random # Generator	Mersenne Twister
Random Seed	2999

Summary Statistics for Total Project Cost (4058B)

Statistics		**Percentile**	
Minimum	42,186,440	**5%**	45,119,533
Maximum	57,493,129	**10%**	45,875,417
Mean	48,926,310	**15%**	46,480,129
Std Dev	2,381,954	**20%**	46,914,092
Variance	5.6737E+12	**25%**	47,274,787
Skewness	0.175699573	**30%**	47,578,957
Kurtosis	2.835748093	**35%**	47,909,169
Median	48,845,317	**40%**	48,208,923
Mode	49,062,723	**45%**	48,514,915
Left X	45,119,533	**50%**	48,845,317
Left P	5%	**55%**	49,143,736
Right X	52,983,777	**60%**	49,461,316
Right P	95%	**65%**	49,769,507
Diff X	7,864,244	**70%**	50,135,295
Diff P	90%	**75%**	50,529,244
#Errors	0	**80%**	50,936,424
Filter Min	Off	**85%**	51,467,592
Filter Max	Off	**90%**	52,168,297
#Filtered	0	**95%**	52,983,777

Change in Output Statistic for Total Project Cost (40

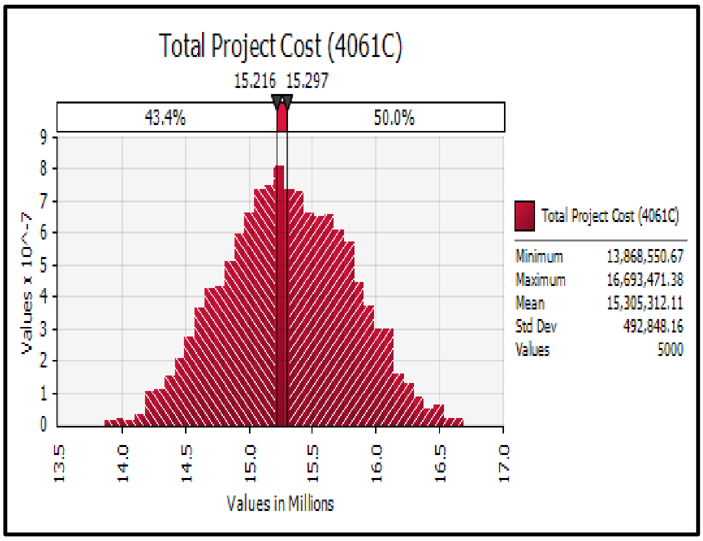
Rank	**Name**	**Lower**	**Upper**
1	inh Inp - Row 23 - T	46,422,093	52,404,397
2	inh Inp - Row 20 - T	47,280,031	50,760,381
3	inh Inp - Row 21 - T	47,008,647	50,118,455
4	Allowance - Row 3 -	47,626,882	49,414,370
5	inh Inp - Row 13 - C	48,137,812	49,841,522
6	TPCRM - Row 121 -	48,462,184	49,239,811
7	TPCRM - Row 122 -	48,620,396	49,279,916
8	Allowance - Row 3 -	48,628,136	49,173,161
9	inh Inp - Row 22 - T	48,674,397	49,202,410
10	TPCRM - Row 123 -	48,739,062	49,253,289
11	TPCRM - Row 35 - C	48,753,375	49,244,098
12	inh Inp - Row 14 - E	48,668,490	49,156,045
13	Allowance - Row 6 -	48,678,126	49,134,498
14	inh Inp - Row 10 - C	48,720,476	49,158,968

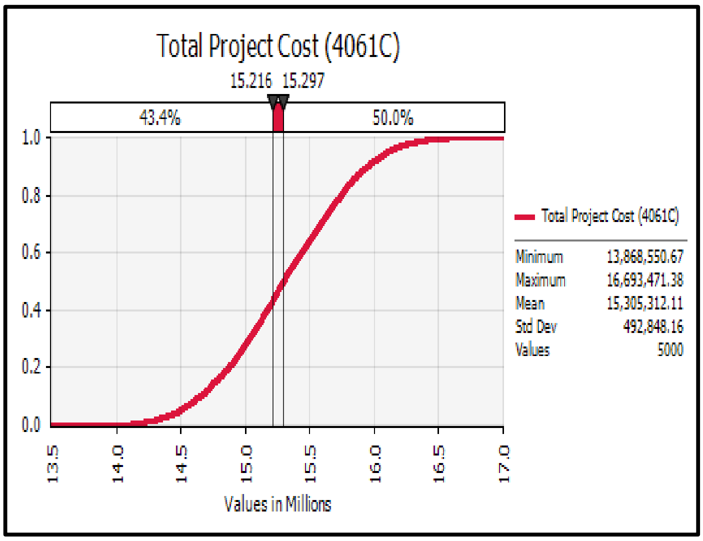
5. Replacement of Tamworth No.2 Transformer

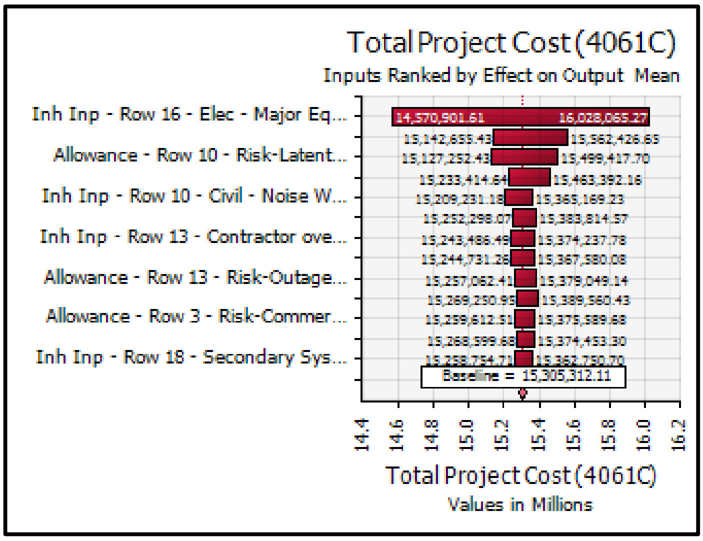
@RISK Output Report for Total Project Cost (4061C)

Performed By: Brendan Jones

Date: Monday, 1 July 2013 2:11:42 PM







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Number of Inputs	53
Number of Outputs	1
Sampling Type	Latin Hypercube
Simulation Start Time	1/07/2013 15:11
Simulation Duration	00:00:08
Random # Generator	Mersenne Twister
Random Seed	2999

Summary Statistics for Total Project Cost (4061C)

Statistics		**Percentile**	
Minimum	13,868,551	**5%**	14,493,793
Maximum	16,693,471	**10%**	14,652,039
Mean	15,305,312	**15%**	14,765,714
Std Dev	492,848	**20%**	14,872,018
Variance	2.42899E+11	**25%**	14,956,775
Skewness	0.008435935	**30%**	15,033,797
Kurtosis	2.574623254	**35%**	15,103,809
Median	15,296,913	**40%**	15,171,845
Mode	15,191,892	**45%**	15,235,253
Left X	14,493,793	**50%**	15,296,913
Left P	5%	**55%**	15,365,704
Right X	16,106,789	**60%**	15,435,023
Right P	95%	**65%**	15,512,352
Diff X	1,612,996	**70%**	15,586,192
Diff P	90%	**75%**	15,662,503
#Errors	0	**80%**	15,745,439
Filter Min	Off	**85%**	15,831,133
Filter Max	Off	**90%**	15,948,178
#Filtered	0	**95%**	16,106,789

Change in Output Statistic for Total Project Cost (40

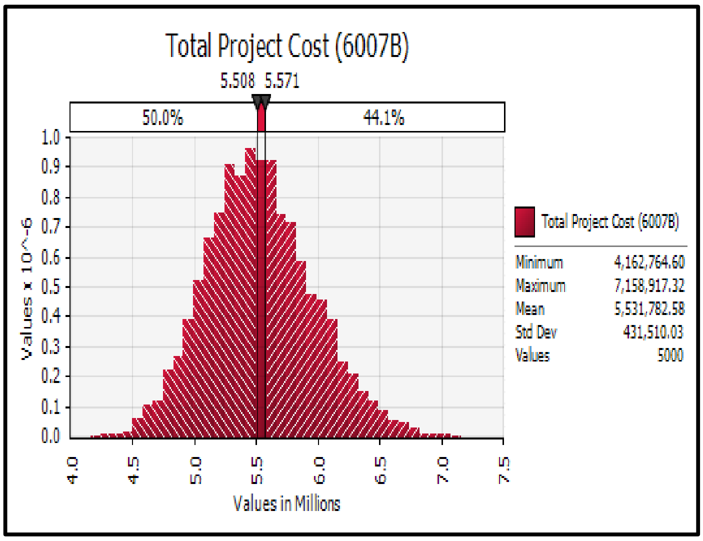
Rank	**Name**	**Lower**	**Upper**
1	Inh Inp - Row 16 - E	14,570,902	16,028,065
2	Inh Inp - Row 5 - Civ	15,142,655	15,562,427
3	Allowance - Row 10	15,127,252	15,499,418
4	Allowance - Row 12	15,233,415	15,463,392
5	Inh Inp - Row 10 - C	15,209,231	15,365,169
6	Allowance - Row 5 -	15,252,298	15,383,815
7	Inh Inp - Row 13 - C	15,243,486	15,374,238
8	TPCRM - Row 154 -	15,244,731	15,367,580
9	Allowance - Row 13	15,257,062	15,379,049
10	Inh Inp - Row 6 - Civ	15,269,251	15,389,560
11	Allowance - Row 3 -	15,259,613	15,375,590
12	Allowance - Row 14	15,268,600	15,374,453
13	Inh Inp - Row 18 - S	15,258,755	15,362,751
14	Allowance - Row 11	15,255,650	15,359,381

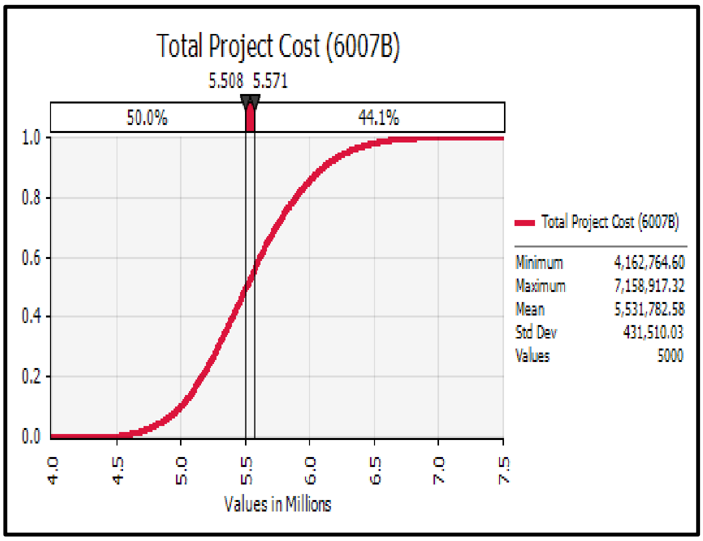
6. Provision of Improved Communication links at Beryl Substation

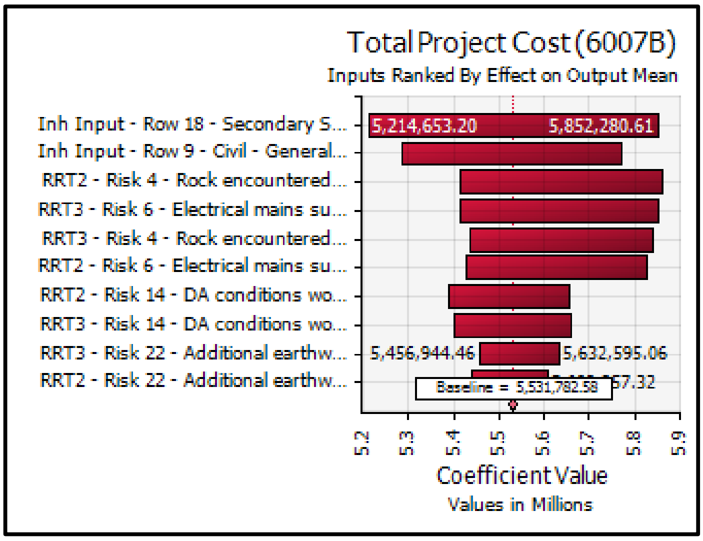
@RISK Output Report for Total Project Cost (6007B)

Performed By: Brendan Jones

Date: Monday, 1 July 2013 12:08:46 PM







Simulation Summary Information	
Workbook Name	Copy of 6007B Risk Model DR
Number of Simulations	1
Number of Iterations	5000
Number of Inputs	134
Number of Outputs	1
Sampling Type	Latin Hypercube
Simulation Start Time	1/07/2013 13:08
Simulation Duration	00:00:11
Random # Generator	Mersenne Twister
Random Seed	2999

Summary Statistics for Total Project Cost (6007B)

Statistics		**Percentile**	
Minimum	4,162,765	**5%**	4,860,693
Maximum	7,158,917	**10%**	5,001,584
Mean	5,531,783	**15%**	5,091,431
Std Dev	431,510	**20%**	5,165,901
Variance	1.86201E+11	**25%**	5,231,832
Skewness	0.279357939	**30%**	5,287,417
Kurtosis	2.999054034	**35%**	5,346,418
Median	5,507,737	**40%**	5,401,778
Mode	5,577,443	**45%**	5,456,844
Left X	4,860,693	**50%**	5,507,737
Left P	5%	**55%**	5,563,333
Right X	6,290,088	**60%**	5,613,175
Right P	95%	**65%**	5,670,478
Diff X	1,429,394	**70%**	5,738,585
Diff P	90%	**75%**	5,808,956
#Errors	0	**80%**	5,891,199
Filter Min	Off	**85%**	5,992,870
Filter Max	Off	**90%**	6,104,514
#Filtered	0	**95%**	6,290,088

Change in Output Statistic for Total Project Cost (60

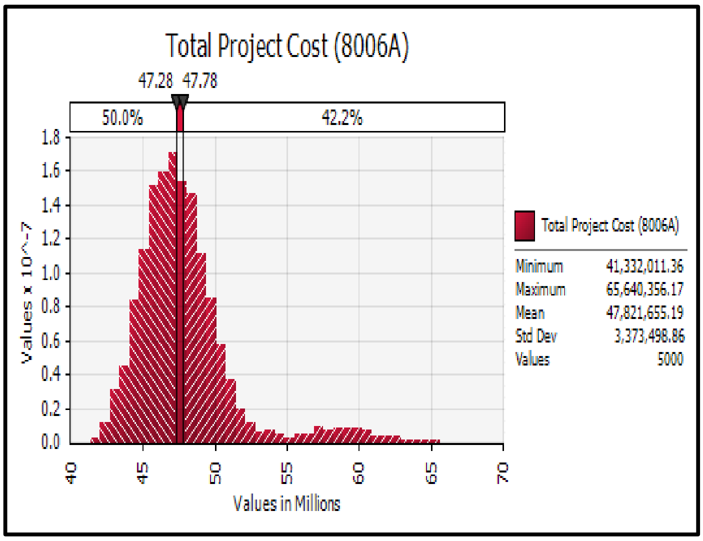
Rank	**Name**	**Lower**	**Upper**
1	Inh Input - Row 18 -	5,214,653	5,852,281
2	Inh Input - Row 9 - (	5,284,648	5,770,912
3	RRT2 - Risk 4 - Rock	5,415,922	5,862,320
4	RRT3 - Risk 6 - Elect	5,415,131	5,850,860
5	RRT3 - Risk 4 - Rock	5,437,487	5,839,218
6	RRT2 - Risk 6 - Elect	5,427,606	5,827,217
7	RRT2 - Risk 14 - DA	5,387,615	5,654,635
8	RRT3 - Risk 14 - DA	5,399,993	5,657,693
9	RRT3 - Risk 22 - Add	5,456,944	5,632,595
10	RRT2 - Risk 22 - Add	5,438,729	5,608,257
11	Inh Input - Row 11 -	5,443,739	5,595,423
12	RRT2 - Risk 15 - Acc	5,478,270	5,593,769
13	RRT3 - Risk 15 - Acc	5,450,034	5,565,158
14	RRT3 - Risk 24 - Ice	5,477,725	5,588,345

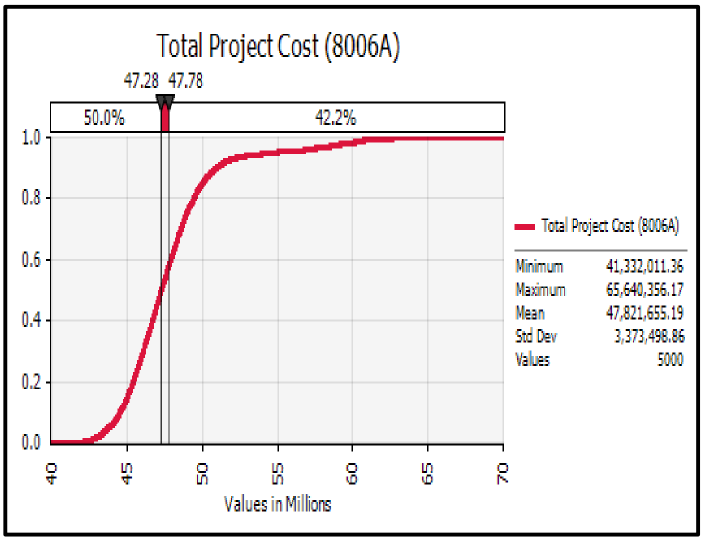
7. Vales Point Substation Rebuild

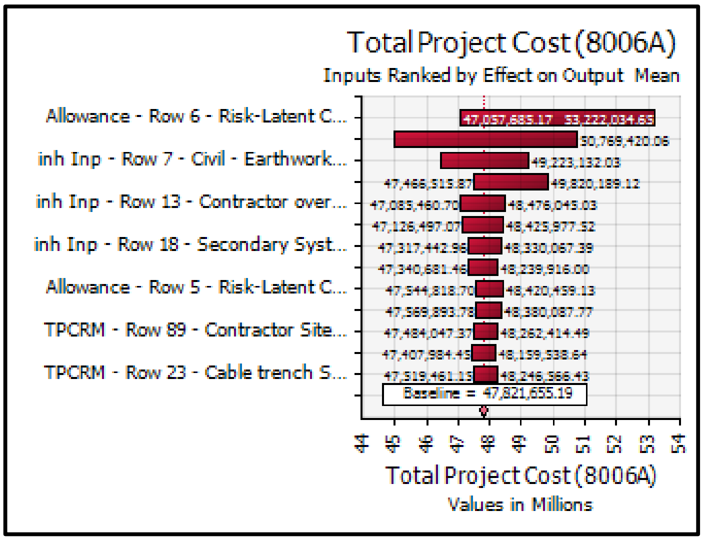
@RISK Output Report for Total Project Cost (8006A)

Performed By: Brendan Jones

Date: Monday, 1 July 2013 2:03:48 PM







Simulation Summary Information

Workbook Name	20130701 8006A Risk Model
Number of Simulations	1
Number of Iterations	5000
Number of Inputs	70
Number of Outputs	1
Sampling Type	Latin Hypercube
Simulation Start Time	1/07/2013 15:02
Simulation Duration	00:00:11
Random # Generator	Mersenne Twister
Random Seed	2999

Summary Statistics for Total Project Cost (8006A)

Statistics		Percentile	
Minimum	41,332,011	5%	43,791,366
Maximum	65,640,356	10%	44,521,236
Mean	47,821,655	15%	45,034,495
Std Dev	3,373,499	20%	45,421,465
Variance	1.13805E+13	25%	45,753,980
Skewness	1.881539599	30%	46,083,071
Kurtosis	8.04684433	35%	46,383,595
Median	47,276,249	40%	46,704,016
Mode	46,904,766	45%	46,993,209
Left X	43,791,366	50%	47,276,249
Left P	5%	55%	47,596,432
Right X	54,621,851	60%	47,918,613
Right P	95%	65%	48,234,845
Diff X	10,830,485	70%	48,594,653
Diff P	90%	75%	48,959,326
#Errors	0	80%	49,455,848
Filter Min	Off	85%	50,031,908
Filter Max	Off	90%	50,906,245
#Filtered	0	95%	54,621,851

Change in Output Statistic for Total Project Cost (80

Rank	Name	Lower	Upper
1	Allowance - Row 6 -	47,057,685	53,222,035
2	inh Inp - Row 9 - Civ	44,983,142	50,769,420
3	inh Inp - Row 7 - Civ	46,464,448	49,223,132
4	Allowance - Row 8 -	47,466,516	49,820,189
5	inh Inp - Row 13 - C	47,085,461	48,476,045
6	inh Inp - Row 16 - El	47,126,497	48,425,978
7	inh Inp - Row 18 - S	47,317,443	48,330,067
8	inh Inp - Row 6 - Civ	47,340,681	48,239,916
9	Allowance - Row 5 -	47,544,819	48,420,459
10	Allowance - Row 3 -	47,569,894	48,380,088
11	TPCRM - Row 89 - C	47,484,047	48,262,414
12	inh Inp - Row 5 - Civ	47,407,984	48,159,539
13	TPCRM - Row 23 - C	47,519,461	48,246,566
14	Allowance - Row 19	47,489,365	48,149,873

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EVANS & PECK

TransGrid

Estimating Risk Assessment

2014/15 – 2018/19 Regulatory Submission
APPENDIX 2

July 2013

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List of Figures

1 Introduction

TransGrid has engaged Evans & Peck to assist with its 2014-19 revenue submission to the AER. Evans & Peck's scope includes on a "look back" basis, reviewing the performance of TransGrid's estimating and project delivery systems in terms of overall financial performance of the e projects that have progressed to completion. This is the subject of this Appendix 2.

TransGrid has provided information on 42 projects that were included in the 2009-14 proposal that have been completed by the end of June 2013. These projects represent $1.03 billion in expenditure ($2012/13). In addition, there are a further eight projects scheduled for completion in 2013/14. These are analysed separately in this report.

For each project, the following information has been provided:

- Project name and type
- The budgetted expenditure included in the CAM , in $2009/10 escalated to include real price increases, but not CPI, for each of the periods:
  - Pre 2008/09
  - 2009/10
  - 2010/11
  - 2011/12
  - 2012/13.
- Actual expenditure, in nominal terms, for the periods:
  - Pre 2008/09
  - 2009/10
  - 2010/11
  - 2011/12
  - 2012/13.

Budgeted expenditure has been escalated to $2012/13 by applying an escalation factor equal the the change in the Consumer Price Index (8 cities) between the June Quarter 2008 and the June Quarter 2012. It should be noted that projected underlying real price changes, based on a basket of commodity, contract and labour factors applicable to each project, was included in the annual CAM budget values. Actual expenditure has also been scaled to $2012/13 by applying the relevant movement in the CPI. Budgetted data has been provided on both a "non-risked" and "risked" basis.

Analysis has been performed in several ways. These include:

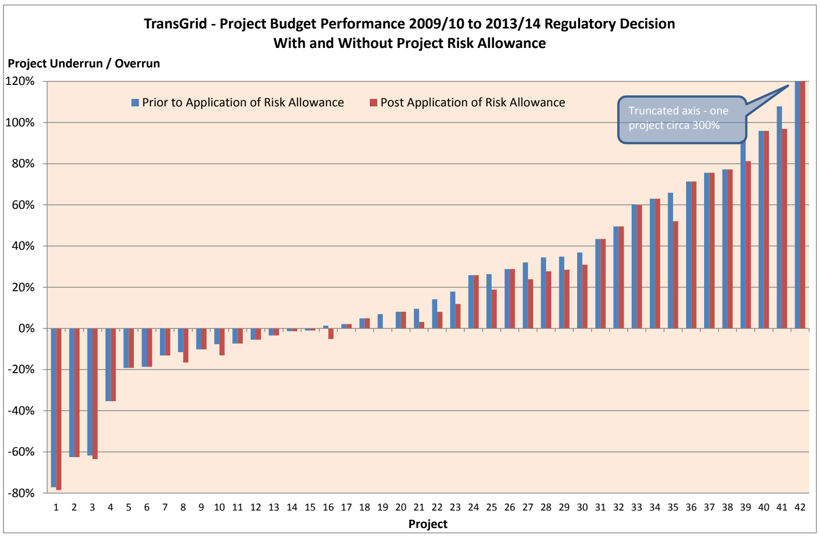
- The overall portfolio of completed projects
- The overall portfolio of completed projects less outliers
- "Committed" vs "Future" completed projects (these categories have differing estimate qualities)
- Augmentation vs Replacement Projects
- Projects nearing completion.

2 Project Outturn to Budget Performance – 2009/14

2.1 Overall Portfolio of Completed Projects

The range of outcomes across the 42 projects is demonstrated in Figure 1.

Figure 1: Project Budget Performance – 2009/10 to 2014/15 Regulatory Period



Overall and after converting budgets and expenditure to one common $2012/13 base, the portfolio incurred an overrun of 10.3% without the risk allowance, and 9.2% with the risk allowances taken into account. With the exception of one project, the project outcomes have ranged from underruns of up to approximately 80%, to overruns of around 100%. The one exception had an overrun in excess of 300%, attributable to a significant change of scope. Whilst the range of project outcomes is wide, it is, in Evans & Pecks's experience, not atypical of the performance generally encountered in the transmission system sector. In reality, TransGrid's range of outcomes in tighter than has commonly been observed.

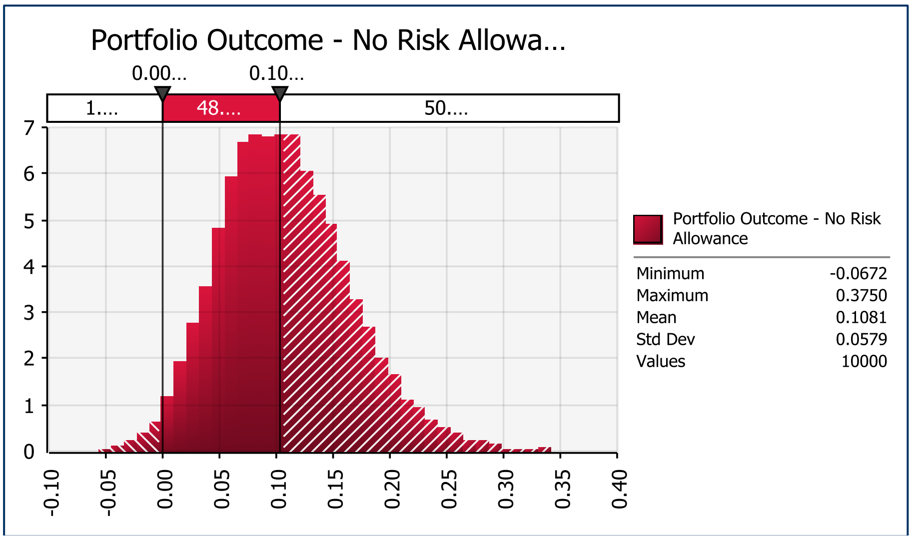
By way of recent regulatory precedent, in assessing ElectraNet's application for a risk allowance as part of its 2013/14 – 2017/18 regulatory determination, the AER[1] (in conjunction with its advisors EMCa and MetServices) utilised a "non-parametric bootstrap"[2] methodology to determine the probability that a portfolio of projects would have an outturn cost below, equal to or above the budget. The bootstrap methodology utilises a technique of repeated sampling from a finite set of project outcomes within a portfolio to expand to the set to the extent that statistical parameters can be inferred for the portfolio as a whole.

Given this precedent, Evans & Peck has applied this methodology to the 42 projects outlined above on both a "risked" basis, and a "non risked" basis. Figure 2 demonstrates the results on a "non-risked" basis when applied to all projects. The "x" axis shows statistical range of expected outcome for the portfolio as a whole. "0.00" represents outturn costs in line with budget, "-0.10" represents a 10% underrun and "0.10" represents a 10% overrun. The vertical axis represents the relative probability of each outcome. The advantage of the "non-parametric bootstrap" technique is that it provides an estimate of not only the "mean" outcome (which can be calculated directly anyway), but also provides insight into the likely statistical spread of outcomes for a different set of projects with individual performance similar to the ranges encountered for the 42 completed projects.

[1] AER Final decision | ElectraNet 2013–14 to 2017–18 | Capital expenditure 73.

[2] EFRON, B., AND TIBSHIRANI, R. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Statistical Science 1, 1 (1986), 54–77.

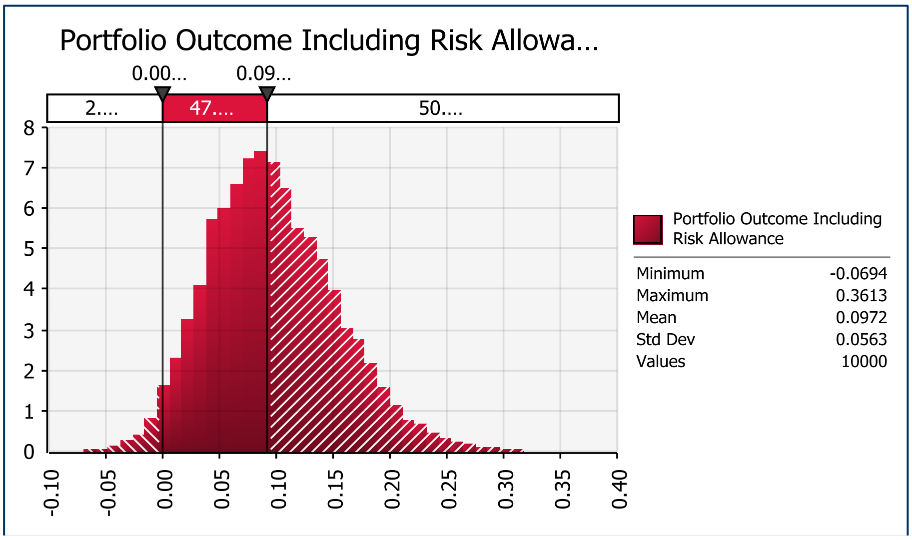
Figure 2: Expected Portfolio Outcomes – No Risk Allowances



Based on application of this methodology, analysis shows that there is only a 1.6% probability that TransGrid would achieve a portfolio outcome below budget, whereas the probability of exceeding budget is 98.4%. The P50 value is a 10.37% overrun – i.e. there is an equal probability of being less than or more than a 10.37% overrun. The assymetry towards an overrun at the portfolio level is self evident.

The introduction of the risk allowances incorporated in the current determination has mitigated these statistics very slightly. The "risked" results are shown in Figure 3.

Figure 3: Expected Portfolio Outcome – Including Risk Allowance



Notwithstanding risk inclusion, there is still only a 2.5% probability of a budget underrun, with a 97.5% probability of an overrun. The P50 outcome of a 9.27% overrun, 1.1% less than in the un-risked case. Put simply, TransGrid has a 9% gap to close, either through improved estimating, increased risk allowance or project outturn management, or a combination thereof.

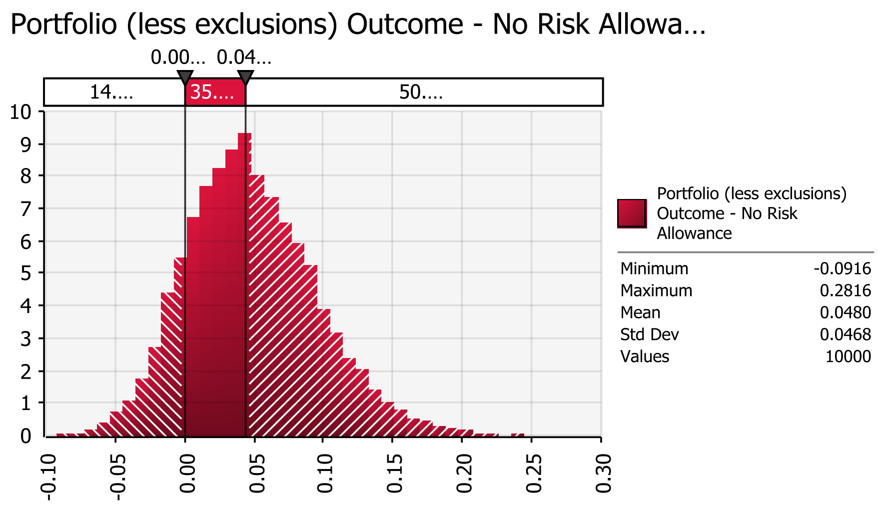
In examining contributors to project overrun, TransGrid identified a systematic problem in the estimated cost three 132kV line projects. When preparing estimates for the 2009-14 regulatory period, recent experience with 132kV line projects was very limited (reflecting limited capital works of a similar nature in the preceding regulatory period) and this resulted in a systematic underestimation of line costs, particularly those components relating to structures. Given that this issue has been identified and remedied in the estimating system, TransGrid has suggested that three line projects be removed from the analysis in order to provide a more balanced view of the likely performance of the estimating system going forward.

In addition to this issue, Evans & Peck has drawn attention to the "statistical" outlier evident in Figure 1 with an overrun of approximately 300%. Unlike the outlying lines projects removed in recognition of a systematic error in the estimating system that should not re-occur, the statistical outlier arose due to significant scope creep rather than a cost error as such. It is also debateable whether some of the costs attributed to the project were in fact funded under other program categories. The project, a "Future" project involving the replacement of a 132kV transformer had a budget of $3.0 million ($2012/13) and was completed in 2012/13 at a cost of $12 million. Scope changes identified as work progressed included significant oil containment works and transformers repair works and other significant deviations from the originally anticipated scope.

Discussions with TransGrid indicate that whilst the possibility of similar occurrences cannot be excluded from future programs, the more exhaustive review process across the portfolio should reduce the likelihood of reoccurence. Evans & Peck is of the view that this project should also be excluded from the overall consideration of the performance of the estimating system when extrapolating conclusions about future performance. For the purpose of this report, all four shall be referred to as "outliers".

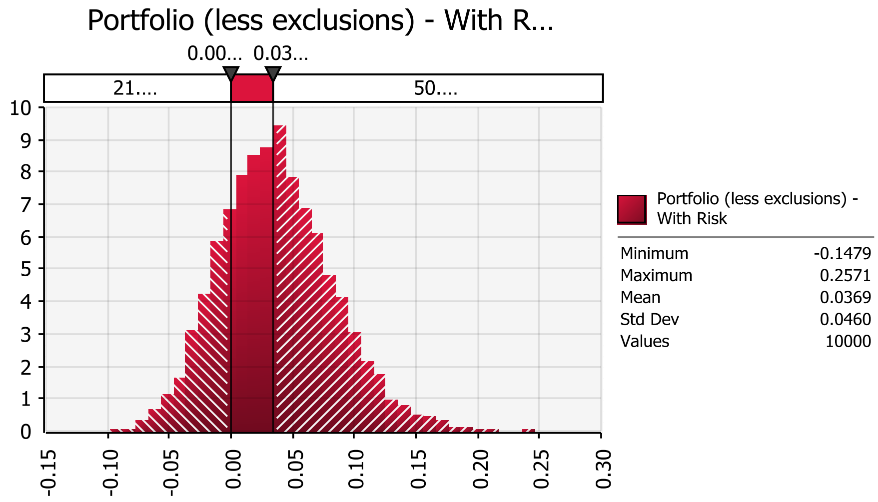
The results of application of the non parametric bootstrap analysis to the un-risked data (less these outliers) is shown in Figure 4. The mean portfolio overrun is 4.8%, well below the 9.27% before consideration of the exclusions. The expected outcome is still highly assymetric towards overruns, with only a 14.7% chance of an underrun, and conversely a 85.3% chance of an overrun. The p50 value is a 4.46% overrun.

Figure 4: Expected Portfolio (less exclusions) Outcome – No Risk Allowances



The impact of the inclusion of the AER approved risk allowance, applied at the project level in accordance with the original CAM, is to further reduce the mean outcome to a 3.69% overrun. The statistical representation of this is shown in Figure 5. There still remains a high level of asymmetry towards an overrun, with only a 21.4% chance of an underrun. The p50 value (equal probability of being above or below) is a 3.45% overrun.

Figure 5: Expected Portfolio (less exclusions) Outcome – With Risk Allowances



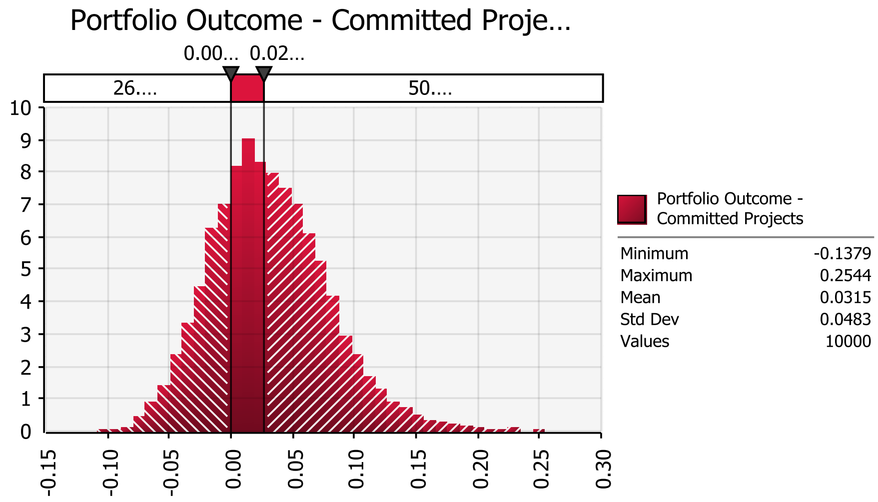
For the projects analysed, application of risk allowances has only reduced the overrun by 1.11%, significantly less that the 3% notionally expected. In order to provide greater understanding of the drivers of these expected outcomes, Evans & Peck has analysed outcomes on the basis of "Committed" vs. "Future" projects, and "Augmentation" vs." Replacement" projects. This analysis follows.

2.2 Future Projects vs. Committed Projects

As outlined earlier in this report, TransGrid's approach to the 2009-14 regulatory period only involved application of risk allowances to "Future" projects" – i.e. those projects at an early stage of estimation. Risk was not applied to "Committed" projects.

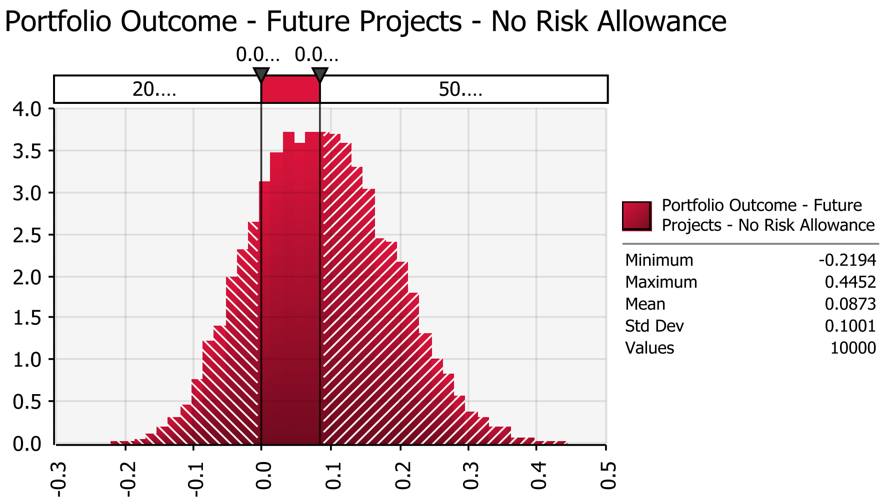
Consistent with this approach, Evans & Peck has split the analysis to consider each of these categories separately. Figure 6 demonstrates the results of application of the "non-parametric bootstrap" analysis to a subset of eighteen "Committed" projects. Consistent with expectations derived from an inspection of Figure 2, bearing in mind the increased level of design incorporated in the estimates, outturn to budget performance for this category has been better than the portfolio as a whole. The expected mean portfolio outcome is an overrun of 3.15%, and whilst still asymmetric toward an overrun, the balance between expected underruns and overruns has improved to 26.5%/73.5%. The P50 expectation is a 2.74% overrun. Notwithstanding that the range of outcomes **at a project level** ranged from a 79% overrun to a 76% overrun (such variability remaining a key area in need of improvement) and a bias towards overruns, the overall performance lends confidence in TransGrid's estimating system for "Committed" projects.

Figure 6: Committed Project Portfolio (less exclusions) Outcome – No Risk Allowances



As would be expected from inspection of the "cone of uncertainty" shown in Figure 2, the performance of "Future" projects has not been as good. Figure 7 shows the results of application of the non-parametric bootstrap technique to twenty one "Future" projects prior to the application of risk allowances.

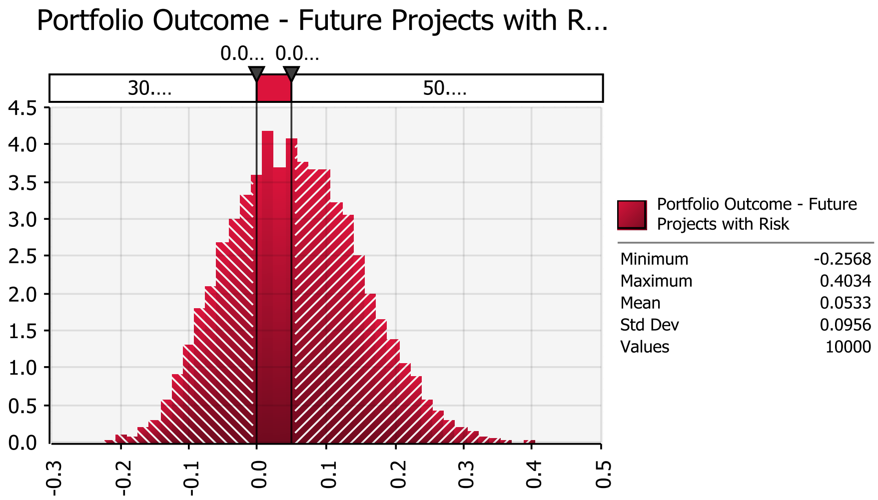
Figure 7: Future Project (less exclusions) Portfolio Outcome – No Risk Allowances



The overall expected mean outcome of this subset is an 8.73% overrun, with a high level of asymmetry to an overrun (79.8%). The P50 value (i.e. an equal probability of being above or below) is an 8.4% overrun. On the basis of this analysis after exclusion of outliers , the "risk gap" between " Future" and "Committed" projects is of the order of 5.58% i.e. (8.73% - 3.15%), consistent with the "cone of uncertainty".

Whereas TransGrid did not apply risk allowances to "Committed" projects, the AER approved the application of risk allowances to "Future" projects. Figure 8 is a repeat of Figure 7, but with the risk allowances included in the CAM applied. The mean expectation for the portfolio of Future projects (after outlier exclusion) is a 5.33% overrun, 3.25% less than the un-risked case.

Figure 8: Future Project Portfolio (less exclusions) Outcome – With Risk Allowances



The above analysis leads to several conclusions. After consideration of known estimation deficiencies and statistical outliers (the exclusions), on a “lookback basis”:

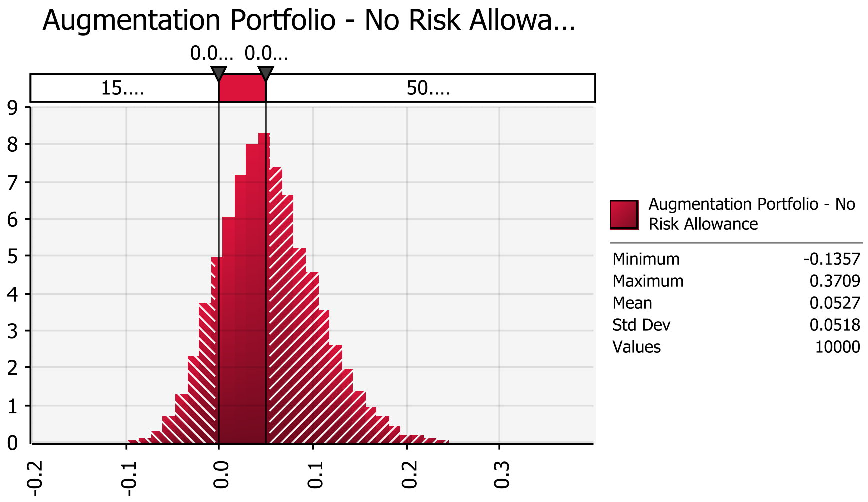
- TransGrid underestimated Committed Projects by approximately 3.15%
- An additional risk factor of approximately 5.33% needed to apply to “Future Projects” to bring them on an equal footing with Committed Projects
- The risk allowance sought by TransGrid and subsequently approved by the AER went slightly over half way to bridging this gap (3.35% vs. 5.33%) but was insufficient to achieve equality between “Committed” and “Future” projects from an outturn cost to budget perspective
- Even with this allowance, there is still a high degree of asymmetry towards an overrun rather than an underrun (69.8% vs. 30.2%) on “Future” projects.

2.3 Augmentation vs. Replacement Projects

In order to assess if there is a fundamental difference between “Augmentation” and “Replacement” projects, Evans & Peck has separated the portfolio into 30 “Augmentation” projects and eight “Replacement , Security and Compliance” (“Replacement”) projects, and repeated the bootstrap analysis on these portfolios separately[3]. The three lines projects have been excluded. Figure 9 contains the results of the analysis of the Augmentation Portfolio without any inclusion of risk allowances.

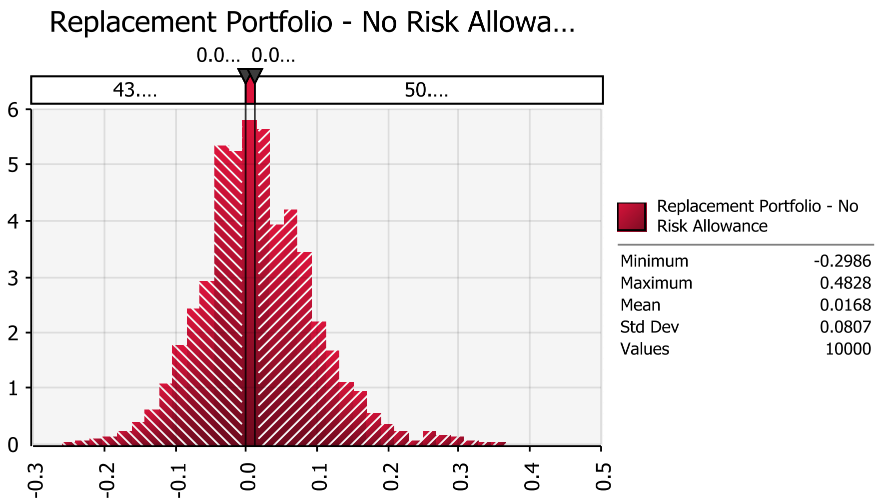
[3] i.e. exclusions have been removed

Figure 9: Augmentation Portfolio Outcomes (less exclusions) – No Risk Allowances



The expected mean outcome for the “Augmentation” portfolio is a 5.27% overrun, with only a 15.2% probability of an underrun across the portfolio. The analysis has been repeated for the “Replacement” portfolio and is shown in Figure 10. The expected portfolio mean outcome is an overrun of 1.68%, significantly lower than that for Augmentation projects. The range of outcomes is less asymmetric towards an overrun (43.3%/56.7% vs. 15.2%/84.8%).

Figure 10: Replacement Portfolio Outcomes (less outlier) – No Risk Allowances



The analysis has been repeated taking into account the risk allowances included in the previous determination. The results are shown in Figures 11 and 12 below.

Figure 11: Augmentation Portfolio(less exclusion) Outcome – With Risk Allowances

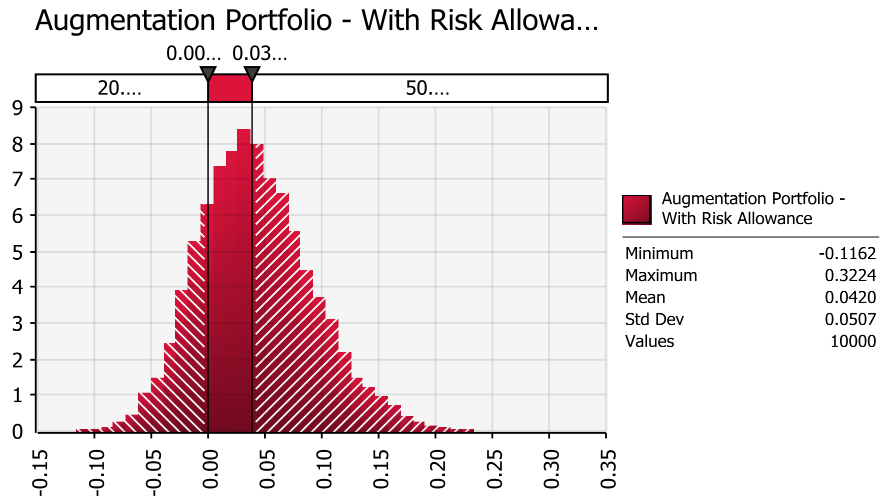
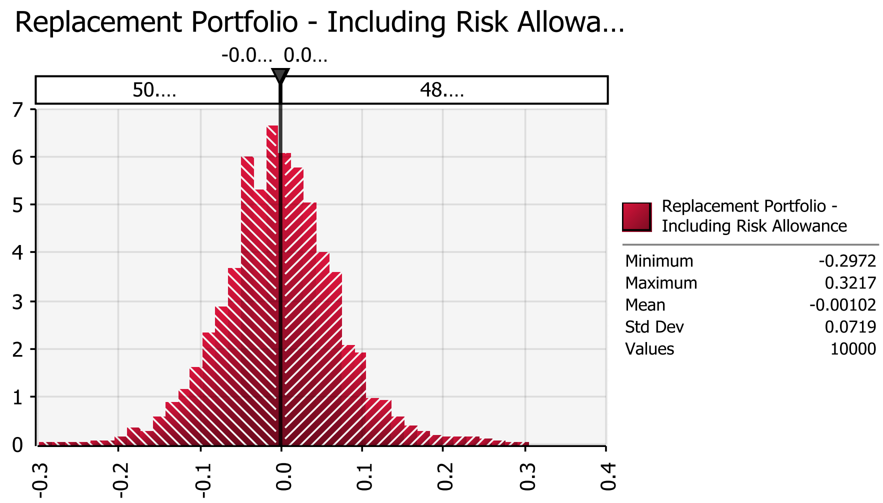


Figure 12: Replacement Portfolio (less exclusion) Outcome – With Risk Allowances



Whilst inclusion of the approved risk allowances has reduced the "Augmentation" portfolio overrun from 5.27% to 4.2%, there remains a high degree of asymmetry towards overruns (bearing in mind that many of these were Committed Projects with no risk allowance). On the other hand, the "Replacement" program with inclusion of the approved risk allowances has effectively achieved a breakeven position (0.1% underrun).

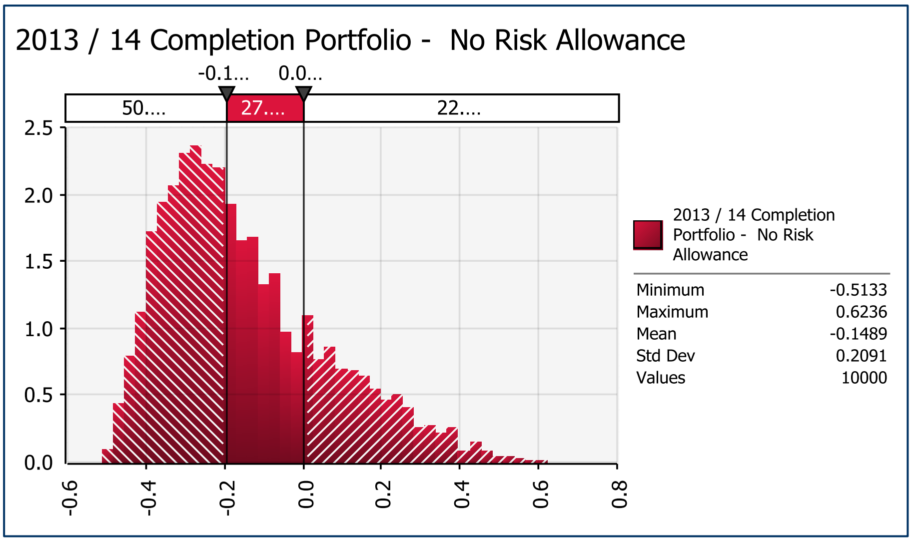
The "Replacement" result, albeit noting the removal of a significant statistical outlier, represents a "perfect outcome" to the extent that:

- The expected portfolio mean outcome is in line with budget including risk allowances (-0.1%) and outcomes are, for all intents and purposes, zero – i.e no underrun, no overrun
- The distribution of portfolio in terms of underruns and overruns is largely symmetrical (52%/48%) and relatively tightly clustered
- Overall for both portfolios and, notwithstanding exclusions, the deviations from budget are quite small at a 4.2% overrun / 0.1% underrun. This suggests that TransGrid's estimating system, when combined with the risk approach adopted in 2009 has provided a comparatively balanced outcome for TransGrid and its customers, particularly in the case of Replacement projects.

2.4 Projects Scheduled for 2013/14 Completion

In addition to those 42 projects scheduled to be completed by 30 June 2013, TransGrid has provided data on 8 projects that are expected to be completed in 2013/14. These projects are all "Future" projects, and 7 of the 8 are "Augmentation". Evans & Peck is of the view that, for completeness, some analysis on this group of projects is warranted. Application on the non-parametric bootstrap approach gives rise to the results shown in Figure 13. Prior to application of risk allowances, the mean projected portfolio underrun is 14.89%[4], confirmed by a high degree of asymmetry towards an underrun rather than an overrun (77.1%/22.9%). However, careful analysis of this result is required.

Figure 13: 2013/14 Completion Portfolio Outcomes – No Risk Allowances



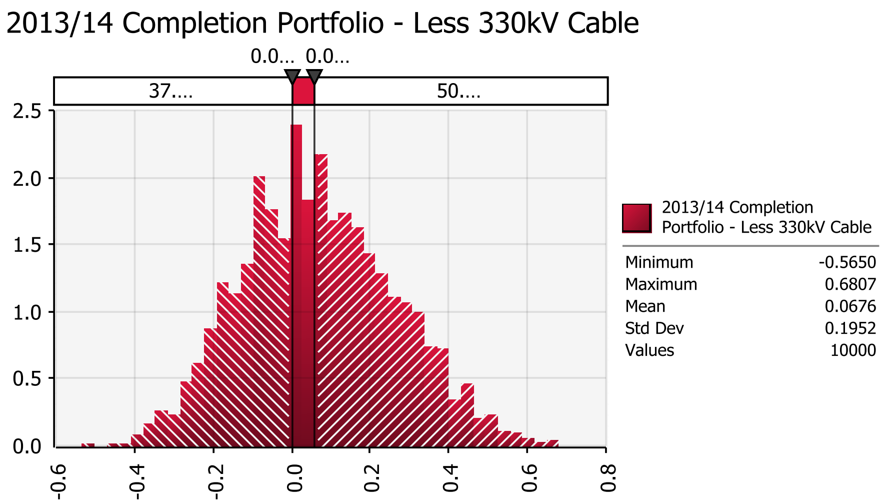
This portfolio includes the Holroyd to Chullora 330kV cable augmentaion project. Excluding risk allowances, this project had a regulatory budget of $299.9 million ($2012/13) and is expected to be completed for $152.2 million ($2012/13). Major contributors to this change are:

- The original cable was planned around an oil filled cable. When tendered, reputable manufacturers offered XLPE cable at significantly lower costs with contractual terms relating to guarantees of performance acceptable to TranGrid
- It was expected that the primary route would entail significant roadway excavation, including concrete removal and reinstatement costs. The final route involves significant co-loaction with a water pipeline at a much lower civil cost.

Clearly the circumstances surrounding this project also make it an outlier that is unlikely to repeat in the portfolio going forward. (should it be mentioned that our default costing for cable now is based on XLPE). If this project is removed and the portfolio expectation re-analysed, the expected mean result (before application of risk allowances) is a 6.82% overrun. This is shown in Figure 14.

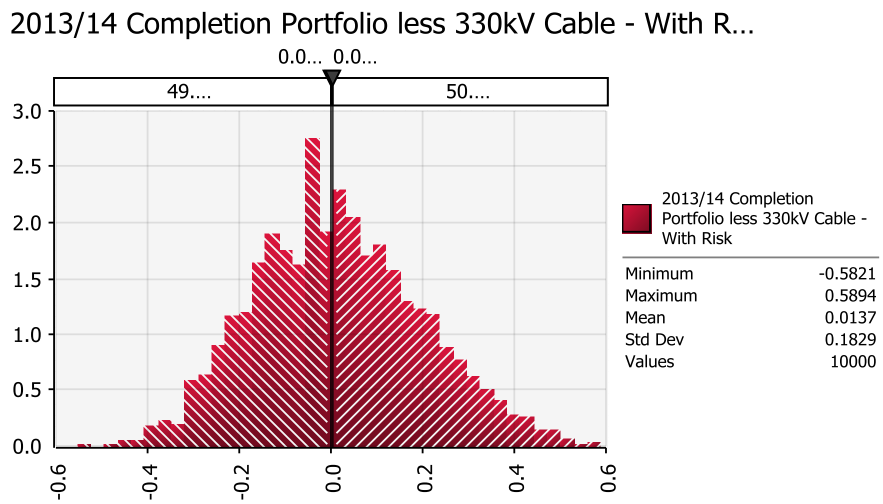
[4] 18.79% underrun if allowances included

Figure 14: 2013/14 Completion Portfolio less 330kV Cable - Expected Outcomes– No Risk Allowances



Inclusion of the risk allowances form the CAM result in an expected portfolio outcome for the 2013/14 completion projects, less the 330kV cable, of a 1.42% overrun. The results of this analysis are shown in Figure 15.

Figure 15: 2013/14 Completion Portfolio less 330kV Cable - Expected Outcomes– With Risk Allowances



This result indicates that the projects currently due for completion have higher risk allowances than those already completed – as evidenced by the 5.4% impact (6.82% - 1.42%) of inclusion of the risk allowances (compared to 1.1% for the completed portfolio). (I don't understand what this means)

An expected outcome of 1.42% overrun with a 48.5% / 51.5% spread between an expected underrun and overrun:

- Again supports the credibility of TransGrid's estimating system
- Reinforces the validity of the approach taken in relation to the 2009-14 regulatory determination of including risk allowances on "Future" projects in contributing to a comparatively balanced outcome for TransGrid and its customers.

3 Conclusions

TransGrid has provided data on the regulatory budget and outturn costs on 50 projects, amounting in total to over $1.54 billion ($2012/13) of capital expenditure. This data lends itself to analysis utilising the non-parametric bootstrap methodology applied by the AER's consultants in the recent Electranet revenue decision.

Overall, the 42 projects completed to the end of the 2012/13 financial year have shown a significant bias at the portfolio level towards a cost overrun. Based on raw data, the expected mean outcome at the portfolio level, before inclusion of risk allowances, is an overrun of 10.81%. The statistical bounds around the portfolio outcome indicate that if this performance was repeated in future years, there is only a 1.6% chance of a portfolio result at or below budget, and a 98.4% probability of exceeding budget.

TransGrid has identified a systematic issue with estimates pertaining to 132kV lines. Due to a lack of costing information at the time of preparation of the current period regulatory estimates, the cost of line structures was significantly underestimated. TransGrid believe that this issue has now been rectified in relation to new estimates. As a consequence, three lines projects have been excluded from the analysis. In addition, one replacement project is clearly identifiable as a statistical outlier. The cost overrun on this project was circa 300%, and resulted from a significant change in scope to that originally estimated. Whilst the possibility of such an outcome reoccurring, increased governance around estimate preparation should reduce this likelihood. As a consequence this project has also been excluded in assessing the likely future performance of the estimating system.

After exclusion of projects with identified estimating deficiencies, TransGrid's estimating system as applied in the current regulatory period and before application of risk allowances, would be expected to deliver an overrun (at the portfolio level) of 4.8%.

As part of its 2009-14 revenue application, TransGrid sought, and the AER approved, the application of an estimating risk allowance to capital portfolio. Whilst assessed by Evans & Peck and TransGrid at a project level, the aggregate of these was approved by the AER at the portfolio level (with some modification). TransGrid's Capital Accumulation Model retained the breakup of this allowance at a project level. When applied to the 38 projects forming this current review, the risk allowances reduce the expected portfolio overrun to 3.7%.

In order to determine whether this shortfall has arisen due to estimation error where no risk applied, or due to the inadequacy of the risk allowance applied, we have separated the analysis into "Committed" (un-risked) and "Future" (risked) projects. "Committed" projects (after exclusions) exhibited a 3.15% over run, whilst the application of risk allowances to "Future" projects reduced the overrun from 8.73% to 5.33%.

Separation of the projects into "Augmentation" and "Replacement" programs shows a tendency for "Augmentation" projects to exceed budget, whilst Replacement programs, after inclusion of risk allowances, have achieved the desired budget outcomes.

Evans & Peck has analysed to likely results for the portfolio of projects that are due for completion in 2013. This result is dominated by one project – the Holroyd to Chullora 330kV cable. At this stage, this project is expected to be completed at approximately one half of its $300million budgeted cost. In our view, this is truly an outlier that is unlikely to be repeated in future portfolios. If this project is excluded, the portfolio of projects expected to be completed in 2013, all of which are "Future" projects, will result in an "un-risked" mean portfolio overrun of 6.8%. After application of the risk allowances embodied in the CAM supporting the AER's approved estimating risk allowance, the expected outcome is a slight overrun (1.42%), again highlighting the prudency of the approach adopted in the current period. The extent of the impact of the risk allowance for these projects (5.38%) compared to that for the projects already completed (1.11%) indicates a bias towards projects with a higher assessed risk towards the end of the program.

Based on this "look back" analysis, Evans & Peck concludes:

- Whilst it has been necessary to exclude a number of projects contributing to both under estimation and over estimation from our analysis, TransGrid's estimating system, as used for the 2009-14 regulatory period, has performed well at a portfolio level with an overall expected variance of less than 5%.
- Whilst there is a bias towards underestimation of projects in relation to "Committed" projects of the order of 3.2% only minor adjustments (other than those already made in relation line structure costs) are required to achieve a high probability of a breakeven oucome. This should also occur naturally as feedback is received from the large portfolio of projects being completed in this regulatory period.
- TransGrid's estimating system in relation to "Future" projects has systematically underestimated the cost of completing these projects. The "gap" between "Committed" project estimates and "Future" project estimates is of the order of 5.7%. This should be addressed by:
  - Leveraging off minor improvents in the estimates for "Committed" projects, as outlined above
  - Increasing the level of design scrutiny on "Future" projects. Qualitatively, we have been advised that TansGrid has engaged independent experts to conduct a peer review of the scope of each of these estimates (not all but a sample).
  - In the absence of a change, continued inclusion of a corporate estimating risk allowance of equal to or slightly greater than that applied in the 2009-13.

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