TransGrid

Risk Assessment of TransGrid Capital Works Program for 2009-2014 Regulatory Reset

9 May 2008

Abridged Version

Table of Contents

Appendices

Figures and Tables

EXECUTIVE SUMMARY

TransGrid engaged Evans & Peck to assess and quantify the risks associated with TransGrid's capital works program for the five-year regulatory period from 1 July 2009 to 30 June 2014. This work is based on approaches taken with Powerlink, Electranet and SPI Ausnet to support their regulatory submissions to the Australian Energy Regulator.

This abridged version of our report is identical to our main report with the exception that details pertaining to specific projects and personnel have been removed. A number of projects are yet to be tendered, and both TransGrid and Evans & Peck consider it inappropriate for specific costing details to be placed in the public domain. These details will be made available to the AER, or their representative, upon request.

Evans & Peck developed a Capital Accumulation Model and prepared data for the model based on budget information provided by TransGrid. An analysis of a sample of TransGrid project estimates and outturn costs over the current regulatory period shows that TransGrid, in common with other infrastructure providers with a portfolio of capital projects extending over a long period of time between project estimation and delivery, has incurred significant variation between estimated cost and outturn cost at the project level.

TransGrid has 160 future projects in its proposed 2009-14 Capital Works Program. These projects have been categorised into eleven groups with similar risk profiles. For each group a representative project has been analysed to determine the *inherent* risk in the estimate of outturn cost for that project. *Contingent* risks were **not** considered. By utilising the specialist skills of TransGrid personnel involved in the estimation and delivery of those projects, Evans & Peck has structured a risk profile for each representative project by looking at the potential variance in individual cost elements in the project. Monte Carlo simulation was then utilised to develop the diversified risk profile applicable to each project type. The ratio of risk adjusted estimate of outturn cost to non-risk adjusted estimate of outturn cost typically varies between 1.02 and 1.07 depending on the nature of the project.

In addition to future projects, TransGrid has 305 "committed" projects that are currently work in progress but will extend into the next regulatory period. These were not risk adjusted. In addition there are 86 future and 148 committed "programs". The term "programs" applies to smaller repetitive capital works (such as replacing a particular type of circuit breaker in a number of substations). Risk was not applied to either of these categories.

The Capital Accumulation Model captures expenditure from all project / programs and applies Monte Carlo techniques to calculate the risk profile of the entire portfolio. The model also applies escalation, and captures the weighted impact of the planning scenarios inherent in TransGrid's works program. The output results arising from application of the modelling is shown in Table 1.1.

Risk Simulation Output_3 May 2008_Data as at 2 May 2008						
Regulatory Period Summary (2009/10 - 2013/14) - $2007/08						
	P50		**P80**		**Mean**	
Cost Component	**($million)**	**(% of base estimate)**	**($million)**	**(% of base estimate)**	**($million)**	**(% of base estimate)**
Base Estimates	$ 2,321.3	100.0%	$ 2,321.3	100.0%	$2,321.3	100.0%
Risk Adjustment	$ 76.5	3.30%	$ 89.9	3.87%	$77.1	3.32%
Escalation (net of CPI)	$ 228.4	9.8%	$ 230.0	9.9%	$228.4	9.8%
Total	**$ 2,626.2**	**113.1%**	**$ 2,641.2**	**113.8%**	**$2,626.8**	**113.2%**

Table 1.1 – Capital Accumulation Model Output Summary

We have expressed the CAM outcomes in terms of the "P50" value and a "P80" value. There remains a 20% probability that the actual outcome will exceed the P80 value and a 50/50 chance that the outcome will be above or below the P50 value. In a commercial environment Evans & Peck would recommend that the P80 value be selected as the prudent value for budget approval. However, in a regulatory environment where a more conservative approach is applied to balancing the allocation of risk between the service provider and its customers, the P50 value is commonly applied.

The Mean is the best estimate of the expected outcome and is the value displayed in all risk adjusted outputs in the Capital Accumulation Model, including the "Risk Adjusted" AER templates Given the closeness of the P50 and the Mean value in this model (3.30% vs. 3.32% of the capital program) our recommendation is to apply a global risk adjustment based in the Mean value.

In summary Evans & Peck recommends that a global risk adjustment of 3.32% be applied to TransGrid's 2009-10 to 2013–14 capital works to reflect the assessed inherent risk. This value compares directly to the 2.6% approved by the AER to apply across Powerlink Queensland's entire works program.

1 INTRODUCTION

TransGrid engaged Evans & Peck to assess and quantify the risks associated with TransGrid's capital works program for the five-year regulatory period from 1 July 2009 to 30 June 2014. This work is based on approaches taken with Powerlink, Electranet and SPI Ausnet to support their regulatory submissions to the Australian Energy Regulator ('AER').

Under the terms of the engagement Evans & Peck developed a Capital Accumulation Model ('CAM') and prepared data for the model based on project budget information provided by TransGrid. TransGrid and Evans & Peck have run the CAM to calculate a "global" risk adjustment to form the basis of TransGrid's application to the AER.

2 STRUCTURE OF THE TRANSGRID CAPITAL ACCUMULATION AND RISK MODEL

As part of this engagement by TransGrid, Evans & Peck has developed a CAM that:

- Accumulates all projects and programs which have an influence on the regulatory period including those projects and programs that are Work in Progress at either the beginning or end of the regulatory period;
- Includes a "weighted scenario" approach to the inclusion and timing of projects, to cater for various implementation scenarios;
- Applies escalation to future projects and programs;
- Applies inherent risk to future projects, based on individual project analyses carried out outside the CAM;
- Calculates both risked and non risked cash flows; and
- Produces output reports in the format of the so called AER templates.

Figure 2.1 provides a graphical overview of the inputs and outputs of the TransGrid CAM (including risk simulation). For operational reasons, the model has been split into three parts:

- Committed projects and programs;
- Future projects and programs; and
- Outputs

These are described below. For the purpose of the CAM "projects" are discrete projects which are forecast to have a defined expenditure profile broken down by financial year. "Programs" on the other hand are ongoing series of similar activities (for example IT infrastructure) and are forecast to incur expenditure on an ongoing basis.

Part 1 – Committed projects and programs

Part 1 of the CAM details the projects and programs to which TransGrid has already committed expenditure. Committed projects are those projects which have already commenced, and for which financial commitments have already been made. Because these projects have already commenced, they are considered to be scenario independent. Committed projects have not been made subject to escalation adjustments on the basis that this is already reflected in the contracted prices of the individual projects.

Committed programs are scenario-independent work programs for which financial commitments have already been made. These are not subject to risk or escalation.

Future expenditure for these projects and programs is forecast to occur, regardless of the future economic situation. For the purpose of the 2009-2014 Regulatory Reset period TransGrid is proposing to use budget data based on contracted prices, with no risk adjustment to allow for potential variation between the contracted price of a project and its final outturn cost.

Part 2- Future projects and programs

Part 2 of the CAM details the projects and programs for which no expenditure has yet been committed by TransGrid.

Future projects are scenario-dependent and have yet to be commenced. Forecast expenditure is subject to risk and escalation adjustments.

Future programs are work programs which have yet to be commenced, which occur consistently across all scenarios (i.e. scenario-independent). Forecast expenditure on future programs is subject to escalation adjustments. Whilst the capability exists within the CAM to apply risk to future programs, TransGrid has made a policy decision to not apply risk. Evans & Peck supports this position on the basis that "programs" are often repetitive in nature and the budgeting process tends to adjust to reflect the average level of risk experienced in implementing similar programs in the past. As a consequence, whilst individual projects within a program will vary from budget, the entire program should trend to reflect the average value established on the basis of past performance.

TransGrid has addressed the uncertainty of project timing with a scenario-based approach, weighting scenarios based on their probability of occurrence. TransGrid has developed 36 scenarios, reflecting potential uncertainty in load growth, inter-regional trade, water availability and environmental emissions policy. For each scenario, a set of projects and their timing is established. Not all projects occur in all scenarios, and individual project timing can vary significantly between scenarios. The impact of each scenario on the transmission system has been separately modelled by ROAM Consulting.

Part 3 – Outputs

Part 3 of the CAM combines the outputs from Parts 1 and 2, and includes these outputs into the AER templates for historical and future capital expenditure.

The following sections of this report describe how TransGrid has estimated the project expenditure for the future projects in its proposed 2009-2014 Capital Works program.

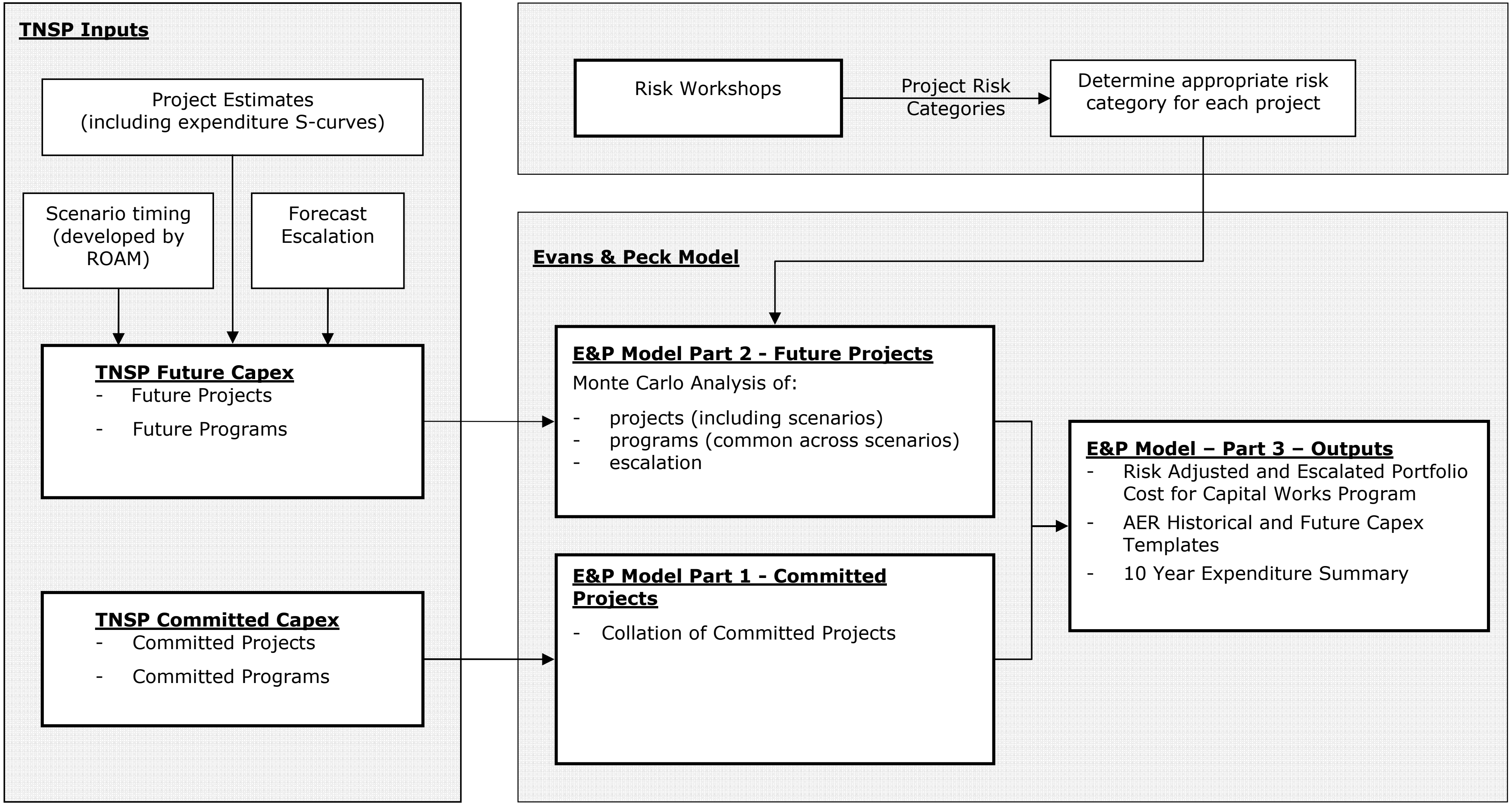

Figure 2.1 – Capital Accumulation Model – Inputs and Outputs

3 RISK/OPPORTUNITY IN A CAPITAL WORKS PROJECT

3.1 Introduction

The long duration of a capital works project and its continued exposure to outside influences until completion means that at any point in time until completion is achieved, the forecast final cost or outturn cost, will contain a degree of uncertainty.

Therefore while a best estimate of outturn cost may be made, the actual outturn cost will almost certainly differ from that best estimate. This is true during the feasibility, concept design, detailed design and construction phases of a project.

Uncertainties relate to the time at which the outturn cost is calculated during the project delivery life cycle, the extent of design on which the outturn cost is based, the extent of investigation to address site specific uncertainties, the cost of land, the cost of individual components of the project (including labour) and unforeseen or unplanned events that impact the project. The manner in which these uncertainties are allowed for will determine the accuracy of an estimate as an indicator of the final outturn cost.

3.2 Simple Contingency Approach

The US Department of Energy recognises the need to address the uncertainty associated with estimates, with an entire directive devoted to contingency, which it defines as:

> *"costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties within the project scope. The amount of contingency will depend on the status of design, procurement and construction; and the complexity and uncertainties of component parts of the project".*

Traditionally project and portfolio managers have made best estimates of project outturn costs, and then defined a contingency for the project, which is intended to allow for unforeseen cost increases. Contingency is simply determined as a percentage of the best estimate of cost, as +/-x%. The value of "x" is generally correlated to the stage of design on which the estimate is based, rather than on any detailed assessment of actual risks and opportunities associated with the project. With this approach the values of (best estimate –x %) and (best estimate + x %) become little more than upper and lower bounds of the expected outturn cost.

This is the approach that has been traditionally adopted by TransGrid. At the project feasibility stage, when TransGrid and its engineering consultants prepare a Feasibility Study Report based on a concept design, a band of +/-25%, or greater, is adopted. The best estimate is based on quantities defined by the stage of design and unit rates based on historical tender data. At the tender stage, when detailed design is complete, the level of uncertainty reduces, but is not eliminated.

Notwithstanding the recognition of uncertainty and the identification of a potential outturn cost band of +/- x%, TransGrid has historically adopted the view that the best estimate will in fact be the outturn cost. Implicit in this approach is that there is an equal probability (or symmetry) of the project risks (denoted by +x%) and the project opportunities (denoted by –x%) occurring, and hence the outturn cost will be the best estimate of cost. This approach reflected in previous Regulatory Reset submissions. In essence, TransGrid does not include any contingency in its project budgeting for the purpose of Regulatory Reset submissions.

Evans & Peck is of the view that this approach does not reflect the risks associated with delivering large capital projects.

3.3 Review of Historical TransGrid Data

Evans & Peck has compared available historical TransGrid data from the 2004 to 2009 regulatory period. For 16 projects that have achieved completion, the sum of the actual outturn costs is 101.4% of the amounts permitted by the regulator. On this basis, a simple argument could be mounted that the risks and opportunities do not cancel out on TransGrid's projects, and an additional allowance of at least 1.4% should be made for this uncertainty.

The magnitude of any additional allowance will depend on the underlying detail of the outcomes for the 16 individual projects. Figure 3.1 shows the actual distribution of cost overruns on a project by project basis.

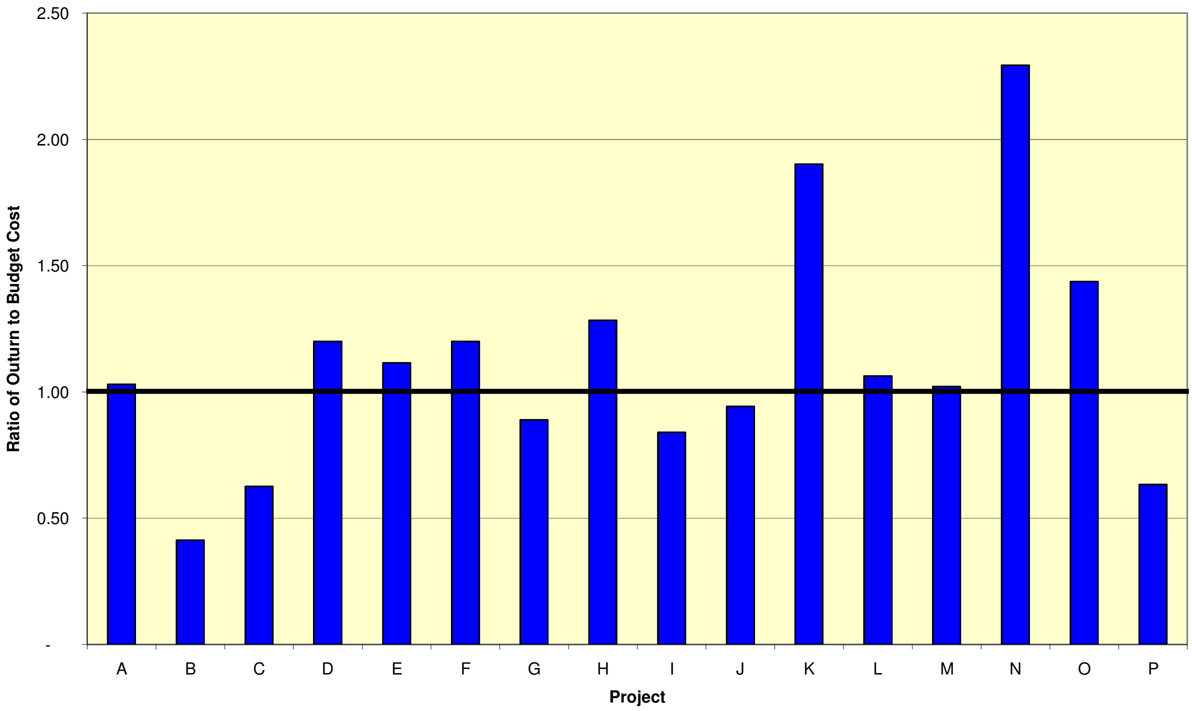

Figure 3.1 – Ratio of Outturn Costs to AER Approved Budgets for 16 Completed Projects

Whilst the volume weighted average indicates a cost overrun across this sample portfolio of only 1.4%, we do not consider this a robust statistic because of the impact of significant outliers in the data. If the highest and lowest outliers are removed, this average increases to approximately 7.5%. This analysis highlights two aspects about the level of variation that does occur in projects carried out by TransGrid:

- There is a significant variation in project outcomes, with the ratio of outturn cost to AER approved budget varying between 41% and 229%; and

- Across the sample portfolio, the risks and opportunities do not balance, resulting in the sample portfolio cost overrun.

Evans & Peck's analysis of the 2009-2014 Capital Works program seeks to quantify the extent of such variation on a look forward basis, rather than a look back basis.

3.4 Quantitative Risk Based Approach

The NSW Government now recognises the validity of risk based simulation for project budgeting. In the NSW Treasury paper TPP07 titled "Commercial Policy Framework Guidelines for Financial Appraisal", dated 4 July 2007, it states:

> *"Risk simulation through modelling programs may be conducted if reliable data exists to estimate the error distributions of key parameter values."*

Whilst a simple contingency based approach and a quantitative risk based approach have the same end goal – to provide an accurate estimate of costs likely to be incurred – the risk based approach is a more structured and accurate tool because it recognises that risks and opportunities may be asymmetric and that uncertainties may differ from component cost item to component cost item.

Consideration of the variation in component costs and the assessment of specific risks and opportunities ensures that small expenditure items with high risk or high expenditures with low risk are appropriately weighted to form the overall risk profile for the project.

The application of computational techniques such as Monte Carlo simulation (refer to Appendix 1) on the assessed variability of component costs then provides a robust means for assessing the likely range of outturn costs of a project. Figure 3.2 shows how a cumulative cost probability curve generated by Monte Carlo simulation overlays with the simple contingency approach described in Section 3.1. This highlights how the values of (estimated cost + 25%) and (estimated cost - 25%) are little more than upper and lower bound extremes, providing no guidance as to the expected outturn cost.

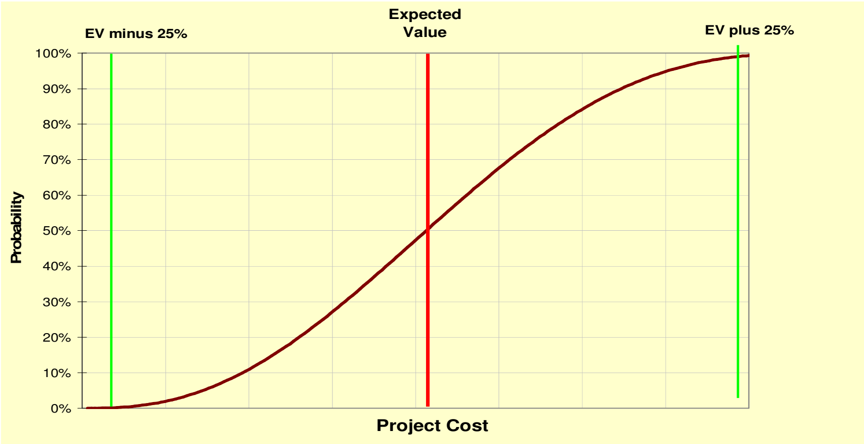

Figure 3.2 - Typical Cumulative Probability Cost Curve

The quantitative risk based approach can consider both inherent risks and contingent risks within a project. Inherent risks (and opportunities) represent the uncertainty in the pricing of a defined scope of work, and are due to uncertainties in either the quantities or unit costs rates adopted when preparing the estimate of cost. Inherent risks can also reflect uncertainty in the construction method that will be adopted, which will impact the rate. The inherent risks associated with TransGrid projects are discussed in detail in Section 5.1.

Contingent risks and opportunities are risk/opportunity events that may occur during the life of a project, and so increase or decrease the cost of the project from the best estimate.

Contingent risks result in a final project scope that differs from that on which the initial estimate was based. Contingent risks may include:

- Scope creep, which alters the quantity of work to be carried out;
- Latent ground conditions, such as contamination, asbestos or Acid Sulphate Soils, which have not been priced in the original estimate;
- Occurrence of an unplanned or unforeseen event such as an extreme weather event or major safety incident;
- Stakeholder issues that result in changes to the scope of the project or method of delivery of the project;
- Delayed access to site; or
- Industrial relations external to the project that nevertheless influence the outcome of the project.

In the context of this TransGrid submission, a conservative approach has been adopted by TransGrid whereby no additional allowance is being sought for contingent risks.

3.5 Modelling Data at the Project Level

Various mathematical distributions can be used to model the variability of individual cost components in a risk based quantitative analysis. The most commonly used distributions are uniform, discrete, triangular or Pert. The uniform distribution is used when the range of possible outcomes each have an equal probability of occurrence. The discrete distribution is used when specific discrete outcomes may occur, and is generally more applicable to some forms of contingent risk than for the inherent risks associated with a known scope of works. The Triangular and Pert distributions are of a similar form, as shown in Figure 3.3 below, but with the Pert distribution giving greater weighting to the best estimate (1.00 in the figure).

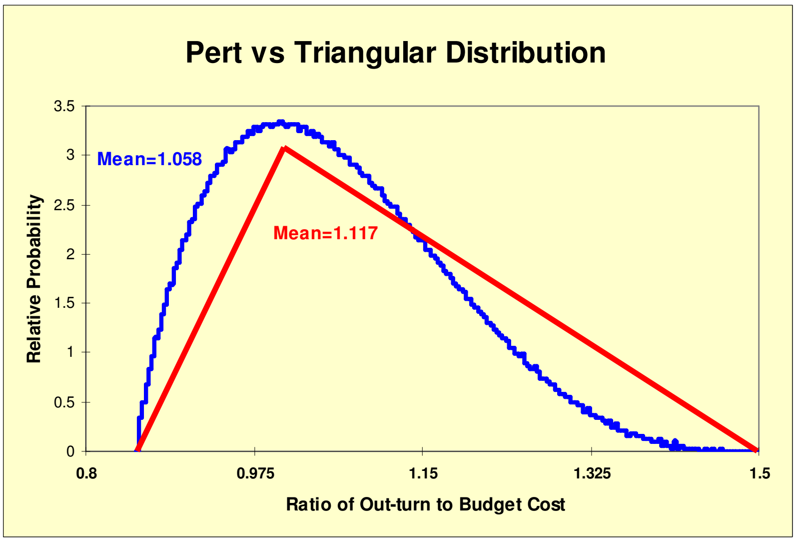

Figure 3.3 – Comparison of Pert Distribution and Triangular Distribution

Evans & Peck generally utilises the "Pert" distribution as the preferred distribution for modelling the range of outcomes for an inherent risk component in a risk based quantitative analysis because:

- It is intuitively easy for clients to understand, being represented by minimum, most likely and maximum values, with the most likely value generally being the best estimate;
- It weights results toward the most likely value, rather than extreme outcomes; and
- The distribution was specifically developed to capture time (and hence cost) overruns on capital type projects.

3.6 Project Outturn Cost and Portfolio Impact

When a Monte Carlo simulation is applied to a project in which individual cost components are modelled by Pert (or other) distributions as described previously, the total cost is more symmetrical than the individual inputs. This is shown graphically in Figure 3.4 below.

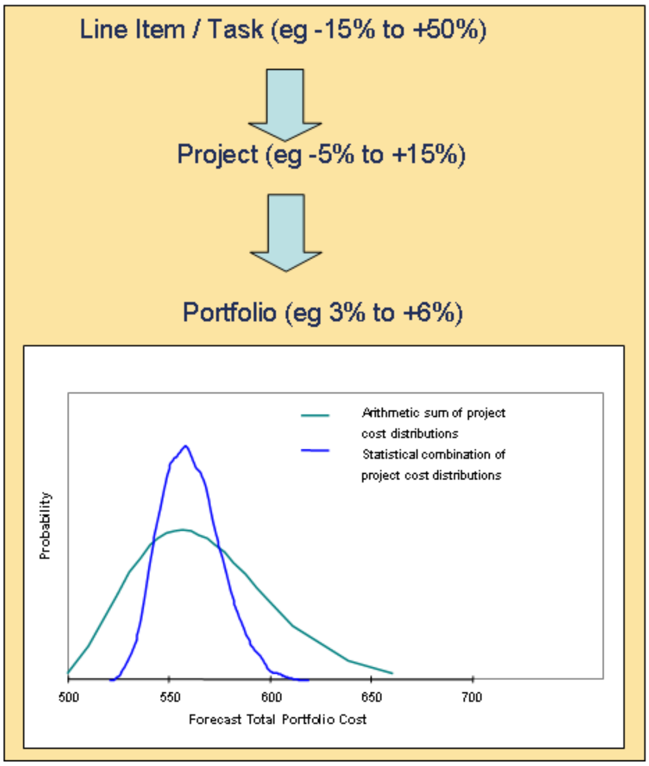

Figure 3.4 – Comparison of Component Cost Distribution and Project Cost Distribution

The output cost curve may be presented as a cumulative probability curve (refer Figure 3.2), or alternatively it may be presented as a discrete probability curve as shown in Figure 3.5 below.

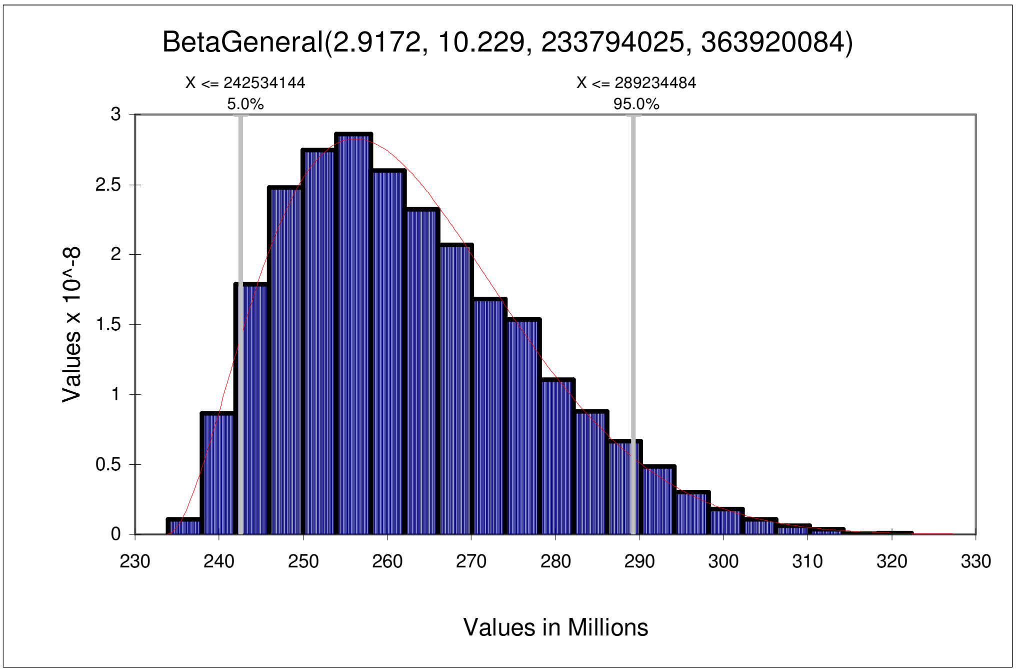

Figure 3.5 – Discrete Probability Outturn Cost Curve

Evans & Peck's analysis has shown that for the TransGrid projects analysed, the curve which best fits the resultant cost outcomes at the project level (i.e. after diversification of the risks at the cost component level) is of the form of a "Beta General" distribution. This is described in terms of four parameters - two shape parameters, the minimum outturn cost and the maximum outturn cost. It is less asymmetric than the Pert curves used at the individual cost component level. The Beta General distribution curve for an individual project can be normalised to make it applicable to a project of any value. We have used the normalised Beta General function to transfer project risk profiles (based on individual analysis) into the CAM. The outturn cost curve confirms that a range of potential outturn costs is possible, centred near the most likely value, but with a skewed distribution.

The "portfolio effect" recognises that in a portfolio of projects such as TransGrid's 2009-2014 Capital Works program, the combined level of risk of the portfolio outturn cost will have a lower spread again than the arithmetic sums of the risks for the individual projects that make up the portfolio. This is also depicted in Figure 3.4.

4 TRANSGRID RISK ANALYSIS METHODOLOGY

It is not commercially viable to carry out quantitative risk based analyses of every one of the projects in TransGrid's 2009-2014 Capital Works program in the compressed time frame associated with the preparation of this regulatory submission.

The methodology adopted by TransGrid for identifying and quantifying risks for the CAM can be summarised as follows:

1. Examine the portfolio of projects under consideration to determine if groups of projects with similar risk profiles can be identified. Once identified, obtain detailed cost estimation data for representative project(s) within each group.
2. Identify key personnel within TransGrid who can provide insight into the real risks and opportunities involved in the design, estimation and delivery of projects.
3. On a project group by project group basis in a facilitated workshop environment, use the selected TransGrid personnel to:
    i. Determine the key risks and opportunities likely to impact delivery cost of each cost component for each representative project;
    ii. Assess the inherent risk and associated risk profiles (usually a Pert distribution) for the project cost components for each of the selected projects;
    iii. Identify any major projects which require risk assessments in their own right, rather than as part of a group of projects.
4. Develop outturn cost profiles for each representative project by using a Monte Carlo simulation on the cost component data; thereby capturing the diversification of risk between the individual component cost items that form the project, and fit a distribution which best represents the result (Beta General).
5. For every project in the TransGrid 2009-2014 Capital Works program, allocate the outturn cost profile from the suite of profiles developed in Step 4, which is considered to best represent that project's risk / opportunity profile.
6. Incorporate the allocated outturn cost profiles on a project by project basis into the CAM.
7. Incorporate cost estimates for the entire portfolio of capital works projects into the CAM.

8. Model the entire portfolio of projects and the scenarios of projects using a Monte Carlo simulation to determine, from the CAM, the "global" risk adjustment appropriate to TransGrid's portfolio of projects and programs.

Not every project or program (as described in Section 2) attracts risk allocations. For example, TransGrid is of the view that where the same or similar tasks are regularly repeated, the risks across a large number of jobs automatically track into the averages used in the estimating process. As a consequence, "Programs" have not been allocated a risk profile.

Similarly, TransGrid has also historically assumed that once a project moves into the construction phase, and a contract for construction issued, the contract sum is an appropriate measure of the outturn cost and no further risk allowances are required, even though TransGrid is still exposed to contingent risks where the risk is retained by TransGrid and not passed onto the contractor. This approach has been applied to the projects forming "Work in Progress". Therefore in this regulatory submission TransGrid has been quite pragmatic – wherever risk can be reasonably absorbed, it has been.

5 RISK MODELLING

5.1 Project Cost Inputs

TransGrid has a portfolio of approximately 160 future projects for the 2009-2014 regulatory period.

In accordance with the methodology detailed in Section 4, TransGrid has subdivided its total portfolio of projects into groups of projects with similar risk profiles, and then analysed individual project(s) within those groups as being representative of each group.

For the purpose of this Regulatory Reset submission, the groups are:

- 500kV transmission line on an existing lower voltage route;
- 330kV transmission line on a new route;
- 330kV transmission line on an existing route;
- 132kV transmission line on a new route;
- 132kV transmission line on an existing route;
- Greenfields substation works (works on a new substation site);
- Brownfields substation works (works on an existing substation site) ;
- SCADA Communications projects;
- SCADA Installation projects; and
- Property acquisition.

For each group a specific project was adopted for review. The project was selected because it was generally representative of the group. The selected projects are shown in parentheses in the list above. If any particular aspect of the project was considered to be uncharacteristic of the group at large, the inherent risk associated with that characteristic was assessed on the basis of a more typical situation. For each project TransGrid had a single point cost estimate for the project prepared for the Project Feasibility Report.

Land acquisition costs and escalation have been excluded from the individual project analyses because land costs and escalation are treated separately within the CAM.

A risk assessment workshop, facilitated by Evans & Peck, was conducted with senior TransGrid personnel covering portfolio managers, planning engineers, project delivery managers and cost estimators. The purpose of the workshop was to review the cost components for each of the selected projects and assess the potential variability of these components.

For each cost component the participants considered the potential range of outcomes. The minimum and maximum values expressed as a percentage of the most likely value, which invariably was the value derived from the cost estimate prepared by TransGrid. These assessments represent TransGrid's considered professional opinion of the likely range of outturn costs for each component.

Evans & Peck considered the probability-cost curves that were generated by these models. In a quantitative risk analysis the steepness of the probability-cost curve reflects the certainty about the outturn cost. There should therefore be a general correlation between the steepness of the probability-cost curve and the level of detail on which the estimate is based. Evans & Peck is satisfied that the generated probability-cost curves reasonably reflect the uncertainty in project definition for the projects that have been considered.

5.2 Property

For the 2009 to 2014 program a total of 31 projects require some form of property acquisition. TransGrid recognises that uncertainty in property costs will vary depending on the nature and timing of the project.

In terms of new substations, three different stages have been recognised in the modelling. New substation projects have the greatest potential variability because at the Feasibility Study stage of a project the actual site has not been identified. It may not be possible to secure an optimal site – ultimately the selected site will depend on availability of property- and so this has the highest potential variability. The second stage is when a site has been identified but acquisition negotiations have not been finalised. Some potential variability still exists. The final stage is when property has been acquired. In this case there is no risk with the acquisition of property.

For brownfields substation works the variability in property costs is less than for new substation works because sites have generally been identified adjacent to the existing TransGrid substation.

There is some change in variability for transmission line projects depending on whether the works are for new lines (with new easements) or upgrading or replacement works (with potentially widened easements). Variability is greater for new easements. Variability is also considered to be less for the smaller 132kV transmission lines than for 330kV transmission lines because the easement width requirements are less.

5.3 Correlation between Variables

The cost estimates provided by TransGrid as the starting point for the workshops include a level of disaggregation greater than that used in our assessment of risk factors for other TNSP's, particularly in relation to transmission lines. It is almost certain that the outturn cost for a number of the component cost items are highly correlated within individual projects. For example, if the conductor length changes, it is highly likely that the length of the overhead earth wire will also change. Failure to recognize these correlations within a project will result in an understatement of the range of outcomes – both above and below the most likely.

It is considered that the following components have at least some cross correlation:

- Clearing;
- Structures;
- Insulators;
- Phase Conductors;
- Fittings;
- OHEW;
- OPGW;
- Stringing; and
- Clipping.

The interdependence of some or all of these variables is qualitatively easy to understand, and correlation parameters have been introduced into the modelling to recognise this inter-dependence. We emphasise that we have only used correlation within projects to establish a representative outturn cost curve for a project, but not between projects as part of the CAM. For substations no correlation between components has been applied.

6 MODEL RESULTS AND RECOMMENDATION

TransGrid's portfolio of future projects within the 2009-14 Capital Works program has been subdivided into 11 groups and individual projects. Representative projects for each group have then been analysed by Evans & Peck using a quantitative risk based approach that recognises the inherent risks in the cost components that make up TransGrid's estimate of the cost for the individual projects.

Normalised Beta General outturn cost curves have been generated following a Monte Carlo simulation of the input data for each representative project. These normalised Beta General curves will be transferred into TransGrid's CAM to allow analysis, by TransGrid, of its total Capital Works program for 2009-2014. The normalised Beta General outturn cost curves are provided in Table 6.1 below.

Project	Beta	General	Shape	Parameters
	Alpha	Beta	Minimum	Maximum
500kV new route	4.9762	23.348	0.93005	1.66364
330kV new route	5.1676	11.6820	0.89996	1.44478
330kV existing route	3.1795	6.2828	0.87546	1.37928
132kV new route	3.1568	9.3626	0.90376	1.37936
132kV existing route	3.4624	8.2556	0.93101	1.31508
Greenfields substation	4.5104	8.1802	0.90355	1.32601
Brownfields substation	3.4615	6.1387	0.92775	1.31643
Cable project	24.967	54.249	0.86876	1.38299
SCADA Comms	2.8487	5.1018	0.91704	1.25106
SCADA Installation	10.042	25.325	0.90519	1.37216
Property	6.7612	8.8476	0.88280	1.27091

Table 6.1 – Normalised Shape Parameters for inclusion in the CAM

Evans & Peck has performed 5000 simulations using CAM. A summary of the outputs is shown in Table 6.2. The model indicates the following global risk parameters:

- P80 3.87%
- P50 3.30%
- Mean or Expected Outcome 3.32%

In a commercial environment, Evans & Peck would normally recommend application of at least the P80 value for budget approval purposes. In previous determinations in a regulatory environment, we have suggested that the P50 value represents a reasonable allocation of risk between the service provider and it customers. The Mean value actually represents the expected outcome. Adoption of the mean value has the added value of providing the default output value in all values impacted by risk in the CAM. It can be assessed without re-running the Monte Carlo simulations. In a risk based model, all outputs are in reality distributions rather than a single point value.

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Table 6.2 – Capital Accumulation Model Output Summary

Given the closeness of the Mean to the P50 value, Evans & Peck recommends that it forms the basis of the global risk adjustment applied to TransGrid’s works portfolio. In summary, we recommend a global risk adjustment of 3.32% applicable to the total value of all projects and programs.

Appendix 1 Monte Carlo Simulation Technique

Appendix 1 Monte Carlo Simulation Technique

A Monte Carlo simulation technique is used in two ways in the TransGrid Capital Accumulation model:

- At the project level, Monte Carlo simulation is used to determine an outturn cost distribution based on the variability of individual components of cost; and
- At a portfolio level, Monte Carlo simulation is used to assess the impact of the potential variability of individual project outturn costs on the portfolio of capital works projects.

Monte Carlo is a simulation technique whereby in each iteration of the model, one possible outcome (from within the defined risk range) is randomly selected for each item in the model. For each iteration of the model, the results are combined to provide a consolidated outcome across the entire range of items in the model. By carrying out a very large number of iterations a smooth output curve can be generated. At least 5000 iterations are usually performed to ensure the analysis results can be replicated.

For quantitative risk analysis of a project, this involves randomly sampling all of the input distributions (forecast range of individual component cost items), and calculating the total forecast outturn cost, to give a single simulated result. This process is iterated to provide a range of simulated outcomes representing the potential outturn cost range of the project. This outturn cost can be approximated by a Beta General distribution.

For quantitative risk analysis of a portfolio, this involves randomly sampling all of the input distributions (forecast outturn cost distribution for the project, as approximated by a Beta General distribution), and calculating the total forecast portfolio cost, to give a single simulated result. This process is iterated to provide a range of simulated outcomes representing the potential outturn cost range of the entire capital works program.

The random nature of each sample for the Monte Carlo simulation in this report means that there will be a cross-section of project costs from within the defined risk profiles weighted by their value, with the sampled costs of some projects being at the higher end of their risk profile, and some sampled costs being at the lower end of their risk profile. By choosing not to assign any correlation between projects, the random sampling nature of this technique treats the different risks as diversifiable. This again, is a conservative assumption which tends to understate the range of possible outcomes. Correlation could occur between projects for a wide range of reasons, most typically errors in the estimation relating to the cost and escalation of common line items.