PUBLIC SUBMISSION
by
CMS GAS TRANSMISSION of AUSTRALIA

THE USE OF STOCHASTIC METHODS FOR REFERENCE TARIFF DETERMINATION

INTRODUCTION

CMS Gas Transmission of Australia (CMS) employed stochastic (probabilistic) methods in its determination of Reference Tariffs for the Parmelia Pipeline.

The use of such methods has been queried in public submissions regarding the Parmelia Pipeline Access Arrangement made to the Office of Gas Access Regulation (OffGAR).

CMS engaged as a consultant Professor Lou Caccetta, Head of School of Mathematics and Statistics at Curtin University, to provide independent expert evaluation of the applicability of Monte Carlo simulation to the determination of Reference Tariffs.

CMS has taken this action in order to address the queries raised in the public submissions.

CONSULTING BRIEF

Professor Caccetta was asked to evaluate the applicability of the Monte Carlo method to the process of Reference Tariff calculation, and to give consideration of the relative merits of deterministic and stochastic methodologies in the context at hand.

Specifically excluded from Professor Caccetta's brief was:

- validation of the actual calculation process itself (i.e. the specific mechanics of the WACC, NPV, and other calculations), and

- commentary on the ranges of values assigned to input variables.

CMS has submitted to OffGAR a proposal which will allow OffGAR to exhaustively validate the computational workings of the CMS Reference Tariff calculation. CMS hopes to work closely with OffGAR in this regard.

CONCLUSIONS: APPLICABILITY OF MONTE CARLO METHOD

Professor Caccetta's report appears below.

In summary, the report finds that:

- stochastic methods, and the Monte Carlo method in particular, are applicable to the determination of Reference Tariffs;

- deterministic methods are applicable when the values of input variables are known with a high degree of certainty and when the values of input variables do not change over time;

- the use of Triangular input distributions to characterise the ranges assigned to input variables is commonly used and well accepted, but the use of Beta distributions would constitute an improvement;

- Latin Hypercube sampling (as used in the Monte Carlo method employed) is appropriate;

- the number of iterations (10,000) used in the Monte Carlo method employed is appropriate;

- the Monte Carlo method used does not address dependencies between input variables, and consideration of these would constitute an improvement.

Report On

1

Parmelia Pipeline
Access Arrangement Information

For

CMS Energy

2

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REPORT ON: Parmelia Pipeline – Access Arrangement Information

FOR: CMS Energy

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Executive Summary:

This document comments on the methodology used by CMS Energy for the determination of a reference services tariff. It is our view that a stochastic model using a Monte Carlo simulation is the most appropriate technique for this analysis.

Introduction

It is understood that the Parmelia Pipeline Access Arrangement Information Document has recently been submitted to the Independent Gas Pipelines Access Regulator Western Australia by CMS Energy. A major part of the document deals with the determination of a reference services tariff which is carried out using stochastic (i.e. probabilistic) Monte Carlo Simulations. This report details our comments in regard to the use of Monte Carlo methods in this particular context.

Based on the National Third Party Access Code for Natural Gas Pipeline Systems, the calculation of a reference services tariff is to depend on a number of input parameters as outlined in the Access Arrangement Information Document. The calculation can be carried out in either a deterministic or in a stochastic manner, as explained below.

Deterministic Modelling

In a deterministic model, the model's outcome is calculated by choosing a 'best guess' value for each input variable of the model. A deterministic model is only suitable for cases where the values of the input variables are known either exactly or with a high degree of certainty. Judging from the Access Arrangement Information document, most, if not all, of the input variables for the tariff calculation are subject to considerable uncertainty and variation over time. It is unclear how sensitive the result of a deterministic calculation is with respect to this degree of uncertainty. The sensitivity of the result can be ascertained to some extent by selecting various combinations of values for the input variables ('what if' scenarios), but if the number of input variables is high, as is the case here, the excessive number of scenarios required to produce a sensitivity analysis is not practical. The only way a deterministic model would be acceptable is if the tariff calculations are carried out at relatively short, regular, intervals, assuming that all of the input variable values are known and virtually constant over these intervals. This situation conflicts with the need for a longer term fixed tariff.

Stochastic Modelling

In a stochastic (or probabilistic) model, the objective is to calculate the combined impact of the model's various uncertainties and to produce a probability distribution of the model outcome, rather than a single value as in the deterministic model. Each input variable is considered as a random variable with a specified probability

distribution. Although a number of stochastic modelling techniques are available, the only technique suitable for general practical problems is the Monte Carlo Simulation technique.

Monte Carlo Simulation

In this technique, a large number of scenarios are generated by randomly sampling each input variable probability distribution in a manner that preserves the distribution's shape. The resulting probability distribution of model outcome values is then a true reflection of the values that could occur. Monte Carlo Simulation is a quite basic, robust technique which has been adopted as a standard tool in the management of many large scale industries. In particular, its advantages are:

- the distributions of the input variables do not need to be approximated in any way
- the outcome distribution can be easily calculated on a computer using widely available commercial software
- any mathematical relationship between the input and output variables can be dealt with easily
- changes to the model can be made with ease
- there is a theoretical basis justifying the use of the technique

Given the nature of the reference services tariff calculation, it is considered that a Monte Carlo Simulation is the most suitable technique available for the tariff determination.

Implementation of the Monte Carlo Simulation

To obtain meaningful results, care is required when using a Monte Carlo Simulation. In particular,

- the probability distributions for the input variables must be chosen carefully
- the sampling scheme used in the simulation must reflect the true input distributions and yet be reasonably efficient
- a suitable number of scenarios must be generated depending on the number of input variables
- any dependency and/or correlation between the input variables should be assessed in terms of its impact on the output distribution and, in case of a significant impact, should be included in the simulation model

Input Distributions
The probability distributions for the input variables of the stochastic model should be as realistic as possible, in particular in terms of their range of values. In the case of the reference services tariff determination problem, it appears that for most of the input variables, precise information on their distributions is not available. Instead a range between a minimum and maximum value and a most likely value is given for each input. Two types of distribution, the triangular and the beta distributions are

suitable for this type of data. The triangular distributions used in the tariff calculations are reasonably flexible, intuitive in the nature of their defining parameters and easy to use, but they suffer from a bias problem in that the mean value is equally sensitive to the minimum, maximum and most likely value. Nevertheless, triangular distributions are commonly used and accepted in management science. Given the nature of the available input data, a more suitable distribution for each of the input variables is the BetaPERT distribution, in which the mean is (four times) more sensitive to the most likely value than to the minimum and maximum values.

Sampling Scheme
A number of sampling schemes can be used for the Monte Carlo simulation. Random (or Monte Carlo) Sampling means that for each scenario, the value of each parameter is randomly selected according to that variable's probability distribution. While it represents an unadulterated purely random sampling method, a very large number of scenarios is required to produce a reasonable outcome distribution. Instead, Latin Hypercube Sampling ensures that a close to full range of possible inputs is selected in the sampling to still produce a representative outcome distribution with far fewer scenarios. The probability distributions of the input variable are still taken into account with Latin Hypercube Sampling. Other sampling methods such as Midpoint Latin Hypercube Sampling are available, but they offer no further advantage.

Number of Scenarios
The theoretical convergence properties of Monte Carlo Simulations are difficult to establish, but the generally accepted practise is that the number of scenarios is sufficient if a reasonably smooth output distribution has been obtained. When Latin Hypercube Sampling is employed, far fewer scenarios are required than for Random Sampling. The results of the tariff calculations (and those for the weighted average cost of capital (WACC) preceding them) appear to result in reasonably smooth output distributions.

Input Dependencies and Correlations
In both the WACC and tariff simulations, a number of the input variables have an obvious dependence or correlation. For example, in the WACC calculations, the market risk premium depends on both the risk free rate and gamma. Similarly, in the tariff calculation, it seems likely that many of the variables depend on the inflation rate and that pipeline life depends on operating costs. Other dependencies also exist. These need to be considered carefully for the Monte Carlo simulation. A rank order correlation, using a correlation matrix, should be set up for the input distributions. The effects of any correlations on the outcome distribution can then be ascertained. If any dependencies are shown to significantly influence the simulation output distribution, it may be difficult to decide on appropriate values for the correlation coefficients. In this case, the input variable dependencies or correlations will need to be analysed more carefully and incorporated into the Monte Carlo simulation via the Envelope Method.

References

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