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Discount Rate for the Grid Investment Test

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1. EXECUTIVE SUMMARY

In 2004, the Electricity Commission commissioned Saha International to advise on the appropriate discount rate to be used in the Grid Investment Test.[1] Following a period of consultation, the Electricity Commission decided that a real pre-tax discount rate of 7% should be used. The Electricity Commission stated that it:

> *believes the WACC is unlikely to have a significant impact on GIT decisions, as alternatives to transmission typically delay grid investment for only a few years. The relevant timeframe is the deferral time of the transmission investment, not the asset life of the project. However, the Commission has modified the GIT to allow evaluation of the sensitivity of specific alternative projects to individual discount rates.*[2]

The Commission's assumption that the discount rate is unlikely to have a significant effect on GIT decisions is incorrect. In particular, the relevant time frame is always the entire period affected by the investment decision and the alternatives available to that decision, including a decision to implement the same investment at a later date. Not all decisions can be deferred and not all deferral decisions involve simply shifting an investment by a period of time. The mix of types of benefits arising from one investment will often differ from the mix of types of benefits arising from alternative investments. The mix of types of costs and benefits of a given investment may also change over time. Again, these are all reasons why the choice of discount rate is an important consideration.

The sensitivity analysis in the Commission's own economic analysis of the North Island grid upgrade project demonstrates that a change in the discount rate can alter which project is preferred, with an increase in the discount rate (from 7% to 10%) favouring the Commission's 220kV proposal over Transpower's 400kV proposal.[3] A lower discount rate puts greater weight on future costs and benefits, whereas a higher discount rate will tend to favour projects that have lower costs in early periods. This could have a material influence on whether the Commission accepts Transpower's investment proposals. Even if the choice of discount rate does not matter in a particular instance, it will matter some of the time, and can be material.

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1 Saha International (2004) *Discount Rate for Application in Grid Investment Test*, Final Report, 30 November.

2 Electricity Commission (2004) *Explanatory Paper: Grid Investment Test*, 3 December, paragraph 106.

3 Electricity Commission (2007) *Economic Analysis of the Revised North Island Grid Upgrade Project*, 23 February, p. 56.

The Electricity Commission considers that

> *the theoretically correct approach would be to assess proposals at their project specific WACC. Although this approach is adopted by businesses in their investment decision-making, the Commission believes it is not appropriate for the GIT because neither Transpower nor the Commission will have robust information on the risk characteristics of investor proposals to reliably estimate WACC's for each proposal, especially if there is no proponent for a transmission alternative. (para 101)*

We reach a different conclusion. The GIT is a form of social net benefit analysis, and as such the theoretically correct discount rate is *not* the project-specific WACC used by an investor but instead is a social discount rate. The project-specific WACC is used by an investor to assess whether the project is a viable investment from a private perspective. The social discount rate is used to assess whether a project is valuable to society as a whole.[4]

The use of a social discount rate for social net benefit analyses is not controversial. In the United Kingdom, the "Green Book" recommends a real social discount rate of 3.5% based on a calculation of the social rate of time preference, for application in "all policies programmes and projects".[5] Similar rates are used in France and the Germany.[6] In the United States the rate currently mandated by the Department of Energy for certain federal programmes is 3%.[7]

4 Note that there may be instances where a project is socially beneficial (NPV > 0), but due to either differences in discount rates, or the private investor's inability to capture a sufficiently large share of the benefits generated, the project is not attractive to a private investor (NPV < 0). In such instances the decision needs to be made whether there the social benefits are sufficiently large to justify pursuing the project through some mix of private and public funding. We do not explore this issue any further in this report.

5 HM Treasury (2003) *The Green Book: Appraisal and Evaluation in Central Government*, Treasury Guidance: London

6 Evans, D.J. (2006) "Social Discount Rates for the European Union", Working Paper n. 2006-20, Università degli Studi di Milano, October, pp. 1-2.

7 Rushing, A.S. and S.K. Fuller (2006) *Energy Price and Discount Factors for Life-Cycle Cost Analysis – April 2006*, Annual Supplement to NIST Handbook 135 and NBS Special Publication 709, NISTIR 85-3273-21 (Rev. 4/06), Prepared for United States Department of Energy Federal Energy Management Program, National Institute of Standards and Technology, U.S. Department of Commerce, April, p. 1. Note, however, that the real discount rate is subject to a floor of 3%.

In 2006 Transpower commissioned Castalia to advise on the appropriate discount rate for the GIT. Castalia estimates the social discount rate from the after-tax rate of return on long-dated Government bonds, and then add a premium for systematic risk. The Australian Department of Transport and Services also recommends the use of long-dated Government bonds.[8] The United States Department of Commerce recommends the use of Government bonds with a maturity equal to the period of the cash flows, and presents both nominal and real estimates.[9] The United States Environmental Protection Agency recommends the use of post-tax real rates of return on US Treasury securities.[10]

Guthrie (2006) critiques the approach adopted by Castalia, but ultimately his conclusion on the additional premium is that it should have a wider confidence interval and a higher mid-point.[11] Adjusting for risk is not universally accepted, however, with the US Environmental Protection Agency concluding that "the discount rate should *not* be adjusted to account for uncertainty in benefit-cost analysis",[12] instead recommending that scenario analysis be used to quantify the effect of any material uncertainty in outcomes. The same conclusion is reached by Quiggin (2005) in Australia.[13] The economic model employed by the Electricity Commission effectively includes 10,000 different scenarios,[14] and thus it is not necessary to adjust the discount rate for any risk in the outcomes, as this is already captured in the analysis.

We have provided two alternative calculations of the social discount rate for New Zealand. The first estimate adopts the same calculation of the social rate of time preference as applied in the Green Book. Our calculations indicate that the social rate of time preference for New Zealand may fall in the range 3.0% to 4.3%, with a best estimate of 3.6%. The second estimate adopts the risk-adjusted after-tax interest rate approach from Castalia (2006), but with updated parameters. Using this methodology, our calculations indicate that an estimated real risk-adjusted social rate of time preference may fall in the range 1.7% to 6.0%, with a best estimate of 3.3%.

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8 Potterton, P. (2005) "Foreword", in Harvey, M., Risk in cost-benefit analysis, Report 110, Department of Transport and Regional Services, Australian Government

9 Rushing and Fuller (2006), p. 1.

10 US Environmental Protection Agency (2000), *Guidelines for Preparing Economic Analyses*, September, p. 47.

11 Guthrie, G. (2006) "Comments on Castalia's 'Discount Rate for the Grid Investment Test", 23 November, p. 7.

12 US Environmental Protection Agency (2000), p. 29.

13 Quiggin, J. (2005) "Risk and discounting in project evaluation", in Harvey, M., *Risk in cost-benefit analysis*, Report 110, Department of Transport and Regional Services, Australian Government, p. 113.

14 Electricity Commission (2006) *Economic assessment of Transpower's Auckland 400kV grid investment proposal*, Prepared by the Modelling Group Electricity Commission, 5 May, pp. 60-61.

Considering all of the available estimates, in our view the best estimate of the post-tax real discount rate to use for the GIT is 3.5%. We suggest sensitivities be performed for discount rates at 2% and 6% to capture the majority of the likely variation around the central estimate. These discount rates should be applied to pre-tax real benefits and costs.

Government agencies around the world have moved to the use of a social discount rate approximating the SRTP for analysis of projects with public benefits. For example, HM Treasury mandates a CRI-based estimate of the SRTP of 3.5% in the United Kingdom. Ofgem uses this rate in the analysis of benefits from smart metering and the benefits for the change in the regulatory framework. The US DOE uses an estimate of the SRTP based on market interest rates, currently 3% real, for evaluating energy conservation and renewable energy investments in federally-owned buildings. The US EPA recommends a CRI of 2-3%. The California Energy Commission recommends the use of a social discount rate for transmission evaluation, and in an assessment of the Palo-Verde line augmentation uses a discount rate of 5%. The social discount rate adopted by France is 4% and by Germany is 3%. Our recommended discount rate lies squarely within the range of estimates presented here.

The actual practice of evaluating transmission investments by regulatory agencies generally appears to be rooted in the belief that a commercial discount rate is appropriate. This is the practice in Alberta, Australia, British Columbia, and California. Central estimates applied in Australia include pre-tax real rates of 8%, 9%, and 11%. British Columbia has employed a real rate of 8%. The commercial discount rate is used in Australia because it is seen as providing for "competitive neutrality" between regulated transmission and commercial generation, even though such considerations are completely irrelevant to a social cost-benefit analysis. It is unclear exactly why a commercial discount rate is used in the other regulatory jurisdictions reviewed, although it seems likely that it is a mixture of the Australian "competitive neutrality" argument, together with concern by the regulated utilities that the same discount rate would be used to set the cost of capital used in calculating their allowable revenues. This latter concern reflects a misunderstanding of the role of a social discount rate: the social discount rate in project evaluation is intended to enable the valuation of benefits that cannot otherwise be captured by specific parties; it is not an appropriate rate for use in setting regulated revenues.

2. INTRODUCTION

The application of the Grid Investment Test (GIT) requires that the benefits and costs for the proposed project and each alternative are discounted to present values using an appropriate discount rate.

In 2004, the Electricity Commission commissioned Saha International to advise on the appropriate discount rate. Following a period of consultation, the Electricity Commission decided that a real pre-tax discount rate of 7% should be used. In 2006 Transpower commissioned Castalia to advise on the appropriate discount rate. Castalia recommended a range of 2.72 to 4.18 percent real post-tax.

Transpower has now asked CRA International to review these previous studies, and other relevant literature, and provide advice on the appropriate discount rate for the GIT.

Our report is divided into three major sections:

- First, we consider the conceptual basis for the discount rate (Section 3);
- Second, we calculate a range for the discount rate based on the conclusions from the conceptual analysis (Section 4); and
- Third, we review the approach that is adopted in other regulatory jurisdictions (Section 5).

3. CONCEPTUAL BASIS

In this section, we discuss the conceptual and theoretical basis for selecting a discount rate, and apply that to the question of the discount rate that should be applied in the GIT.

3.1. THE GIT REQUIRES A SOCIAL DISCOUNT RATE

The GIT is intended to enable the Board of the Electricity Commission to select the "transmission upgrade options that maximise the total net benefits to those who produce, distribute, and consume electricity".[15] It is clear from this rule that the GIT is a social cost-benefit analysis because it includes the costs and benefits to a wide range of parties, not just the costs and benefits accruing to the investor.[16]

The appropriate discount rate to apply when calculating a net present value (NPV) depends on the purpose for which the NPV calculation is being used. Where the purpose of the calculation is to determine whether a private investor should invest in a project, then it is appropriate to use the private investor's discount rate. This is commonly calculated as a weighted average cost of capital (WACC) that may include a return on equity derived using the capital asset pricing model (CAPM).

Where the purpose of the calculation is to determine whether one project has greater social benefits than another, then the appropriate rate to use is a social discount rate.

These points were made in more detail by Castalia (2006, p. 5) and Saha (2004, pp. 24-25).

3.2. APPROACHES TO CALCULATING A SOCIAL DISCOUNT RATE

Before reviewing the various approaches to calculating the social discount rate, it is instructive to review the nature opportunity costs associated with the costs and benefits. The nature of the opportunity costs determines the discount rate that should be applied.

Whether the NPV calculation is for a private investment decision or a social net benefit calculation, a key element of the calculation is the calculation of the present value of investment costs and the subsequent costs of operating and maintaining the asset. When the calculation is for a private investment, then all such costs will be displacing other investment that could be undertaken by the investor, and the appropriate discount rate is the opportunity cost of private investment. When the calculation is for a social net benefit assessment, the costs may be displacing ("crowding out") private investment, or they may be displacing private consumption.

15 Part F, Section III, Rule 6.3.4.

16 This point was made in more detail by Castalia (2006), p. 5.

The other element of the NPV calculation is the calculation of the present value of the benefits of the project. For a private investment, the benefits are revenues, and these increase the ability to undertake additional private investment. The appropriate discount rate for the benefits from a private investment is therefore the opportunity cost of private investment. For a social net benefit calculation, the benefits will typically be increases in consumption (or reductions in negative impacts on consumption),[17] although there may also be some impacts on investment.

With these categorisations of opportunity cost in mind, we now turn to the four main approaches to calculating a social discount rate:[18]

- The Social Rate of Time Preference (SRTP), which is the rate at which society trades consumption in the present for consumption in the future (i.e. the social opportunity cost of consumption);
- The Social Opportunity Cost (SOC), which is the rate that reduces the NPV of the best alternative private use of the funds to zero. In essence, this rate is the Internal Rate of Return from the best alternative private use of the funds, and reflects the return that society requires from investment;
- The Weighted Average Method, which weights the SOC and the SRTP in proportion to the sources of the resources in terms of lost private investment and lost consumption; and
- The Shadow Price of Capital (SPC), which uses the SPC to convert all costs and benefits into their equivalents in terms of changes in consumption, and then applies the SRTP as the discount rate.

The first three methods are listed in Saha (2004, p. 25), and Saha prefers the Weighted Average Method. Castalia correctly criticises Saha's use of the Weighted Average Method on the basis that it is based on a closed economy model. In a closed economy, an increase in public expenditure will reduce both consumption and private investment, so the Weighted Average Method is appropriate. However, in a small open economy with flexible exchange rates and (near) perfect capital mobility, the domestic interest rate is effectively set at the world interest rate. This means that an expansion in government spending does not alter interest rates and does not, therefore, alter private investment. In a small open economy, therefore, the SRTP is appropriate discount rate. This is the same conclusion reached by Castalia (2006, p. 24).

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17 Note that any costs and benefits accruing to individuals are consumption effects. A negative environmental externality faced by individuals is a cost, and is assessed essentially as if it was negative consumption. A reduction in the externality is therefore a positive consumption benefit.

18 See Boardman, Anthony E., David H. Greenberg, Aidan R. Vining, and David L. Weimer (2001) *Cost-Benefit Analysis: Concepts and Practice*, Prentice Hall: New Jersey, pp. 165-175

3.3. THE SOCIAL RATE OF TIME PREFERENCE

The rate at which individuals are willing to trade consumption now for consumption in the future is the individual consumer's marginal rate of time preference. Just as the rate at which investors are willing to trade value now for value in the future is the appropriate discount rate for their decisions, the appropriate discount rate for an individual is the rate at which they are willing to trade consumption now for consumption in the future (i.e., the marginal rate of time preference).

The SRTP is the marginal rate of time preference for society as a whole rather than the rate for individuals, and there are many plausible reasons why the SRTP may differ from the individual's marginal rate of time preference. For example, Trostel and Taylor (2001) propose a model whereby individuals prefer current consumption to future consumption because of the expected reduction in future utility from consumption due to declining health and eventual death. According to this view, society does not die, and it does not suffer from declining health, so society as a whole has little or no preference for current consumption over future consumption.

Notwithstanding the examples described above, arguments have also been advanced as to why the SRTP could be higher than the individual's marginal rate of time preference.[19] Given the lack of clear consensus in the literature, a reasonable approximation that is often used in practice is to assume that the SRTP is equal to the individual's marginal rate of time preference.

3.4. THE SOCIAL DISCOUNT RATE IS NOT TRANSPOWER'S COST OF CAPITAL

There is no reason why the social discount rate would ever necessarily equal the cost of capital of the firm undertaking an investment, whether that firm is Transpower or a privately-owned firm.

The firm's cost of capital reflects the opportunity cost of the capital that will be used to fund the investment. The opportunity cost in turn reflects the risks borne by lenders and investors. These risks can be altered significantly by the design of the regulatory system and the pricing and contracting mechanisms in place. For example, the regulatory system may allow full cost recovery, it may disallow recovery of costs over a specified limit, or it may impose a theoretical calculation of asset values that determines the level of costs that can be recovered. None of these alternatives alters the total profile of benefits to society as a whole, but each can radically alter the level of risk to the investor. It therefore follows that there is no reason to expect that the social discount rate and the firm's cost of capital would ever be equal.

We note that Guthrie (2006, p. 3) in his critique of Castalia (2006) accepts that the social discount rate and the firm's cost of capital will not necessarily be equal. Guthrie goes on to argue that

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19 See Boardman et al, (2001), p. 166.

> *"the mathematics of expected rates of return imply that (like any cost of capital) the social cost of capital will be a weighted average of the costs of capital of individual stakeholders, with the weights reflecting the relative importance of the various stakeholders. Thus, Transpower's cost of capital is one component of the weighted average that comprises the social cost of capital."*

While this establishes that the average will not necessarily equal Transpower's cost of capital, it does not provide any useful assistance for estimating an actual value for the social discount rate. We are ultimately concerned with the rate at which society trades off consumption in the current period against consumption in future periods; the manner in which pricing and contractual arrangements transfer risk between members of society is not of any particular interest, so neither is the discount rates that individual groups may face.[20]

3.5. THE DISCOUNT RATE SHOULD BE POST-TAX

A social cost-benefit analysis should be performed using a post-tax discount rate, although taxes do not need to be included in the calculation of costs and benefits.

In a small open economy public expenditure displaces consumption.[21] The marginal rate of time preference is the rate at which an individual trades off consumption in the present for consumption in the future. Consumption always occurs on a post-tax basis because consumers purchase using post-tax income, so their marginal rate of time preference is a post-tax rate.[22]

Although the appropriate discount rate is post-tax, the tax flows do not need to be included within the cost-benefit analysis. Taxes are a wealth transfer, reducing the wealth of the firms and individuals that pay taxes, but providing additional benefits via the goods and services that the taxes fund. As a wealth transfer, taxes can therefore appear as a negative in one part of the calculation but a positive in another part of the calculation. The negative and positive effects cancel out and taxes can therefore be omitted from the cost-benefit analysis.[23]

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20 To use an analogy from financial economics, we are interested in the discount rate that should be applied to the total portfolio. We could calculate the discount rates for each security within the portfolio, and then calculate the weighted average that applies to the portfolio as a whole, or we could calculate the discount rate for the whole portfolio. There are tools for calculating the approximate value of the social discount rate, but there are insufficient tools for calculating the discount rates that would apply to each individual stakeholder.

21 In economics, consumption is the direct use of goods and services by end consumers.

22 See, for example, the discussion in Boadway, R. (2006) "Principles of Cost-Benefit Analysis", *Public Policy Review*, Vol. 2 No. 1, pp. 28-29.

23 Note that for analytical convenience this assumes that there are no deadweight losses arising from the taxation considered. If there are deadweight losses then the positive and negative impacts will not quite cancel out. Given the magnitude of uncertainties in other variables, however, it is usually reasonable to treat taxation as a straight wealth transfer.

3.6. UNCERTAINTY OVER LONG TIME HORIZONS

The discount rate, like other parameters in a cost-benefit analysis is inherently uncertain. To account for the uncertainty in other parameters we typically employ scenario analysis. Scenarios may include a low, central, and high estimate, or monte carlo analysis may be used to allow for random variation in multiple parameters. Monte carlo analysis could also incorporate uncertainty in the discount rate. However, scenarios are often limited in number, and hence are not able to capture the full range of uncertainty. It will therefore often be necessary to specify a "best estimate" of the discount rate around which sensitivities are performed. This is the approach employed in the GIT.

Due to the mathematical properties inherent in discounting, the "best estimate" of a discount rate is not simply the mid-point of a range. Instead, when there is uncertainty in the discount rate the best estimate should decline over time. An example demonstrates why a declining discount rate is appropriate. Table 1 below shows the present value (PV) of one dollar at 10 year intervals for discount rates of 4%, 7%, and 10%. The three discount rates are expected to have the indicated probabilities of occurring. The weighted average present value is then calculated by weighting each of the three PV's by the respective probabilities. We then calculate the discount rate that is implied by the weighted average.

Table 1: Example of Discount Rates Declining due to Uncertainty

Discount Rate	4%	7%	10%	Weighted Average Present Value	Implied Discount Rate
Probability	**25%**	**50%**	**25%**		
Year					
1	0.9615	0.9346	0.9091	0.9349	7.0%
10	0.6756	0.5083	0.3855	0.5195	6.8%
20	0.4564	0.2584	0.1486	0.2805	6.6%
30	0.3083	0.1314	0.0573	0.1571	6.4%
40	0.2083	0.0668	0.0221	0.0910	6.2%
50	0.1407	0.0339	0.0085	0.0543	6.0%

In year 1, the implied discount rate is 7.0%, which is same as the weighted average of the three discount rates. However, as the time horizon becomes longer, the implied discount rate reduces. By 50 years, the discount rate has reduced to 6.0%. Even greater reductions in the implied discount rate occur at long time horizons.

Uncertainties in the discount rate will generally arise from parameter uncertainty. For example, any discount rate that is based on interest rates will have uncertainty arising from interest rate volatility. Newell and Pizer (2001) construct two models of US interest rate behaviour, and calculate the expected PV of $100 under each model.[24] Table 2 replicates data Newell and Pizer's calculations of present value given alternative interest rate models. We then calculate the value for each of the two interest rate models relative to the use of a constant discount rate, and also calculate the implied discount rate.

Table 2: Effects of Interest Rate Uncertainty

Years in future	Value Today of $100 in the Future			Value relative to Constant Discounting		Implied Discount Rate	
	Constant 4% rate	Mean Reverting	Random Walk	Mean Reverting	Random Walk	Mean Reverting	Random Walk
0	100.00	100.00	100.00	1.00	1.00	4.00%	4.00%
20	45.64	46.17	46.24	1.01	1.01	3.94%	3.93%
40	20.83	21.90	22.88	1.05	1.10	3.87%	3.76%
60	9.51	10.61	12.54	1.12	1.32	3.81%	3.52%
80	4.34	5.23	7.63	1.21	1.76	3.76%	3.27%
100	1.98	2.61	5.09	1.32	2.57	3.71%	3.02%

Source: Newell and Pizer (2001); CRA calculations.

As can be seen from Table 2, interest rate risk can have a significant impact on the present value of future costs and benefits. The PV of costs and benefits occurring in 40 years time may be 5-10% higher than the PV calculated with a constant discount rate. Similarly, the PV of costs and benefits occurring in 60 years time may be 10-30% higher than the PV calculated with a constant discount rate.

While the impact on the implied discount rate may appear small, the impact on PVs is such that it could potentially change the ordering of projects that have significant future costs. Given uncertainty, it is therefore appropriate to choose a discount rate from the lower end of the range when discounting over long time horizons.

24 Newell, R. and W. Pizer (2001) "Discounting the Distant Future: How Much Do Uncertain Rates Increase Valuations", Discussion Paper 00-45, Resources for the Future, 14 May.

3.7. ADJUSTMENT FOR RISK

The standard practice for calculating discount rates for corporate financial decisions is to use the cost of capital calculated with the standard capital asset pricing model. The cost of capital is calculated as a risk-free rate plus a risk premium equal to the product of the market risk premium and the covariance between returns on the asset of interest and the market as a whole (i.e. the "beta"). This approach is adopted by Castalia (2006) for adjusting their estimated social discount rate for the GIT. Guthrie (2006) critiques the parameters used by Castalia, but does not directly challenge the use of a CAPM.[25]

Adjusting for risk is not universally accepted, however, with the US Environmental Protection Agency concluding that "the discount rate should *not* be adjusted to account for uncertainty in benefit-cost analysis",[26] instead recommending that scenario analysis be used to quantify the effect of any material uncertainty in outcomes. The same conclusion is reached by Quiggin (2005) in Australia.[27] The economic model employed by the Electricity Commission effectively includes 10,000 different scenarios,[28] and thus it is not necessary to adjust the discount rate for any risk in the outcomes, as this is already captured in the analysis.

Notwithstanding the argument that it is not necessary to adjust the discount rate for risk in outcomes, we assume that there is some systematic risk component to the benefits received by society, and therefore that it is appropriate to make some adjustment to the discount rate. In the sub-sections that follow we consider the appropriate market risk premium and beta estimate for a CAPM-based risk adjustment.

3.7.1. Market Risk Premium

The consumption-based capital asset pricing model (the "CCAPM") leads to the familiar result that discount rates should be a function of systematic risk. In particular, the CCAPM provides an explanation of the return from the market as a whole as a function of consumption, the income to be received from the market, and risk aversion. The CCAPM should, in theory, provide a suitable estimate of the market risk premium to be used in adjusting the social discount rate to reflect the systematic risk of the project. However, the CCAPM predicts a market risk premium of only about 0.1%,[29] whereas observed

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25 Guthrie (2006, p. 2) does however note that if the CAPM is used to price risk then only the systematic risk is included in the risk premium, implying that there are other factors that could be priced.

26 US Environmental Protection Agency (2000), *Guidelines for Preparing Economic Analyses*, September, p. 29.

27 Quiggin, J. (2005) "Risk and discounting in project evaluation", in Harvey, M., *Risk in cost-benefit analysis*, Report 110, Department of Transport and Regional Services, Australian Government, p. 113.

28 Electricity Commission (2006) *Economic assessment of Transpower's Auckland 400kV grid investment proposal*, Prepared by the Modelling Group Electricity Commission, 5 May, pp. 60-61.

29 Quiggin, J. (2005) "Risk and discounting in project evaluation", in Harvey, M. *Risk in cost-benefit analysis*, Report 110, Department of Transport and Regional Services, Australian Government, pp. 106-107.

equity market risk premiums are roughly in the order of 4-9% depending on the markets, time periods, and methods of averaging. The difference between the theoretical prediction and empirical observation is known as the equity premium puzzle. The equity premium puzzle is a major area of research in financial economics, but there is no universally accepted explanation for the puzzle. Some of the explanations advanced are:[30]

- Bonds are considerably more liquid than equities, and thus equity attracts a significant illiquidity premium;
- Individual consumption is around seven times more variable than aggregate consumption, thus indicating that individuals are not as diversified as theory suggests, and reducing willingness to invest in risky equities;[31]
- Investors over-estimate the riskiness of equity;
- The absence of markets in which individuals can insure themselves against systematic risk in labour income and non-corporate profits;
- Ex-post systematic risk is concentrated on a small subset of the population;
- Credit constraints which constraint the young from optimal borrowing.

The risk premium measured from the stock market is a proxy for the risk premium, but it excludes the impact of other sources of wealth, including human capital and the housing stock. Jagganathan and Wang (1993, p. 15) note that over the period 1959-1992 income from dividends was less than 3% of the monthly personal income from all sources. Jagganathan and Wang construct a multi-factor CAPM with labour income as a proxy for human capital, and show that it adds significantly to the explanatory power of the standard CAPM. Unfortunately, however, we are left with a situation where the only empirically observable risk premium is measured against a proxy (the stock market) that is only a small fraction of the complete market portfolio (which would include all assets including human capital).

It is also not obvious that the observed market premium is necessarily more appropriate for social cost benefit analysis than the premium predicted by the CCAPM:

30 For citations for these examples and further discussion of the equity premium puzzle, see Quiggin (2005).

31 Note that if there is less willingness to invest in equities then the price of equities will drop. The underlying income stream associated with the equities remains unchanged, so the price drop must be a result of an increase in discount rate.

> *Use of the market price of risk would be consistent with efficiency if the observed market premium for systematic risk was an accurate reflection of the preferences of individuals trading in an efficient capital market where all risks were perfectly diversified, or if any deviations from market efficiency were small and unimportant. However, no satisfactory explanation of the equity premium puzzle consistent with approximate market efficiency has been proposed.*[32]

If the observed market risk premium were relevant, there is also the question of the appropriate value for New Zealand. Lally (2005) sets out five estimates of the post-tax market risk premium for New Zealand. Aspects of Lally's analysis are critiqued by Boyle, Evans, and Guthrie (2006). Taking the relevant elements of that critique into account, we estimate a median post-tax market risk premium for New Zealand of approximately 7.7%, lying within a range of estimates from 6.0% to 8.9%.

Given the two extremely divergent estimates of the market risk premium, we use a market risk premium of 0.1% - consistent with the CCAPM – to adjust the consumption rate of interest estimate of the SRTP, and we use a risk premium in the range 6.0% to 8.9% to adjust the estimate of the SRTP obtained from the after-tax interest rate.

3.7.2. Beta

The stream of costs associated with a transmission investment is essentially fixed over a long period of time. However, the benefits are positively correlated with economic growth that drives increased use of the augmented transmission network capacity. Taking the North Island 400kV upgrade as an example, the greatest benefits from the upgrade will occur if there is strong economic growth leading to strong growth in demand for electricity.

The positive correlation of benefits from transmission with economic growth suggests that the "beta" for transmission investment will be positive. We do not, however, know the precise magnitude of the beta, and nor can we measure it. Again we are forced to rely on measurements against an imperfect market portfolio. Unfortunately, there are few pure transmission companies that are traded on global stock markets, so there are also few observations of the beta against the market portfolio. The measurement error in the beta must, therefore, be very large.

Castalia (2006) present evidence from the UK to support an asset beta in the range 0.31 to 0.41, data from Australia which supports a range of 0.02 to 0.18, and some additional evidence repeated from Lally (2005). Castalia adopt a beta range of 0.2 to 0.4. Guthrie (2006) critiques Castalia's approach on two fronts: the range is likely to be wider than that suggested by Castalia, as the estimates used in the range have uncertainty; and he also suggests there are some reasons to believe that the mid-point should be higher than the 0.3 that is the mid-point of Castalia's range.

32 Quiggin (2005), p. 110.

We do not have any superior data to that which is discussed by Castalia (2006) and Guthrie (2006). To develop estimates of a risk-adjusted social discount rate, we arbitrarily expand the beta range to 0.0 to 0.6, but do not change the mid-point.

4. CALCULATING THE SRTP FOR NEW ZEALAND

There are two main ways for calculating the SRTP:

- Calculating an estimate of an individual's marginal rate of time preference from observed interest rates; and
- Calculating the "consumption rate of interest" from more fundamental data.

Both of these methods are discussed by Castalia (2006, pp.7-8). Castalia express a preference for the first method; we estimate values for New Zealand using both methods.

4.1. MARKET RATE OF INTEREST

The first means of estimating the marginal rate of time preference is to note that consumers face an opportunity cost of forgone interest when we consume now rather than saving for the future. In equilibrium in perfect markets, consumers will trade consumption now for consumption in the future until the marginal rate of time preference is equal to the real after-tax rate of interest that can be earned on saving.[33] Thus, one estimate of the SRTP is the after-tax interest rate on (risk-free) investments. We calculate below the SRTP and then apply a risk adjustment based on the observed equity market risk premium.

4.1.1. After-Tax Market Interest Rate

The calculation of the after-tax interest rate is complicated by the fact that different individuals face different marginal tax rates. As a first approximation, we assume that the average marginal tax rate across all consumers is 33%. The secondary market bond yield on 10 year Government bonds averaged 5.94% for February 2007,[34] so the estimated nominal SRTP is 3.98%. Inflation for the five years ending December 2006 has averaged 2.63%.[35] Assuming that inflation in the recent past conditions expectations of future inflation, then the expected real after-tax rate interest rate (and hence the real SRTP) is 1.32%.

Our estimate of 1.32% is close to Castalia's (2006, p. 11) estimate of 1.25%. The difference in values primarily arises from the difference in the interest rate on long-term Government bonds (the interest rate that we use is 0.14% higher, which contributes to a 0.09% increase in the SRTP).

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33 Ibid.

34 Source: Reserve Bank of New Zealand website, B2 Wholesale Interest Rates, http://www.rbnz.govt.nz/statistics/exandint/b2/data.html.

35 Calculated as the arithmetic average of quarterly Year-on-Year CPI estimates, Reserve Bank of New Zealand website, A3 Income and Prices, http://www.rbnz.govt.nz/statistics/econind/a3/data.html.

4.1.2. Risk-Adjusted Market Interest Rate

To calculate the estimates of the risk-adjusted SRTP from the parameter point estimates and ranges, one option would be to use a monte-carlo simulation to do random draws from an assumed distribution for each parameter. We have opted for a simpler approach, dividing the ranges in to bands, and assuming a probability for each point estimate and each band. We have a single estimate of the risk-adjusted market interest rate, although a more comprehensive analysis would potentially employ an interest rate projection model. We also have three point estimates for the market risk premium (6.0%, 7.7%, 8.9%), and five bands for the beta, which means that we have fifteen estimates of the risk-adjusted post-tax market interest rate. Our estimates do not all have the same probability of occurrence, as we have assumed that the central point estimate for the market risk premium is twice as likely as each of the other two estimates.

We use the ranges and various point estimates to generate estimates of the risk-adjusted SRTP, each with an assumed probability of occurrence. We then use each estimate to calculate the present value of one dollar for a specified number of years in the future (i.e., 10, 20, 30, 40, 50). At each time horizon we use the assumed probabilities to calculate an expected present value. We then calculate the single discount rate that would yield the same present value.

Table 5 in Appendix A shows the calculation of the SRTP from the risk-adjusted market interest rate. The estimated real risk-adjusted CRI ranges from 1.7% to 6.0%. The expected discount rates calculated at the bottom of the table decline from 3.45% for an amount occurring in 10 years to 3.15% for an amount occurring in 50 years, with an average of 3.29%. Given the range of variation in the possible risk-adjusted CRI, the second decimal place provides only a spurious level of accuracy. It is therefore appropriate to adopt a value of 3.3% as the best estimate of the risk-adjusted SRTP.

4.2. CONSUMPTION RATE OF INTEREST

The second means of estimating the marginal rate of time preference is a more fundamental calculation of what is known as the consumption rate of interest (CRI). We calculate below the CRI and then apply a risk adjustment utilising the risk premium from the CCAPM.

4.2.1. Calculating the CRI

The CRI is estimated as:

$$CRI = \delta + \mu \cdot g$$

where δ is the "rate of time preference" (the rate at which utility is discounted), μ is the elasticity of the marginal utility of consumption, and g is the expected rate of growth in average consumption per capita.

The rate of time preference can be further defined as:[36]

$$\delta = \rho - L$$

where ρ is the "pure rate of time preference", which is the rate at which welfare arising in the future is discounted purely by virtue of this utility arising later; and L is the "rate of growth of life chances".[37]

Pure Rate of Time Preference

There is no clear agreement around the value of ρ, with some commentators suggesting that it should be equal to zero on point of (philosophical) principal that present consumption should not be assumed to be more valuable than future consumption. Setting that philosophical argument aside, HM Treasury (2003:98) use an estimate of δ = 1.5 without considering how this is comprised of ρ and L.[38] If Pearce and Ulph's (1995:8) estimate of L = -1.1 is correct, then this implies ρ = 0.4. Pearce and Ulph (1995:16) use a range of 0 to 0.5, with a best estimate of ρ = 0.3.

Rate of Growth of Life Chances

Pearce and Ulph estimate L as the death rate. Statistics New Zealand calculate the standardised death rate as 6.5 deaths per 1,000 people,[39] which equates to L = -0.65.[40] Given an range of ρ = 0.3 to 0.5, the New Zealand-specific value of L implies that δ = 0.95 to 1.15. This accords with Arrow's (1995:17) tentative view that the value of this parameter "should be about 1%".

Elasticity of the Marginal Utility of Consumption

Based on an academic review of relevant studies HM Treasury adopts a value of μ = 1.[41] Arrow (1995:17) uses a figure of μ = 1.5. Pearce and Ulph (1995) examine several studies and conclude that (p. 14):

> *a value of μ = 1.5 is unquestionably at the upper end of the range. A value of μ = 1 is defensible and a value relevant to current UK conditions is μ = 0.8-0.9.*

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36 Note that this decomposition is not always performed, with the assumption being made that $\delta = \rho$.

37 See Pearce and Ulph (1995), p. 6.

38 Note that HM Treasury and Pearce and Ulph have reversed the use of ρ and δ. We have followed the notation of Pearce and Ulph.

39 Statistics New Zealand (2004), p. 41.

40 Pearce and Ulph divide total deaths by the total population and then multiply by 100. This is the same as the standardised death rate (0.0065) multiplied by 100.

41 See Clarkson and Deyes (2002), pp. 53-54 and HM Treasury (2003), p. 98.

Evans (2006) surveys eleven studies based on demand models, providing a range of 1.06 to 1.97 with an average of 1.47 and a median of 1.56.[42]. Oxera (2002) conclude that "values … in the range 0.5-1.2 seem reasonable".[43]

Given these estimates of the elasticity of the marginal utility of consumption, we use values of 1.0 and 1.5 in developing a range for the CRI.

Growth in Average Consumption per Capita

Pearce and Ulph (1995:15) note that:

> *"[if] the population choose to substitute leisure for consumption, then a value of g based on real per capita consumption will understate the relevant magnitude. Second, real consumption per capita may fail to reflect rising social costs of consumption, in which case g will be overstated. One way to smooth out such considerations is to take [very] long-run rates of growth in real [per] capita consumption."*

The historical growth in average consumption per capita depends on the time period over which growth is measured. To avoid difficulties in valuing consumption according to different price indices in this preliminary analysis, we use recent consumption growth rates based on the latest data from Statistics New Zealand. As shown in Table 3 below, we use a value of g = 2.35%, calculated over a period of 15 years.

Table 3: Growth Rate in New Zealand Per-Capita Final Consumption Expenditure

March Year	Consumption per capita ($)	Growth Rate
	1995/96 constant prices	
1991	13,619	
1996	14,376	1.09%
2001	15,894	2.03%
2006	19,282	3.94%
Full Period		2.35%

42 Evans omits the studies considered by Pearce and Ulph from his sample, even though he includes other studies by the same authors.

43 Oxera (2002) , *A Social Rate of Time Preference for Long-Term Discounting*, 17 December, p. 17.

The Consumption Rate of Interest

Given the parameters above, the estimated CRI is 3.30% to 4.68%. The growth rate may be overstated by the very high rate of 3.94% growth in final consumption expenditure achieved for the five years from March 2001-March 2006. If the March 1996-March 2001 growth rate of 2.03% is more representative of the long-term average, then the CRI drops to the range 2.98% to 4.20%, as shown in Table 4. The SRTP derived from the calculation of the consumption rate of interest is, in this instance, higher than the estimate calculated using real after-tax interest rates.

Table 4: Calculation of Consumption Rate of Interest at Selected Parameter Values

Rate of Time Preference δ	elasticity of marginal utility of consumption, μ	
	1.0	**1.5**
	Growth in Per-Capita Consumption, g = 2.35%	
0.95%	3.30%	4.48%
1.15%	3.50%	4.68%
	Growth in Per-Capita Consumption, g = 2.03%	
0.95%	2.98%	4.00%
1.15%	3.18%	4.20%

Note: CRI is calculated as $CRI = \delta + \mu \cdot g$

4.2.2. Risk-Adjusted CRI

There are four point estimates of the CRI, each of which is assumed to be equally likely. There are also five assumed bands for the beta, each of which is assumed to be equally likely. This means that we have twenty estimates of the risk-adjusted CRI, all with equal likelihood of occurrence.

We use the ranges and various point estimates to generate estimates of the risk-adjusted SRTP, each with an assumed probability of occurrence. We then use each estimate to calculate the present value of one dollar for a specified number of years in the future (i.e., 10, 20, 30, 40, 50). At each time horizon we use the assumed probabilities to calculate an expected present value. We then calculate the single discount rate that would yield the same present value.

Table 6 in Appendix A shows the calculation of the risk-adjusted CRI. The estimated real risk-adjusted CRI ranges from 3.0% to 4.3%. The expected discount rates calculated at the bottom of the table decline from 3.60% for an amount received in 10 years to 3.55% for an amount received in 50 years. Given the limited range of variation in the possible risk-adjusted CRI, the second decimal place provides only a spurious level of accuracy. It is therefore appropriate to adopt a value of 3.6% as the best estimate of the risk-adjusted CRI.

4.3. SUMMARY

We have calculated the risk-adjusted SRTP using two methods. Using an estimate of the CRI, and adjusting for risk using the premium suggested by the CCAPM, we calculate a best estimate of 3.6%, within a range of 3.0% to 4.3%. Using an estimate of the post-tax market rate of interest, and adjusting for risk using estimates of the equity market risk premium, we calculate a best estimate of 3.3%, within a range of 1.7% to 6.0%.

Considering all of the available estimates, in our view the best estimate of the post-tax real discount rate to use for the GIT is the 3.5% recommended in the Green Book for the UK. Sensitivity analyses should be conducted to encompass the range of possible variation around this figure. We suggest sensitivities be performed for discount rates at 2% and 6% to capture the majority of the likely variation around the central estimate. These discount rates should be applied to pre-tax real benefits and costs.

5. INTERNATIONAL REVIEW

It is important to note that the purpose of the analysis determines whether the discount rate used in the analysis is comparable to the discount rate used in the GIT. If the analysis is used for calculating an asset value based on projected cash flows, or for calculating a cost of service or building block revenue requirement, then the appropriate discount rate is the commercial discount rate that would be used by an investor. A calculation of social net benefit requires a social discount rate.

We also note that there is nothing particularly special or unique about electricity transmission when conducting a social cost benefit analysis. For example, public investments in road infrastructure present exactly the same issues. Discount rates applied to other public infrastructure investments are also relevant for consideration.

5.1. United Kingdom

Ofgem employs the distinction between the commercial discount rate and the social discount rate. For example, at the last Electricity Distribution Price Control Review (EDPCR), Ofgem calculated the PV of revenues using the cost of capital of 6.5% as the discount rate. Similarly, in calculating the Regulated Asset Value of the Scotland-England Interconnector, Ofgem discounted the (contracted) expected cash flows from the interconnector using the estimated cost of capital for the interconnector of 10%.[44] Neither of these examples are comparable to the discount rate used for the GIT, as Ofgem is essentially applying the same test applied by a private investor when valuing an asset.

On the other hand, Ofgem (2006a) calculates the net benefit of installing domestic smart meters using a social discount rate of 3.5%.[45] Similarly, Ofgem (2006b, p. 9) calculate the net benefits to customers of reforms to the incentive framework for the gas national transmission system using a discount rate of 6%, with a sensitivity performed using a social discount rate of 3.5%.[46] The 3.5% applied by Ofgem in its calculations of net economic benefit comes from the “Green Book” issued by HM Treasury.[47] The green book applies the formulae set out in Section 4 to calculate a social rate of time preference for the UK. This example is comparable to the discount rate used for the GIT, as it is assessing the net benefits arising from a particular proposal.

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44 Ofgem (2004) *Transmission Price Controls and BETTA: Final proposals and Impact Assessment*, 279/04, December, pp. 28-41.

45 Ofgem (2006a) *Domestic Metering Innovation*, Consultation, 1 February, p. 16.

46 Ofgem (2006b) *Transmission Price Control Review: Initial Proposals*, Appendix 16, Ref 104c/06, 26 June; See also Appendix 17, Ref 104d/06, 26 June, pp. 5-6.

47 Ofgem (2006a), p. 16.

5.2. EUROPE

There has been a move within Europe towards the use of social discount rates for social cost benefit analyses.[48] These rates are 3% In Germany and 4% in France,[49] which closely bracket the 3.5% used in the United Kingdom.

5.3. AUSTRALIA: THE NEM

Saha International review the discount rate applied in applications of the regulatory test in the Australian National Electricity Market (NEM).[50] Consistent with the regulatory test, all applications have applied a discount rate that would be consistent with a commercial rate of return. Discount rates that are specifically mentioned by Saha International are:

- Pre-tax real discount rates of 6%, 8%, and 10% for VENCorp's evaluation of the Latrobe Valley-Melbourne augmentation;
- Pre-tax real discount rates of 9%, 11%, and 13% for the Inter Regional Planning Committee's evaluation of SNOVIC and SNI; and
- Discount rates of 7%, 8%, and 9% for VENCorp's evaluation of SNOVIC.

We also note that ActweAGL and Transgrid's application for proposed new transmission and distribution assets to service the Australian Capital Territory applied a real discount rate of 9%, with sensitivities of 6% and 12%.[51]

There are two main reasons advanced in Australia for the use of a commercial discount rate in the Regulatory Test. The primary reason advanced is that a commercial discount rate should be used "in order to ensure network and non-network investments are compared on a competitively neutral basis".[52] This reason does not make sense in the context of a cost-benefit analysis. The purpose of the analysis is to determine the option that provides the greatest net benefit from a societal perspective, and "competitive neutrality" – whatever that is supposed to mean – is not relevant. One insight into what might be meant by "competitive neutrality" is TransÉnergie's argument that "to be comparatively worthwhile, regulated investments should at least match the rate of return

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48 Evans, D.J. (2006), pp. 1-2.

49 Ibid.

50 Saha International (2004), pp. 30-35.

51 Transgrid (2006) *Southern Supply to the ACT: Proposed New Large Transmission Network Asset, Proposed New Large Distribution Network Asset,* Final Report, December, p. 12.

52 ACCC (2004) *Review of the Regulatory Test for Network Augmentations*, Decision, File no: c2001/944, 11 August, p. 48.

on private investments".[53] This reasoning is flawed as it confuses the Regulatory Test with the decision to be undertaken by a private investor. The Regulatory Test, like the GIT, is a social cost-benefit analysis, and the best option should be selected from a social perspective using a social discount rate. Alternatively, it is possible that "competitive neutrality" is being used as a short hand to suggest that the revenue stream from a transmission project should be calculated on a similar basis to what would be expected for a commercial project. However, this also does not make sense because the revenue streams are irrelevant for a social cost-benefit analysis. Revenue streams are a wealth transfer from consumers to producers, and wealth transfers always cancel out in a cost-benefit analysis.

The second reason advanced for using a commercial discount rate is that there is a perceived link between the discount rate used for the Regulatory Test and the weighted average cost of capital used in revenue determinations. For example, TransÉnergie states that:[54]

> *the discount rate used to evaluate the worth of proceeding with a regulated investment pursuant to the Regulatory Test should be closely linked to the determination of the WACC used to calculate the maximum return attributed to that asset in any subsequent revenue cap decision. That is, if a lower discount rate is used in the Regulatory Test, effectively signalling that there is less risk of the benefits being achieved, then the revenue cap determination should reflect a similarly lower WACC reflective of the lower risk that returns will be achieved.*

This link is reinforced by the ACCC, which states that the regulatory WACC is the lower bound for the WACC to be applied in the Regulatory Test.[55] A lower discount rate therefore implies that a lower regulatory WACC is appropriate.

Linking the regulatory WACC and the discount rate for the Regulatory Test is flawed, because the discount rate that is appropriate for discounting social benefits and costs has no relationship to either the discount rate or the systematic risk inherent in a particular revenue path associated with a particular asset. This point addressed earlier in Section 3.4.

53 TransÉnergie Australia (2002) "Re: Issues Paper Review of the Regulatory Test", letter to Mr Michael Rawstron, General Manager, Regulatory Affairs – Electricity, ACCC, 14 June, p. 5.

54 Ibid.

55 ACCC (2004), p. 48.

5.4. CANADA

There are three main markets in Canada for potential consideration: Alberta, British Columbia, and Ontario. Alberta and British Columbia are both in the process of assessing several transmission upgrade options, and a summary of the practice applied in both states is presented below.

5.4.1. British Columbia

British Columbia Transmission Company's (BCTC's) latest capital plan uses a real discount rate of 6% for a cost-benefit analysis of reliability investments.[56] The same discount rate was used in a January 2006 BCTC evaluation of transmission reinforcement on Vancouver Island.[57] This rate was accepted in the British Columbia Utility Commission's (BCUC's) July 2006 decision to approval the Vancouver Island Transmission Reinforcement project.[58]

In its 2004 Open Access Tariff Application, BCTC used a nominal discount rate of 8%, which was BCTC's weighted average cost of capital.[59] The 8% nominal equated to a 6% real discount rate.

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56 British Columbia Transmission Corporation, *Transmission System Capital Plan F2008 to F2017*, 21 December 2006. Note that the document does not explicitly specify whether the discount rate is nominal or real, but it is applied to damage costs that are in real dollars.

57 Wenyuan Li, *Expected Energy Not Served (EENS) Study for Vancouver Island Transmission Reinforcement Project*, Report-BCTC-R009D, British Columbia Transmission Corporation, 9 January 2006

58 British Columbia Utilities Commission, An Application For A Certificate Of Public Convenience And Necessity For The Vancouver Island Transmission Reinforcement Project, Decision, 7 July 2006. See p. 174 for the use of the 6% discount rate.

59 BCUC Information Request No. 3 1.0 Dated: 9 November 2004, British Columbia Transmission Corporation Response issued December 7 2004, pp. 84-85.

5.4.2. Alberta

The Alberta Electric System Operator (AESO) also uses a discount rate of 8%, and has applied this in a 2004 evaluation of an upgrade of the transmission lines between Edmonton and Calgary,[60] as well as in the more recent 2006 evaluation of transmission augmentation requirements in Northwest Alberta.[61] AESO claims that this rate is calculated as the mid-point of the "social and opportunity cost of capital range".[62] However, the 8% rate is also the same as ATCO Electric's before-tax weighted average cost of capital.[63]

5.5. United States

5.5.1. California

The California Energy Commission (CEC) conducts an annual assessment of energy policies in California, including electricity transmission planning, electricity demand management, natural gas use, petroleum demand, and greenhouse emissions. In its 2004 report, the CEC notes that the discount rate used by the California Independent System Operator (CA ISO) and the California Public Utilities Commission (CPUC) is based on the utility industry's cost of capital. The CEC instead

> *Recommends using a social discount rate, comparable to that used for its building and appliance standards, for evaluating the costs and benefits of transmission investments in a properly focused state transmission planning process.*[64]

Saha International includes a discussion of the California Standard Practice Manual for the economic analysis of electricity demand-side programmes and projects. Saha International notes that the manual is

> *silent on the discount rates to be used, stating only that an (unspecified) societal discount rate is to be used for the Societal test.*[65]

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60 AESO (2004) *Edmonton-Calgary 500kV Transmission Development Need Application*, Volume 1, RP-05-388, 6 May, p. F-5.

61 AESO (2006) *Northwest Alberta Transmission Development Need Application*, Volume 1, RP-05-535, 7 March, p. 169.

62 AESO (2005) Northwest (NW) Alberta Transmission Development Alternative Assessment Methodology, Draft for Discussion, 7 June, p. 3.

63 AESO (2005) Northwest (NW) Alberta Transmission Development Alternative Assessment Methodology, Draft for Discussion, 7 June, pp. 2-3.

64 California Energy Commission (2004) *Integrated Energy Policy Report 2004 Update*, October, p. 31.

65 Saha International (2004), p. 37.

A 2005 review for CEC of CAISO's economic evaluation methodology for the Palo Verde Devers Line uses a social discount rate of 5%.[66]

5.5.2. Federal Recommendations

The US EPA recommends that:

> *For economic analyses of intra-generational policies analysts should apply the consumption rate of interest approach. … Based on historical rates of return on relatively risk-free investments, adjusted for taxes and inflation, a consumption rate of interest measured at two to three percent is justified.*[67]

Sensitivity analyses are recommended using discount rates of zero and the OMB's recommended rate of 7%.[68]

The Department of Energy currently specifies a real discount rate of 3.0% for use in the Federal Energy Management Program's procedures for life cycle cost analysis. The life-cycle costing methods and procedures are required to be followed by all federal agencies for evaluating the cost effectiveness of potential energy and water conservation and renewable energy investments in federally owned and leased buildings.[69] For most other federal LCC analyses Circular A-94 from the Office of Management and Budget (OMB) provides the relevant guidelines.70

OMB Circular A-94 mandates a real discount rate of 7% for benefit-cost analyses of public investments and regulatory programs that provide benefits and costs to the general public.[71] However, the basis for this assessment is that "public investments and regulations displace both private investment and consumption".[72] If only consumption is displaced then the OMB-mandated rate may not be appropriate. For internal government activities the OMB mandates the use of "the real Treasury borrowing rate on marketable securities of comparable maturity to the period of analysis". The current real discount rate is 3.0% for all programs with a term of 20 years or longer.[73]

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66 Eto, J. (2005) *Review of CAISO's Economic Evaluation Methodology for the Palo Verde Devers Line No. 2 (PVD2)*, Energy Commission Workshop Presentation, 2005 Integrated Energy Policy Report, Consortium for Electric Reliability Technology Solutions and Electric Power Group, 19 May, p. 12.

67 US Environmental Protection Agency (2000), *Guidelines for Preparing Economic Analyses*, September, p. 48.

68 Ibid.

69 Rushing and Fuller (2006), p. iv.

70 Ibid.

71 OMB (1992) *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, OMB Circular A-94, 29 October, pp. 7-8.

72 Ibid.

5.6. SUMMARY

Government agencies around the world have moved to the use of a social discount rate approximating the SRTP for analysis of projects with public benefits. For example, HM Treasury mandates a CRI-based estimate of the SRTP of 3.5% in the United Kingdom. Ofgem uses this rate in the analysis of benefits from smart metering and the benefits for the change in the regulatory framework. The US DOE uses an estimate of the SRTP based on market interest rates, currently 3% real, for evaluating energy conservation and renewable energy investments in federally-owned buildings. The US EPA recommends a CRI of 2-3%. The California Energy Commission recommends the use of a social discount rate for transmission evaluation, and in an assessment of the Palo-Verde line augmentation uses a discount rate of 5%. The social discount rate adopted by France is 4% and by Germany is 3%.

The actual practice of evaluating transmission investments by regulatory agencies generally appears to be rooted in the belief that a commercial discount rate is appropriate. This is the practice in Alberta, Australia, British Columbia, and California. Central estimates applied in Australia include pre-tax real rates of 8%, 9%, and 11%. British Columbia has employed a real rate of 8%. The commercial discount rate is used in Australia because it is seen as providing for "competitive neutrality" between regulated transmission and commercial generation, even though such considerations are completely irrelevant to a social cost-benefit analysis. It is unclear exactly why a commercial discount rate is used in the other regulatory jurisdictions reviewed, although it seems likely that it is a mixture of the Australian "competitive neutrality" argument, and concern by the regulated utilities that the discount rate would be used to set the cost of capital used in calculating their allowable revenues. Further research is required to establish whether or not this speculation is correct.

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73 OMB (2007) "Appendix C: Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses", *OMB Circular No. A-94*, Revised January 2007

6. REFERENCES

ACCC (2004) *Review of the Regulatory Test for Network Augmentations*, Decision, File no: c2001/944, 11 August

AESO (2004) *Edmonton-Calgary 500kV Transmission Development Need Application*, Volume 1, RP-05-388, 6 May

AESO (2005) *Northwest (NW) Alberta Transmission Development Alternative Assessment Methodology*, Draft for Discussion, 7 June

AESO (2006) *Northwest Alberta Transmission Development Need Application*, Volume 1, RP-05-535, 7 March

Arrow, Kenneth J. (1995) "Intergenerational Equity and the Rate of Discount in Long-Term Social Investment", IEA World Congress, December

Boadway, R. (2006) "Principles of Cost-Benefit Analysis", *Public Policy Review*, Vol. 2 No. 1

Boardman, Anthony E., David H. Greenberg, Aidan R. Vining, and David L. Weimer (2001) *Cost-Benefit Analysis: Concepts and Practice*, Prentice Hall: New Jersey.

Boyle, G., Evans, L, Guthrie, G. (2006) "Estimating the WACC in a Regulatory Setting", New Zealand Institute for the Study of Competition and Regulation Inc, March

British Columbia Transmission Corporation (2004) "BCUC Information Request No. 3 1.0 Dated: 9 November 2004, British Columbia Transmission Corporation Response issued December 7 2004"

British Columbia Transmission Corporation (2006) *Transmission System Capital Plan F2008 to F2017*, 21 December

British Columbia Utilities Commission (2006) An Application For A Certificate Of Public Convenience And Necessity For The Vancouver Island Transmission Reinforcement Project, Decision, 7 July

California Energy Commission (2001) *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects*

California Energy Commission (2004) *Integrated Energy Policy Report 2004 Update*, October

Castalia (2006) *Discount Rate for the Grid Investment Test*, Report to Transpower, August

Clarkson, Richard and Kathryn Deyes (2002) *Estimating the Social Cost of Carbon Emissions*, Environmental Protection Economics Division, Department of Environment, Food and Rural Affairs, HM Treasury: London

Electricity Commission (2004) *Explanatory Paper: Grid Investment Test*, 3 December

Electricity Commission (2006) *Economic assessment of Transpower's Auckland 400kV grid investment proposal*, Prepared by the Modelling Group Electricity Commission, 5 May

Electricity Commission (2007) *Economic Analysis of the Revised North Island Grid Upgrade Project*, 23 February

Eto, J. (2005) *Review of CAISO's Economic Evaluation Methodology for the Palo Verde Devers Line No. 2 (PVD2)*, Energy Commission Workshop Presentation, 2005 Integrated Energy Policy Report, Consortium for Electric Reliability Technology Solutions and Electric Power Group, 19 May

Evans, D.J. (2006) "Social Discount Rates for the European Union", Working Paper n. 2006-20, Università degli Studi di Milano, October

Guthrie, G. (2006) "Comments on Castalia's 'Discount Rate for the Grid Investment Test", 23 November

HM Treasury (2003) *The Green Book: Appraisal and Evaluation in Central Government*, Treasury Guidance: London

Lally, M. (2005) "The Weighted Average Cost of Capital for Electricity Lines Businesses", *mimeo*, September

Jagganathan, R. and Z. Whang (1993) "The CAPM is Alive and Well", The Fourth Annual Conference on Financial Economics and Accounting, Washington University, St. Louis, November 22

Newell, R. and W. Pizer (2001) "Discounting the Distant Future: How Much Do Uncertain Rates Increase Valuations", Discussion Paper 00-45, Resources for the Future, 14 May

Ofgem (2004) *Transmission Price Controls and BETTA: Final proposals and Impact Assessment*, 279/04, December

Ofgem (2006a) *Domestic Metering Innovation*, Consultation, 1 February

Ofgem (2006b) *Transmission Price Control Review: Initial Proposals*, Appendix 16, Ref 104c/06, and Appendix 17, Ref 104d/06, 26 June

OMB (2007) "Appendix C: Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses", *OMB Circular No. A-94*, Revised January 2007

Pearce, David and David Ulph (1995) "A Social Discount Rate for the United Kingdom", CSERGE Working Paper GEC 95-01, Centre for Social and Economic Research on the Global Environment, University College London and University of East Anglia

Quiggin, J. (2005) "Risk and discounting in project evaluation", in Harvey, M., *Risk in cost-benefit analysis*, Report 110, Department of Transport and Regional Services, Australian Government, pp. 67-116

Rushing, A.S. and S.K. Fuller (2006) *Energy Price and Discount Factors for Life-Cycle Cost Analysis – April 2006*, Annual Supplement to NIST Handbook 135 and NBS Special Publication 709, NISTIR 85-3273-21 (Rev. 4/06), Prepared for United States Department of Energy Federal Energy Management Program, National Institute of Standards and Technology, U.S. Department of Commerce, April

Saha International (2004) *Discount Rate for Application in Grid Investment Test*, Final Report, 30 November

Statistics New Zealand (2004) *New Zealand Life Tables 2000-2002*, Catalogue Number 10.005: Wellington

Statistics New Zealand (2006) *Gross Domestic Product, September 2006 Quarter*, 21 December

Statistics New Zealand (2006) *National Population Estimates, December 2005 Quarter*, 7 February

Statistics New Zealand (2007) *National Population Estimates, December 2006 Quarter*, 9 February

TransÉnergie Australia (2002) "Re: Issues Paper Review of the Regulatory Test", letter to Mr Michael Rawstron, General Manager, Regulatory Affairs – Electricity, ACCC, 14 June

US Environmental Protection Agency (2000), *Guidelines for Preparing Economic Analyses*, September

Wenyuan Li (2006) Expected Energy Not Served (EENS) Study for Vancouver Island Transmission Reinforcement Project, Report-BCTC-R009D, British Columbia Transmission Corporation, 9 January

APPENDIX A: CALCULATION OF RISK-ADJUSTED SOCIAL DISCOUNT RATES

Table 5: Calculation of the Risk-Adjusted Market Interest Rate

Parameters			Risk-Adjusted Market Interest Rate		Present Value of $1 received in indicated number of years				
Nominal Interest Rate	MRP	beta	Nominal	Real	10	20	30	40	50
3.98%	6.00%	0.06	4.34%	1.67%	0.8473	0.7179	0.6083	0.5154	0.4367
3.98%	6.00%	0.18	5.06%	2.37%	0.7910	0.6257	0.4949	0.3915	0.3097
3.98%	6.00%	0.30	5.78%	3.07%	0.7388	0.5458	0.4032	0.2979	0.2201
3.98%	6.00%	0.42	6.50%	3.78%	0.6903	0.4766	0.3290	0.2271	0.1568
3.98%	6.00%	0.54	7.22%	4.48%	0.6453	0.4165	0.2688	0.1735	0.1119
3.98%	7.70%	0.06	4.45%	1.77%	0.8391	0.7040	0.5907	0.4957	0.4159
3.98%	7.70%	0.18	5.37%	2.67%	0.7683	0.5903	0.4536	0.3485	0.2677
3.98%	7.70%	0.30	6.29%	3.57%	0.7041	0.4957	0.3490	0.2458	0.1730
3.98%	7.70%	0.42	7.22%	4.47%	0.6457	0.4169	0.2692	0.1738	0.1122
3.98%	7.70%	0.54	8.14%	5.37%	0.5926	0.3512	0.2081	0.1233	0.0731
3.98%	8.90%	0.06	4.52%	1.84%	0.8333	0.6944	0.5786	0.4822	0.4018
3.98%	8.90%	0.18	5.59%	2.88%	0.7527	0.5666	0.4265	0.3211	0.2417
3.98%	8.90%	0.30	6.65%	3.92%	0.6807	0.4633	0.3154	0.2147	0.1461
3.98%	8.90%	0.42	7.72%	4.96%	0.6161	0.3796	0.2339	0.1441	0.0888
3.98%	8.90%	0.54	8.79%	6.00%	0.5582	0.3116	0.1740	0.0971	0.0542
		Weighted Average			0.7127	0.5157	0.3787	0.2819	0.2126
		Expected Discount Rate			3.45%	3.37%	3.29%	3.22%	3.15%

Table 6: Calculation of the Risk-Adjusted CRI

CRI		Risk-Adjusted CRI			Present Value of $1 received in indicated number of years				
Real	**Nominal**	**beta**	**Nominal**	**Real**	**10**	**20**	**30**	**40**	**50**
2.98%	5.69%	0.06	5.69%	2.99%	0.7451	0.5552	0.4137	0.3082	0.2297
2.98%	5.69%	0.18	5.71%	3.00%	0.7443	0.5539	0.4123	0.3069	0.2284
2.98%	5.69%	0.30	5.72%	3.01%	0.7434	0.5527	0.4109	0.3055	0.2271
2.98%	5.69%	0.42	5.73%	3.02%	0.7426	0.5514	0.4095	0.3041	0.2258
2.98%	5.69%	0.54	5.74%	3.03%	0.7417	0.5502	0.4081	0.3027	0.2245
3.18%	5.89%	0.06	5.90%	3.19%	0.7308	0.5341	0.3903	0.2852	0.2084
3.18%	5.89%	0.18	5.91%	3.20%	0.7300	0.5329	0.3890	0.2839	0.2073
3.18%	5.89%	0.30	5.92%	3.21%	0.7291	0.5317	0.3877	0.2827	0.2061
3.18%	5.89%	0.42	5.94%	3.22%	0.7283	0.5305	0.3863	0.2814	0.2049
3.18%	5.89%	0.54	5.95%	3.23%	0.7275	0.5293	0.3850	0.2801	0.2038
4.00%	6.73%	0.06	6.74%	4.00%	0.6755	0.4563	0.3082	0.2082	0.1407
4.00%	6.73%	0.18	6.75%	4.01%	0.6748	0.4553	0.3072	0.2073	0.1399
4.00%	6.73%	0.30	6.76%	4.02%	0.6740	0.4543	0.3062	0.2064	0.1391
4.00%	6.73%	0.42	6.77%	4.04%	0.6732	0.4532	0.3051	0.2054	0.1383
4.00%	6.73%	0.54	6.78%	4.05%	0.6725	0.4522	0.3041	0.2045	0.1375
4.20%	6.94%	0.06	6.94%	4.20%	0.6627	0.4391	0.2910	0.1928	0.1278
4.20%	6.94%	0.18	6.95%	4.21%	0.6619	0.4381	0.2900	0.1920	0.1271
4.20%	6.94%	0.30	6.97%	4.22%	0.6612	0.4371	0.2890	0.1911	0.1263
4.20%	6.94%	0.42	6.98%	4.24%	0.6604	0.4362	0.2881	0.1902	0.1256
4.20%	6.94%	0.54	6.99%	4.25%	0.6597	0.4352	0.2871	0.1894	0.1249
		Average			0.7019	0.4939	0.3484	0.2464	0.1747
		Expected Discount Rate			3.60%	3.59%	3.58%	3.56%	3.55%