Input methodologies

Review of the
'75th percentile' approach

Prepared for
New Zealand Commerce Commission

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Contents

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Executive summary

The New Zealand Commerce Commission (the Commission) asked Oxera to provide evidence to support its response to the High Court's challenge in respect of the choice of the 'weighted average cost of capital (WACC) percentile' to be applied within the WACC for electricity transmission and distribution.

Within the Input Methodologies (IMs) applied for electricity transmission and distribution, the Commission uses a WACC approach to set allowed returns for investment in the networks. This provides incentives to invest, as investors can expect to earn sufficient returns to cover their cost of capital.

In addition, given the uncertainty over the definition of the cost of capital, the Commission chose to assume a WACC based on the '75th percentile' of the distribution of potential values supported by its technical analysis.[1] This percentile was chosen based on the Commission's judgement that setting the WACC too low would carry more risks than setting it too high.

Following a challenge of the 75th percentile from the Major Energy Users' Group, the High Court asked for evidence to support the Commission's approach, and why it would be better than the 50th percentile. While the Commission based its choice of a higher percentile on expert opinion, the choice of the 75th percentile was based largely on judgement. The Court highlighted alternative approaches that could be applied, and requested that the Commission obtain evidence to support any revised decision.

Oxera's approach

The Commission asked Oxera to propose an approach to determining a WACC percentile for electricity businesses, applying relevant evidence and without taking either the 75th or the 50th percentile as a focal point, but assuming otherwise that the current regulatory framework continues to apply. Based on the Commission's request, Oxera took the following steps.

- **Step 1: design an analytical framework**. Drawing on precedent and submissions to the Commission, we identify relevant options for the Commission, and propose an analytical framework that is capable of being applied in practice in assessing those options.
- **Step 2: identify the relevant data sources**. Drawing on evidence from both New Zealand and international comparisons, we propose a framework for estimating relevant parameters, including the impact of underinvestment, which can be used to populate the analytical framework.
- **Step 3: provide recommendations on the WACC percentile**. This evidence should support the Commission in reaching a decision on the choice of the WACC percentile.

This approach appears to be consistent with the intention of the Commission in setting a percentile. In considering the evidence, it is important to reflect that there is a fundamental uncertainty over some of the relevant measures, and therefore it will not be practicable to seek to establish a single point value for the percentile. As with the WACC itself, the optimal percentile is subject to uncertainty.

[1] The '75th percentile' relates to the level of WACC assumed in the price control, based on a distribution assessed by the Commission. The choice of the 75th percentile means that the Commission considers that there is a 75% probability that the assumed cost of capital is at least as high as the actual cost of capital.

However, this does not mean that evidence will not improve the Commission's understanding of the right decision. Our approach is intended to provide the Commission with sufficient evidence to understand the implications of a particular percentile, and therefore to choose a percentile that correctly balances its objectives within the regulatory framework.

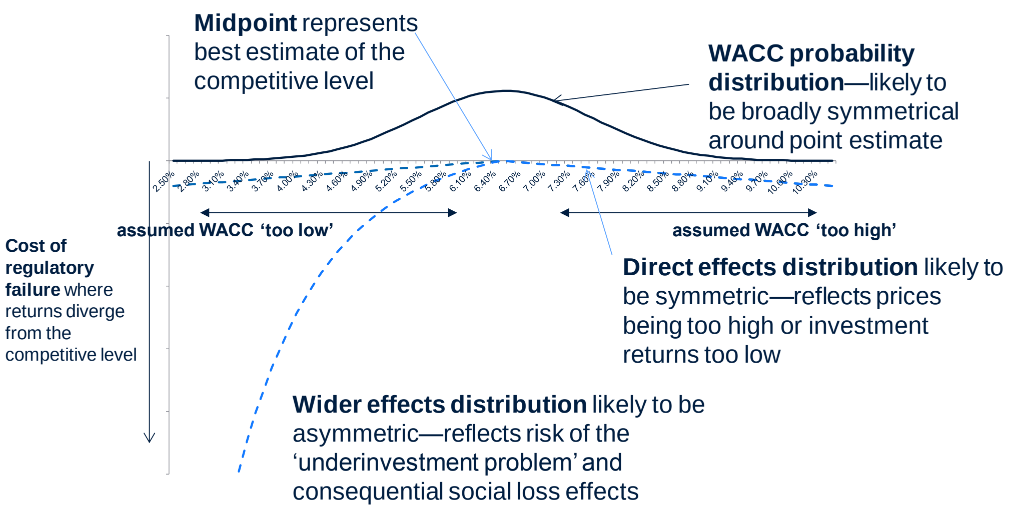
Step 1: A practical approach to developing an analytical framework

The choice of a particular value for the WACC requires a balance between competing and potentially complex objectives for the regulatory framework. In general, regulatory precedent has followed the Commission's approach of applying judgement in coming to a view on the appropriate level of the WACC.

While the calculation of a particular value may be complex, the aims of regulators in choosing the level of the WACC are well understood. The Commission was concerned about the risks associated with the WACC being set too low. These risks are around the incentives to invest, and are consistent with the requirements of Part 4 of the Commerce Act to promote investment and innovation. In the absence of a sufficiently high WACC, investment may fall, resulting in an 'underinvestment problem'. This problem is a form of regulatory failure with potentially significant adverse effects if it leads to the reliability and resilience of the network falling over time.

Taking into account these aims of the regulator, alongside the practical limitations in terms of data availability, this report proposes a framework for identifying the appropriate level of the WACC percentile (see the figure below). As with the WACC itself, the framework cannot provide certainty around the correct percentile, but can provide greater evidence to support the Commission in its decision-making. In assessing the effects of decisions on the WACC and on incentives more generally, the report draws from a combination of the social loss function identified in Dobbs (2011),[2] and wider regulatory considerations identified by the Commission and others.

Illustration of Oxera's framework for the percentile



Source: Oxera.

[2] Dobbs, I.M. (2011), 'Modelling welfare loss asymmetries arising from uncertainty in the regulatory cost of finance', *Journal of Regulatory Economics*, **39**, pp. 1–28.

The figure illustrates Oxera's conclusions on the regulatory application of the social loss function concept. A downside risk is likely to result from a shortfall between the actual and assumed WACC. This is likely to be skewed and to increase sharply as the gap between actual and assumed WACC grows, since this will quickly increase the incentive for the companies to underinvest. In electricity, this risk is derived from the consequential effect that, over time, underinvestment will lead to failures on the network, with potentially significant social and economic costs. In setting the cost of capital, the Commission will need to consider the risks associated with a WACC that is too high or too low, and to determine the point at which these are balanced.

Our framework illustrates that this is only likely to be the 50th percentile either where the consequences of underinvestment are low, or where the link to the WACC is low. For example, this would be the case where underinvestment can be readily remedied in future periods, or because the primary driver of investment is not the WACC but other measures, such as quality requirements. Where there is a significant probability of an adversely skewed outcome such as that illustrated above, the appropriate percentile is more likely to be one that 'aims up' and moderates the risk of such an outcome.

Identifying relevant data sources

As part of the analysis above, sources of the effects in the above figure were identified and the following estimated.

- **Direct financial effects (wealth transfers)**. If the return is different to the WACC, there is a transfer of value between energy users (and potentially intermediaries) and investors in the network operator. We estimated this value based on the regulatory asset base (RAB) for the relevant business, adjusted for WACC differentials calculated by applying the Commission's methodology for the percentile.

- **Indirect financial effects**. The consequences of direct financial effects may also be felt through changes in supply and demand conditions within wider markets, and within incentives to invest. This could include distorting incentives to invest, changing demand for energy, and, potentially, adjusting competitive conditions between users and non-users (e.g. international competitors for New Zealand production). Having estimated a range of the potential indirect effects, we found that, relative to the direct financial effects, these indirect effects were not significant. Therefore these effects would not be expected to affect the Commission's decision.

- **Wider social and economic benefits (and therefore the risk of loss of these benefits)**. The continuation of service provision in regulated industries has an economic value. For energy, this value is likely to be significant. Interruptions would disrupt quality of life for residential users, and would affect the economics of New Zealand businesses. This concept is similar to the concept of the value of lost load (VOLL), which is reviewed by the Electricity Authority, but will be affected by the actual expectation of lost load that might arise in the case of network outages. For example, evidence from actual events and analysis of potential events in other countries suggests that a severe outage event resulting from underinvestment could have an annualised economic cost equivalent to over NZ$1bn.

- **The 'probability of loss' for different levels of the WACC**. The higher the estimate of the WACC and the higher the choice of percentile, the lower is the probability of loss, measured as actual expected loss, or the probability that the actual WACC rises above the assumed WACC such that the incentive to invest is reduced or removed. This can be estimated directly from the approach taken by the Commission to determining the standard error around the range.

These effects will be taken into account, together with a review of the regulatory framework, in coming to recommendations for the Commission.

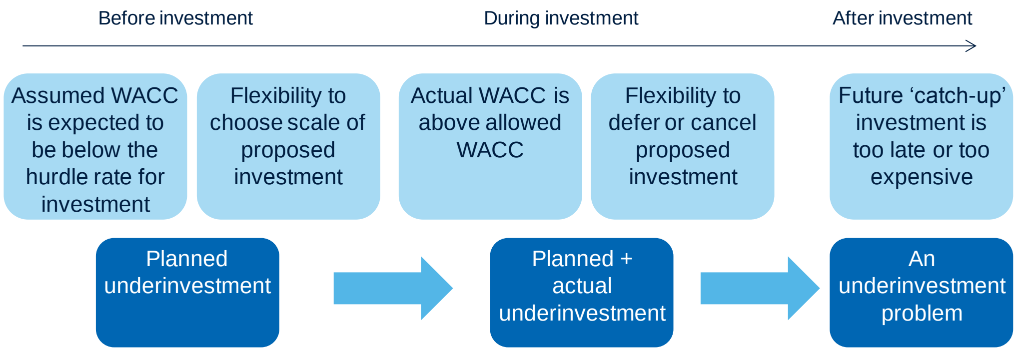
Recommendations on the WACC percentile

This step draws together our analysis, and uses various sources of evidence in making recommendations to the Commission. An assessment of the appropriate WACC percentile should reflect the following questions.

- What is the underinvestment problem?
- Given the regulatory framework, what is the most likely period over which an underinvestment problem would be likely to occur?
- What is the potential scale of risk relating to underinvestment?
- What does this imply for what customers should be willing to pay to offset this risk?
- How does this translate into the choice of WACC percentile?

The underinvestment problem implies that there is both underinvestment, and that it becomes a problem. The figure below illustrates how this is likely to arise in electricity in particular. Within periods, there will be flexibility to defer, or in some cases cancel, investment, and this is linked to the price control structure. However, an underinvestment problem will arise where the WACC is set low and consistently so, such that the business both plans to minimise investment (for example, relative to operating costs) and actually delivers such low investment, or even less.

What is the underinvestment problem?



Source: Oxera.

The recommendations of this report therefore balance the factors that will influence the existence of such an underinvestment problem. We consider both the analytical evidence and the regulatory implications of the percentile choice. Our approach is based on comparison of the following evidence.

- **What is the 'probability of loss'?** We assume a link between the shortfall between actual and assumed WACC and the underinvestment problem. This is consistent with the flexibility for investors to manage the level of investment over time to reflect expectations on current and future returns. We propose that a proxy for this measure should be the risk associated with a 0.5–1.0% differential between the actual and assumed WACC, which would be likely to trigger a move away from capital investment in the networks. At the 50th percentile there is a 20–30% probability of such a shortfall; at the 80th percentile this falls below 10%.

- **What is the potential impact of the underinvestment problem?** We propose that the most practicable approach is to consider the scale of the future potential impact of underinvestment, on a gross basis. This then reflects the adverse event against which customers (and investors) are 'insuring themselves' through increasing the level of capital invested in the network. There is no certainty that such an event will occur, even at the 50th percentile, but the likelihood of underinvestment will increase. In coming to a view on the percentile, it is important that the Commission understands the relative scale of the economic cost of such an event. While there is a wide range of events that could occur, our analysis suggests that a major event could result in an economic cost of the order of an annualised equivalent of at least NZ$1 billion. This represents a reference point for understanding the potential scale of the benefit of mitigating the underinvestment problem.

- **What is the cost of 'insuring' against the underinvestment problem through a higher WACC?** If the WACC is set above the 50th percentile, customers will pay higher prices—arguably, higher than those that would be observed in competitive markets. The cost can be determined directly by estimating the scale of the differential between the actual WACC and the assumed WACC percentile. This additional cost may be appropriate, to the extent that the Commission determines that a low WACC may result in worse overall outcomes for customers. However, this analysis allows the Commission to understand the size of the cost paid by consumers, relative to the potential impact of an adverse effect, which will be more probable, but not certain, should there be a reduced incentive to invest.

The table below demonstrates the extent to which customer charges increase with greater protection against the WACC being insufficient to cover the actual cost of capital. The probability of loss (0.5–1.0%) reflects the proportion of the time during which the actual WACC will be as much as 0.5–1% above the assumed WACC, which we assume to be relevant focal points for understanding the risks of underinvestment. Both the probability of loss and the increase in charges will be linked to the size of the standard error assumed by the Commission. In the case of the increase in charges, the charges will rise in proportion to the size of the standard error.

Choice of percentile (calculated using the Commission's methodology)	Probability of loss (0.5–1%)	Increase in charges, relative to 50th percentile (NZ$m)
50th	18–32%	0
60th	12–24%	40
70th	7–16%	83
80th	4–10%	133
90th	1–4%	203

These figures are then considered together with the size of a potential event (NZ$1 billion or higher) and the potential driver of an event (continued underinvestment over multiple periods). Based on the analytical framework, and assuming a continuation of the current IMs, we therefore propose the following.

- **The 50th percentile is likely to be too low**. At the 50th percentile, the incentives to invest will be relatively low as new investment adds no value to the business. The potential costs of underinvestment are material. Evidence from actual events and analysis of potential events in other countries suggests that a severe outage event resulting from underinvestment could result in a cost with an annualised economic value equivalent to over NZ$1bn. Some premium for customers to reduce these costs appears reasonable and proportionate.

- **The 90th percentile is likely to be too high**. Even at the 80th percentile, the cost of protection appears relatively high compared with the level of benefits, given the wider measures put in place by the Commission.

- **The proposed form of economic impact analysis has limitations, but some of these relate to points of fundamental uncertainty, rather than points that can be readily addressed with further analysis**. It will be difficult to identify a probability that a particular value for the assumed WACC directly results in underinvestment. However, it is instinctively consistent with the workings of financial markets and the competition for capital that a shortfall of 0.5–1% (or more) is likely to increase the risk of triggering a rebalancing of medium-term investment plans, and a move by investors towards deferring investment as far as possible.

- **Any premium should be applied to all RAB assets and applied consistently**, as the expected whole-life return on assets should be the relevant test for investors. This also strongly points to the New Zealand approach of providing certainty over the need for a premium, rather than a case-by-case basis, as applied more generally by other regulators.

Given the specific circumstances of electricity transmission and distribution, some recognition of the need for investment is likely to be appropriate in setting the WACC. Based on the Commission's approach, and considering the specific need for investment in electricity distribution and transmission, a point estimate around the 60th to 70th percentile appears to provide a suitable balance between the costs and benefits of the approach of setting a higher percentile in mitigating the risks associated with the underinvestment problem. As such, it should achieve the intended benefits of the WACC percentile approach.

An 80th percentile approach would be more conservative, and would imply that customers are paying as much for protection within a seven-year IM period as our analysis indicates could be the potential annualised cost of a severe period of outages. Given that the Commission has other regulatory measures in place to offset the risk of underinvestment, and is strengthening those measures, this appears to be a potentially excessive level of protection.

We would expect the exact choice of a percentile by the Commission to reflect these considerations, and its view on the desirability of taking into account other factors that are not explicitly reflected in the current approach to defining the percentile, but which might nevertheless point to a cautious approach in setting the percentile either high or low. These could include, as an example, the risks not currently reflected within the percentile, such as the risk of model error or the incremental risks within regulatory periods around parameters such as the risk-free rate.

1 Introduction

The New Zealand Commerce Commission (the Commission) has asked Oxera to advise on one specific aspect of its approach to setting the cost of capital for electricity distribution and transmission, which is the choice of percentile to be applied when estimating the weighted average cost of capital (WACC). This report provides additional evidence to the Commission to support it in reaching a conclusion on the appropriate percentile to be applied in future.

1.1 Background—how was the current approach derived?

The approach taken by the Commission is documented within its Input Methodologies (IMs), which were published in December 2010 in accordance with the Commerce Act.[3]

As part of these IMs, the Commission sets out a detailed approach to the development of an assumption for the WACC. The WACC is then recalculated each year as part of the process of setting allowed charges for the companies regulated by the Commission. At present this is done for a number of energy distribution and pipelines businesses, and is expected to be extended to telecoms networks (i.e. Chorus) later in 2014.

Estimating a WACC is difficult, and cannot be done precisely. As part of the development of the IMs, the Commission considered whether it was appropriate to choose the midpoint of its range of estimates. It engaged independent experts, including Stewart Myers, Professor Julian Franks and Martin Lally, whose paper included the recommendation that the WACC be set above the midpoint, although the authors did not recommend a particular value.[4]

The experts also raised issues relating to the optimal way in which the WACC can be set for the different industries regulated by the Commission, with Professor Franks arguing for a case-by-case basis, reflecting the different economic conditions within each sector.

Drawing on this advice, the Commission chose to apply the 75th percentile within the IMs, which are relevant for energy and airports, and decided that this percentile should be calculated using a prescribed approach.

The Commission estimates the standard error of certain assumptions within the WACC calculation, assuming that these may all vary and are not correlated. It then calculates the 75th percentile—i.e. the WACC that has a 75% probability of being above the actual WACC, and a 25% probability of being below the actual WACC. Some variables, such as the risk-free rate, are assumed to be known with certainty, on the basis that they can be observed at the time of determining prices.

This approach is then used when setting default, customised or individual price–quality paths in determining charges for electricity and gas transmission and distribution networks.

[3] Commerce Commission (2010), 'Input Methodologies (Electricity Distribution and Gas Pipeline Services), Reasons Paper', December, paragraphs H11.1–H11.67 and H13.44.
[4] Franks, J., Lally, M. and Myers, S. (2008), 'Recommendations to the New Zealand Commerce Commission on an Appropriate Cost of Capital Methodology ', 18 December, paragraphs 155–57.

1.2 Challenge from the Major Energy Users' Group

In 2013, the Major Energy Users' Group (MEUG) challenged the Commission's approach before the High Court, arguing that the 75th percentile was inappropriate and that the 50th percentile would be more appropriate.[5] The High Court did not allow the MEUG's challenge, but did raise concerns about the evidence offered by the Commission and asked the regulator to reconsider and provide evidence to support its decision. Specifically, the High Court stated:

> At that time, we would expect that our scepticism about using a WACC substantially higher than the mid-point, as expressed above, will be considered by the Commission. We would expect that consideration to include analysis – if practicable, of the type proposed by MEUG.

As a result, the Commission has consulted again on the evidence to support the 75th percentile.[6]

It is important to note that the choice of percentile should properly be considered alongside all elements of the WACC assessment and price-setting process, in order to develop a coherent framework. There are some aspects specific to the choice of percentile that can be properly addressed on a stand-alone basis; others should perhaps be considered alongside a wider review of the IMs.

However, following the High Court's recommendation, this report from Oxera considers the evidence to support a choice of percentile within the current framework, including information from the Commission as to any changes it is considering to that framework.

Since its consultation, the Commission has received extensive submissions from a wide range of stakeholders, and their advisers. Having reviewed these submissions, we have taken them into account in coming to our assessment, where appropriate within the scope of our review.

1.3 Scope of Oxera's review

The Commission asked Oxera to consider the evidence to support a choice of percentile and, in particular, whether, under the current regulatory framework, there is sufficient evidence to demonstrate the level of the percentile for the WACC that optimally balances the relevant costs and benefits.

In particular, this review considers further details on the key parameters that would influence an impact assessment of the range of options to choose from in relation to the WACC. Below we examine what we consider to be the salient question in this regard.

What choice of percentile (from a range) best balances the economic costs of setting the WACC too high with those of setting it too low?

Based on the High Court judgment[7] and the Commission's duties, we consider that to address this question would require an assessment of the impact on customers who might be paying higher charges as a result of the allowed WACC being set at too high a level. We also consider that the High Court judgment and

[5] The MEUG questioned whether the point estimate should be set at the 50th percentile, or whether the 75th percentile should be applied to new investment only. Judgment of the High Court of New Zealand [2013] in the matter of under s 52Z of input methodology determinations of the Commerce Commission', paragraph 1423.
[6] Commerce Commission (2014), 'Invitation to have your say on whether the Commerce Commission should review or amend the cost of capital input methodologies', 20 February.
[7] Judgment of the High Court of New Zealand (2013) in the matter of under s 52Z of input methodology determinations of the Commerce Commission', paragraph 1486.

the regulator’s duties imply the need to consider other effects, such as the distortion of investment incentives throughout the supply chain.

As highlighted by the majority of respondents to the Commission’s second consultation round, the most material other effect is likely to be the risk of the ‘underinvestment problem’. This is why regulators, where they explicitly provide a reason, tend to set the WACC above the midpoint. According to Franks, Myers and Lally (2008):

> As a general principle, the Commission considers that the costs of setting allowed returns too low outweigh the costs of setting them too high.[8]

This principle is not unique to the New Zealand Commission. Given the nature of the regulatory contract, regulated companies have some flexibility over the level of investment both that they plan for the network, and that is actually made. The higher the expected return on investment in the network, the stronger the incentive to invest. By contrast, if the expected return on investment falls below the required level of return on investment, investors will effectively be destroying value with all new investment on a stand-alone basis. This will inevitably lead to a desire, within the constraints of the regulatory framework, to minimise investment to the level necessary to meet quality standards,

In the electricity industry there is a concern that, over time, this underinvestment problem could lead to a degradation of service, including interruptions and losses across the networks into the future.

1.4 Areas outside the scope of the current review

There are many areas that are important to the choice of the WACC but that are outside of the scope of this review:

- **the approach to defining the WACC under the IMs**. We have assumed that the Commission correctly estimates the parameters that it includes in its estimate of the 75th percentile;
- **the treatment of asymmetric risk**. Consistent with the IMs, we assume that asymmetric risk is **not** reflected in the choice of the WACC percentile;
- **the accuracy of the capital asset pricing model (CAPM) approach**. We do not revisit whether the CAPM, as applied by the Commission, is accurate in determining a best estimate of the WACC;
- **the design of the regulatory framework**. The choice of regulatory framework will affect the choice of percentile. In responding to the High Court judgment, while the Commission is considering the theoretical framework under which the percentile should be calculated, it is in particular assessing how the percentile should be calculated in the current regulatory framework.

In practice, as discussed below, the optimal choice of percentile will be likely to depend on a wide range of factors that influence incentives to invest, including identifying an optimal balance of wider regulation and the allowed return on investment. However, within this report we focus on the specific question raised by the High Court as to what evidence there is to support the choice of the 75th percentile.

[8] Franks, J., Lally, M. and Myers, S. (2008), ‘Recommendations to the New Zealand Commerce Commission on an Appropriate Cost of Capital Methodology ‘, 18 December, paragraph 155.

2 Outline of the analytical framework

In assessing the options for the WACC percentile, and in coming to practical recommendations, it is necessary to develop a framework for consideration of the options. In this section we briefly review the approaches proposed in other submissions, and summarise our proposed framework.

2.1 Proposed framework—previous experience

Prior to the current review, there have been some submissions that have specifically considered the choice of percentile, including:

- Van Zijl (2007), who proposed a framework for calculating the optimal point for setting the WACC, based on a distribution for the WACC and a separate distribution for the economic impact of the WACC being set too high or too low;[9]
- Dobbs (2011), who provided an analytical framework, argued that the primary justification related to new investment, and therefore concluded that a potentially higher percentile could be justified for that investment.[10]

In addition, the Myers, Franks, Lally (2008) review considered the relevant evidence, but did not go further in making any recommendations beyond the need to consider a figure above the 50th percentile.

The Commission has now received a wide range of submissions in response to its consultation. The detailed submissions, which are largely from companies, fall into one of two categories:

- **analytical submissions**, which provide a framework for assessing the percentile;
- **regulatory submissions**, which provide recommendations on the regulatory considerations in assessing the percentile (including those beyond the scope of Oxera's current review), but do not provide direct evidence for a particular recommended percentile.

Within this report, we have largely focused on the analytical approaches. Section 3 below describes the options in the context of regulatory precedent, but the primary scope of our analysis has been to focus on the options for the analytical framework, to support the Commission in coming to a view on a percentile within the current regulatory framework.

2.2 Analytical approaches

A number of analytical approaches have been proposed, which inform a suitable analytical framework for assessment of the correct percentile. For example, submissions were provided by Sapere (including van Zijl) for Vector and NZIER (for MEUG).[11] These build on the Dobbs (2011) model.

However, none of these submissions addresses how to identify all the sources of evidence required to determine the appropriate percentile in practice. The High Court judgment also addressed this issue. As part of the gathering of evidence,

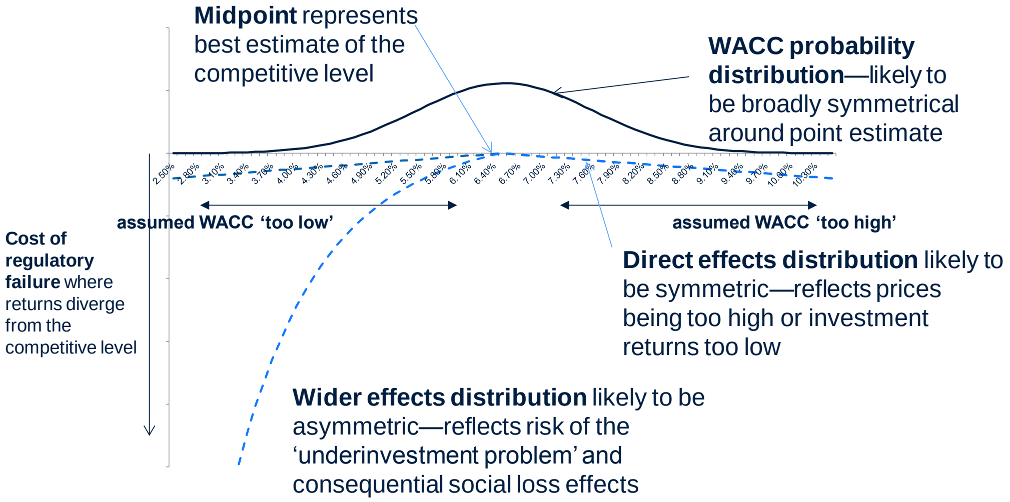
[9] van Zijl, T. (2007), 'Response on behalf of Vector Limited to the Commerce Commission's Estimate of WACC in the Draft Authorisation for the Control of Supply of Natural Gas Distribution Services by Powerco Limited and Vector Limited', November.
[10] Dobbs, I.M. (2011), 'Modelling welfare loss asymmetries arising from uncertainty in the regulatory cost of finance', *Journal of Regulatory Economics*, **39**, pp.1–28.
[11] Sapere (2014), 'Setting the WACC percentile for Vector's price-quality path', May.

van Zijl's model was considered, which identifies the effect of the 75th percentile if the loss function is linear. However, the Court noted that there is no evidence that the loss function is linear, nor is there any evidence to show whether, even if this were the case, a 75th percentile would be the best way to apply the Commission's duties.[12]

Building on these concepts, the ASEC response for Unison seeks to quantify elements of the framework, while recognising the difficulties in measuring the links between the elements.[13]

Nevertheless, these approaches are informative in understanding the question posed by regulators, including the Commission, in considering the level of the cost of capital to be assumed within the regulatory framework. This can be illustrated in Figure 2.1.

Figure 2.1 Potential asymmetric risks of regulatory failure



Source : Oxera.

The 'wider effects distribution' is comparable to that described in much of the literature as a 'social loss function', although in practice some of the effects will also accrue to business users. The adverse effects can be characterised as the costs of regulatory failure from setting the cost of capital too high or too low, given the uncertainty around the actual level that should be applied.

The ultimate aim of this social loss analysis will be to identify the choice of the cost of capital that minimises the expected costs from the effects identified in Figure 2.1, considering both direct and indirect effects. Some of the papers, including Dobbs (2011), provide examples of an optimal percentile within this framework. However, while these papers come up with indicative percentiles, they all rely on a range of untested assumptions, the most important being the form and quantification of the social loss function.

Within this report, therefore, we have sought to consider the primary sources of evidence as to what the size and shape of the social loss function will reflect in practice. We have considered the following.

[12] Judgment of the High Court of New Zealand [2013] in the matter of under s 52Z of input methodology determinations of the Commerce Commission', paragraph 1465.
[13] ASEC (2014), 'Selection of the WACC Percentile in the Context of Risks faced by Electricity Distribution', May.

- **Direct financial effects (wealth transfers)**. If the return is different to the WACC, there is a transfer of value between energy users (and potentially intermediaries) and investors in the network operator.

- **Indirect financial effects**. The consequences of direct financial effects may also be felt through changes in the conditions in wider markets, and within incentives to invest. This could include distorting incentives to invest, changing demand for energy, and, potentially, adjusting competitive conditions between users and non-users (e.g. international competitors for New Zealand production).

- **Wider social and economic benefits (and therefore the risk of loss of these benefits)**. We have focused on the level of assurance that has been given over future investment. The continuation of service provision in regulated industries has an economic value. In the case of energy, this value is likely to be significant. Interruptions would disrupt individuals' lives, and therefore have an impact on their quality of life, and would affect the economics of New Zealand businesses. This concept is similar to the concept of the value of lost load (VOLL) which is reviewed by the Electricity Authority. We discuss this further in section 5.

- **The 'probability of loss' for different levels of the WACC**. The higher the estimate of the WACC and the higher the choice of percentile, the lower is the probability of loss, measured as actual expected loss or the probability that the actual WACC rises above the assumed WACC, such that the incentive to invest is reduced or removed.

We also consider other related issues, such as the drivers of underinvestment, and the link between the WACC and underinvestment. As discussed in the other evidence submitted to the Commission, there may be limited evidence to support a direct quantification of the 'probability' of underinvestment. Nevertheless, this does not mean that the Commission should refrain from undertaking any analysis. The 'probability of loss' will directly influence investors' expectations, and represents a useful reference point for the Commission in understanding the risks associated with the choice of percentile.

We do not consider other economic effects, which appear to be beyond the scope of consideration by the Commission. For example, if electricity prices are higher due to a choice of a higher percentile then costs to customers will rise. However, these increases will form increased profit for the relevant electricity businesses, which could be argued to have an economic impact on the New Zealand economy more generally.

While these effects could be relevant to a full economic impact assessment of the choice of the WACC, they appear to be only indirectly relevant to the Commission's decision on the WACC percentile.

Sections 4 and 5 consider these effects further, through understanding the scale of potential impact of the assumed WACC being different to the actual WACC. Section 5 also explains the limitations of the wider effects analysis in particular, as there is a fundamental uncertainty about the exact way in which a lower WACC might convert to lower investment—i.e. that the WACC could cause an underinvestment problem.

2.3 Defining the underinvestment problem

We introduced above the underinvestment problem, where a lower WACC may lead to underinvestment. This may arise in three ways:

- **prior to the price control period ('pre-flight')**. A company has an information advantage in developing a plan for the level of investment over the next regulatory period. In particular, it can plan the optimal ways to invest in, develop, and improve the medium-term resilience of the network. If the WACC is higher, this will strengthen the company's desire to convince the regulator of the need to expand investment;
- **during the price control period ('in flight')**. During the price control period, a company arguably has the incentive to underinvest unless this will immediately result in failure to meet output requirements, as the prices are fixed over the period, and underinvestment will therefore result in better cash flows. However, if the WACC is higher, this will be mitigated in two ways: the incentive to underinvest will be weaker since, by exercising an option to defer investment, the company will forgo the shareholder value which could be created by undertaking a positive-net present value (NPV) investment; and the company will undermine the credibility of future requests for investment, and therefore reduce the likely longer-term level of positive-NPV investment assumed by the regulator;
- **after the price control period ('post-flight')**. After the end of the period, the regulator may seek to impose investment requirements. However, this may be difficult to prove in practice, and, if underinvestment continues over multiple periods, may be insufficient to offset costly network failure.

These are all complex concepts, with a number of interactive elements, including the level of asymmetric information between the company and the regulator on the longer-term approaches to network investment. The probability that a particular WACC will link directly to a level of underinvestment that causes network failure will therefore be difficult to assess reliably.

Nevertheless, such an analysis provides valuable insight in understanding the impact of different percentile options. The Commission will be better able to weigh up the impact of different percentile options based on a set of tangible scenarios for the link between the WACC and the underinvestment problem.

Therefore, while a fully analytical approach is never likely to develop beyond a theoretical model that can be used to test sensitivities to different assumptions, and cannot actually lead to a specific recommendation, it does provide important evidence to support the Commission in reaching an informed decision on the correct percentile.

2.4 Approaches to addressing the underinvestment problem

The underinvestment problem is common to most infrastructure industries, and is therefore a focus for the majority of economic regulators. As described further in the next section, the common response from regulators is to retain flexibility. The precedent largely applies on a period-by-period, case-by-case basis. Regulators take individual views on the best approach to balancing their duties. This is logical, given the uncertainty discussed above. The benefits of this case-by-case, period-by-period approach include that it:

- avoids spurious accuracy, where the 'correct' answer is uncertain;

- allows the specific circumstances of each decision to be reflected in the choice of the WACC.

However, these benefits should be considered against the risk that this approach might not deliver the Commission's objectives. There are three primary risks to this approach:

- owing to the lack of evidence considered, this approach might materially under- or overestimate the premium required to offset the risk of underinvestment;
- the majority of any WACC adjustment is applied to 'assets in place', and it may therefore not be appropriate to reflect issues in a particular price control period;
- the use of a case-by-case basis, with little or no regulatory certainty, might undermine the benefits of the approach of applying a WACC above the 50th percentile, to the extent that these benefits include an expectation of a certain level of return on investment over the life of the relevant assets. If the regulator, as has happened in certain sectors, has shifted between percentiles over time, this leads to windfall gains and losses relative to perceived expectations for the future WACC, and this risk around asset values might increase the risk of underinvestment.

In this report we propose to the Commission an approach consistent with the current framework. This approach recognises the need for judgement and to take a case-by-case approach to different industries, but provides greater certainty on the approach over multiple periods.

2.5 Proposed approach

Oxera's proposed approach is to seek, as far as possible, to balance the practical approaches applied in the precedent and the theoretical approaches applied in the literature, to support the Commission in coming to a view on the decision to be made in respect of the IMs. In this report, we:

- **identify the material constituents within a social loss function**. Section 4 considers the financial effects (direct and indirect) and section 5 assesses the wider economic consequences (potential failures). This is within a materiality constraint that can be used to limit the scope of the analysis;
- **estimate the size of those effects, where feasible**. While recognising the difficulty of estimation, we identify the scale of the various effects;
- **calculate the WACC uncertainty range** based on the Commission's approach to estimating the standard error of the WACC;
- **create a range of realistic regulatory options** together with an understanding of the weights that these options give to different competing outcomes between addressing the underinvestment problem and resulting in higher costs to consumers.

This is potentially similar to the approach proposed by ASEC in its response, and we broadly agree with the material effects identified in that response to the consultation. However, we consider that a further step of identifying the link between the costs of setting the WACC above the midpoint, the benefits (including the impact on the probability of different values for the WACC), and the size of the estimate of costs which could result from underinvestment, will support the Commission in coming to a view on the appropriate percentile.

We note that there are difficulties in estimating the absolute level of the effects, that some of these effects may occur over different periods (i.e. that there may be a potential risk of time-inconsistency), and that there will be value judgements required by the Commission in making the trade-offs between different options.

Nevertheless, the analysis should help the Commission in providing evidence, first as to whether the 50th percentile is appropriate, and, if not, what assumptions would be consistent with a choice of a particular higher percentile.

2.6 Conclusions—proposed framework

This section has briefly reviewed the precedent and approaches proposed to the Commission, both in the past and as part of the current review. There are a number of approaches, and the intention of Oxera's framework is to seek to balance the benefits of each.

We propose the following framework:

- a 'social loss' function approach, consistent with the evidence previously submitted to the Commission by, among others, van Zijl and Dobbs;
- to analyse explicitly the evidence that exists of the scale of social loss, should the underinvestment problem arise;
- to analyse the risk of certain WACC scenarios, in order to provide evidence as to the scale of the risk of the underinvestment problem for different choices of percentile; and, in doing so,
- to provide evidence to the Commission as to what trade-offs it is making when choosing the appropriate percentile.

This approach will not fully resolve all the questions about the probability that a certain level of the WACC will actually result in network failure. However, it will provide the Commission with stronger evidence to take into consideration when coming to views on the appropriate percentile, and will help to address what the scale of the risks are from the alternative approach considered by the Court—i.e. the use of the 50th percentile.

3 Regulation and the choice of the WACC

This section provides context on the role of the WACC, why the WACC is uncertain, and how this is addressed within the standard approach to economic regulation.

3.1 Background—estimating the WACC

At any point in time, including when a regulator is setting prices, the actual WACC for the regulated firm on future investment in the network will be unknown. The WACC is meant to capture the *expected* return required by investors. In other words, the WACC must be estimated, typically with reference to historical data, to infer what the actual forward-looking expected return might be.

It is therefore common to derive a range for the WACC to reflect the uncertainty surrounding its estimation. Once a range for the WACC has been derived, the regulator is faced with the question of which point estimate to pick from the range. While the uncertainty remains about what the WACC will be, the choice of a number other than the midpoint of the range is likely to result in a greater probability of the estimated WACC being higher (lower) than the actual WACC. In choosing a point estimate for the WACC from a range, the consequences of setting the WACC too high or too low must therefore be considered.

- If the WACC is set too high, investors will earn a return on their investment that is above what they would expect to earn on other investments of similar risk. This means that customers will effectively be paying more than they should for the regulated service compared with the price that would be expected to prevail in a competitive market.
- If the WACC is set too low, the expected return will be below what is required by investors. This raises the risk that investment may be discouraged, and may therefore lead to necessary investments not being undertaken. Over time, this may lead to deterioration of service quality and in the health of the network, which in the long run will be detrimental to consumers.

Therefore, the choice of the point estimate for the WACC in a regulatory context is generally informed by the judgement of the regulator about the relative costs of setting the WACC too high or too low. The nature of this regulatory judgement will be influenced by the relevant statutory duties which the regulator is expected to take into account.

In the rest of this section, we briefly discuss the principles that may influence the regulator’s choice of the point estimate (section 3.2), and consider the pros and cons of regulatory options for the WACC (section 3.3). We then review the rationale for the Commission’s current approach to setting the 75th percentile (section 3.3) and provide specific examples of the approaches taken by other regulators (section 3.4).

3.2 Background

Under incentive-based regulation of the type used in New Zealand and other jurisdictions (such as the UK), regulators have tended to choose WACC estimates above the midpoint of the estimated range, and typically cite two main reasons for doing so:

- the costs to society of setting the WACC too low are generally considered to be greater than the costs of setting it too high—this is typically the **main** reason that regulators give to justify their decision;
- another reason used by some regulators is to recognise that the midpoint of the WACC range, depending on the methodology used, is more likely to understate the actual WACC than to overstate it. In other words, it is possible that biases in the way that the standard regulatory model estimates the WACC may imply that the 'mean is not the mean'.

In this report, we focus on analysing the evidence behind the first reason described above. This is because, given the methodology adopted in the IMs, our understanding is that the Commission's WACC range is estimated such that the midpoint of the range is the best estimate of the median of the WACC distribution. While parameter uncertainty is given some consideration in the Commission's choice of the point estimate (see section 3.3), it is understood to be a secondary factor and one that has been largely addressed in the estimation methodology itself. Other factors, such as asymmetric risk, are assumed to be captured elsewhere in the regulatory regime.

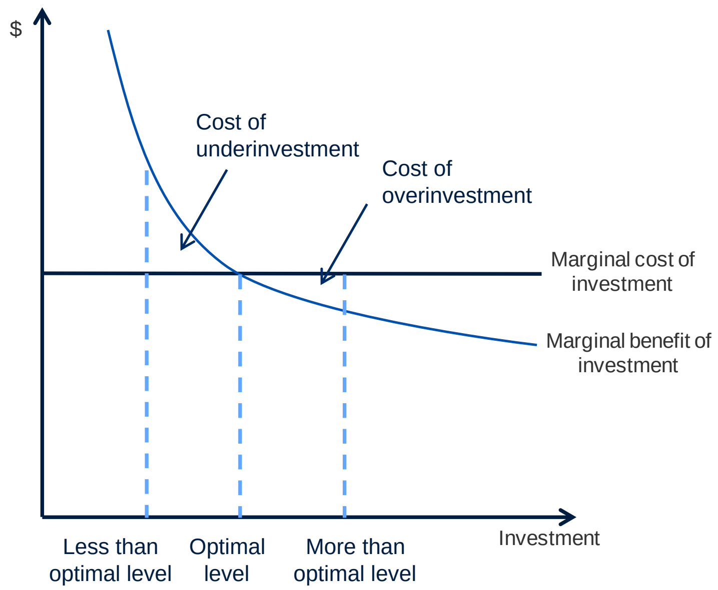
In essence, getting the WACC 'wrong' has two effects:

i) a short-term effect of distorting consumer prices and subsequently consumption choices ('static allocative efficiency');

ii) a long-term effect of distorting investment incentives ('dynamic efficiency').

As discussed above, when considering the latter effect, it is often assumed that the costs of underinvestment are greater than those of overinvestment. For example, this may reflect the diminishing marginal utility of the firm's investment (Figure 3.1).[14]

Figure 3.1 Asymmetric costs of over-/underinvestment



Source: Oxera.

[14] Brealey, R. and Franks, J. (2009), 'Indexation, investment, and utility prices', *Oxford Review of Economic Policy*, **25** :3, pp. 435–50.

In general, however, regulators do not seek to measure these effects in choosing from a range. As shown below, the significant majority of regulatory decisions do result in a choice above the midpoint of the range, but this is not generally based on direct economic analysis of these effects.

3.3 Options for choosing a point estimate

Without any ex ante assessment of the likely costs of setting the WACC too high or too low, and assuming that the WACC has a symmetric distribution around the mean (e.g. the CAPM assumes that the WACC is normally distributed), selecting the midpoint of the range could be a reasonable starting point for the regulator in choosing a point estimate.

However, if it is deemed that the costs of possible underinvestment (setting the WACC too low) are greater than the costs of customers paying more than they should (setting it too high)—e.g. for the reasons set out in the previous section—then setting a point estimate above the midpoint of the range could also be appropriate.

As demonstrated in section 3.4, this latter approach is a common assumption among regulators. If this is indeed the case, in order to determine how much to aim up from the midpoint, regulators can undertake a number of approaches, such as:

- **a case-by-case, period-by-period approach** where the cost of capital is set based on judgement around the prevailing costs and benefits of the choices of WACC level in each period;
- **a defined point estimate from a range**—i.e. the approach taken by the Commission to define a range, and to identify a point estimate from that range, on a pre-specified basis;
- **a more complex approach** such as applying a premium for new investment which is different to that applied to existing investment.

Table 3.1 summarises the relative advantages and disadvantages of the options for choosing a point estimate.

Table 3.1 Pros and cons of different regulatory options

	Pros	**Cons**
Option 1: midpoint (P50) of the range	Simple and transparent In the absence of robust evidence on the asymmetric costs of setting the WACC too high or low, this option can be considered to lead to a fair outcome for both investors and consumers	If there are indeed asymmetric costs of setting the WACC too high or low, there is a considerable risk of underinvestment Even without asymmetric costs, investors may still choose not to invest as they expect only to break even—some margin above the WACC might still be required to incentivise investment
Option 2: aim up on a case-by-case basis	Reduces the risk of underinvestment compared with Option 1 Flexible—can be adapted to each price control, taking into account prevailing market conditions/ investment cycle	Can create additional uncertainty at each price review, which may reduce in itself incentives to invest Requires judgement—risk of ‘getting it wrong’ is likely to be relatively high

	Pros	Cons
Option 3: formulaic aim-up, based on a specified percentile	Reduces the risk of underinvestment compared with Option 1 Creates regulatory certainty and ensures a consistent approach at each price review—can further help to mitigate any disincentives to invest	Choice of percentile is likely to be subjective. There is a risk of placing too much weight on an analytical approach that is inevitably still rooted in judgement Can be too inflexible—cannot be adjusted to take into account changes in market conditions/investment cycle
Option 4: aim up based on a calculation other than a standard percentile (e.g. a premium on new investment only)	Reduces the risk of underinvestment compared with Option 1 Recognises that the risk of underinvestment relates primarily to new investment projects	Increase in complexity and reduction in transparency over average returns for investors If the uplift is granted only for the first period of the investment, the effectiveness to reduce the risk of underinvestment is likely to be limited, in particular given that the framework is designed to provide incentives not to overinvest within periods. If the uplift were granted over the whole life of the investment, over time this option becomes quite similar to Options 2 and 3

Source: Oxera.

In general, most regulators that explicitly consider the question of where to choose from within a range appear to use Option 2 (see section 3.5), where their decisions are mainly guided by judgement. In the case of specific large one-off investments that are likely to have a different risk profile to the average risk of the business, Option 4 has also been used. (For example, the UK Civil Aviation Authority used it in relation to the construction of a new terminal at Heathrow Airport.)

The relative appeal of different regulatory options for setting the WACC is also likely to be influenced by the regulatory framework in place, in particular in relation to:

- regulatory duties—e.g. the trade-off between ensuring financeability of the regulated businesses versus promoting competition;
- the extent to which the regulated company is committed (through licence or other statutory obligations) to a certain level of investment or to deliver specific investment projects;
- how the CAPEX allowance is determined, and how it is reviewed ex post for efficiency/compliance with pre-agreed requirements or outputs;
- how network health and service quality are measured, including any associated rewards and penalties;
- uncertainty mechanisms to address the impact of shocks to costs/revenues during the control period.

3.4 Rationale for the Commission's current approach

In the December 2010 IMs for electricity distribution services, the Commission adopted the 75th percentile estimate of the WACC to set price–quality paths.[15] In

[15] NZCC (2010), Input Methodologies (electricity distribution and gas pipeline services), December, section 6.7.

reaching its view on the appropriate percentile, the Commission considered a range of factors, including its regulatory duties in a number of areas:

> the Part 4 Purpose is to promote the long-term benefit of consumers, including:
>
> - ensuring suppliers of regulated services have incentives to invest and innovate (s.52A(1)(a)) and the potential long-term benefits to consumers from investment and innovation;
> - ensuring regulated suppliers are limited in their ability to extract excessive profits (s.52A(1)(d));
> - the risk that the true (but unobservable) WACC is above the estimated midpoint WACC;
> - the risk that CAPM and the simplified Brennan-Lally CAPM may underestimate the returns on low beta stocks;
> - the risk that the simplified Brennan-Lally CAPM may lead to higher estimates of the cost of capital than the International CAPM would for international investors, and that international investors are likely to be the marginal investors in the New Zealand markets; and
> - the risk of error in estimating individual parameters of the simplified Brennan-Lally CAPM including the asset beta and the TAMRP.[16]

In considering these factors, the Commission was particularly concerned with preserving the incentives to invest and innovate. This has led to the choice of the 75th percentile.

While the specific choice of the percentile is not extensively discussed in the IMs, the implied point estimate for the WACC was cross-checked against evidence from other sources, such as submissions by other parties and regulatory precedent, to ensure its overall reasonableness. The Commission also noted that selecting a higher percentile (e.g. the 95th percentile) would leave suppliers with too little risk, which would not be in the long-run interests of consumers.[17]

The Commission's decision to choose a point estimate above the midpoint of the range was supported by its expert advisory panel (Professor Franks, Dr Lally and Professor Myers).[18] However, the panel did not comment on the specific percentile to use.

The approach to the percentile in the IMs was not to include any adjustments to the WACC to account for asymmetric risk. The Commission considered two types of asymmetric risk:[19]

- Type I risk: risks unrelated to the day-to-day operations of the firm that can arise due to infrequent external events, such as natural disasters, terrorist attacks, etc.;
- Type II risk: risks that can arise from the threat of competitive entry and exit, which typically cap the upside returns but can expose the firm to significant downside risk, for example as a result of asset stranding.

[16] NZCC (2010), Input Methodologies (electricity distribution and gas pipeline services), December, paragraph 6.7.11.
[17] NZCC (2010), 'Input Methodologies (electricity distribution and gas pipeline services)', December, paragraph H11.66.
[18] Franks, J., Lally, M. and Myers, S. (2008), 'Recommendations to the New Zealand Commerce Commission on an Appropriate Cost of Capital Methodology', December, paragraphs 155–7.
[19] NZCC (2010), 'Input Methodologies (electricity distribution and gas pipeline services)', December, paragraph H12.4.

For both types of downside risk, the Commission did not explicitly adjust the WACC. To deal with Type I risks, it was concluded that a firm could self-insure with the insurance costs reimbursed in regulatory charges either ex ante or ex post.[20] For Type II risks, the Commission was not persuaded that these risks were significant in the context of regulated industries with relatively stable demand and the regulatory regime in place, including the regulatory asset base (RAB) mechanism.

In subsequent price review proceedings, the Commission noted that one of the practical effects of setting the WACC above the midpoint was to provide a buffer for catastrophic risks. For example, Orion (an electricity distribution business) suffered large losses as a result of the Christchurch earthquake in 2013. In deciding whether to make an ex post adjustment to compensate Orion for higher costs incurred prior to the revised price–quality path taking place, the Commission noted that: '(t)he practical effect of using the 75th percentile WACC (determined under the IMs) is to provide a buffer against the financial impact of catastrophic events.'[21]

Until the establishment of the IMs, we understand that any departure from the midpoint of the range was typically a matter of judgement by the Commission.[22] The Commission was of the view that the exact choice of the point estimate would depend on the specific case, and would consider factors such as the degree of uncertainty in parameter estimates, and whether the final WACC value was reasonable given the industry characteristics and prevailing economic conditions.[23]

3.5 Regulatory precedent – examples from the UK

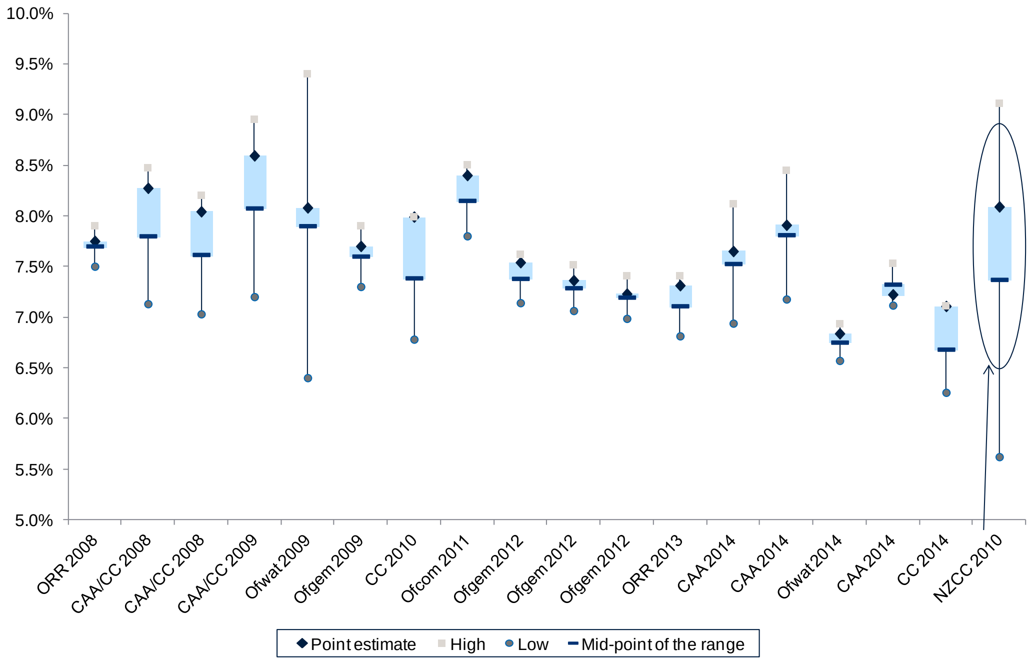
In nearly all recent price control determinations in the UK, the regulators have adopted WACC values above the midpoint of their estimated range. We have focused on the UK both because there is generally an explicit recognition of a range for the WACC, and to demonstrate cross-sectoral comparison. As can be seen in Figure 3.2, the estimated WACC range is wide, and there is considerable variation in how far from the midpoint the final estimate is. This is important as it highlights that the estimation methodology itself will have some bearing on the regulator's choice within the range.

In this context it is important to understand the difference between the definition of 'percentile' as applied by the Commission, and that of other regulators. For the Commission, the 75th percentile is based on a statistical assessment of the uncertainty around the WACC, and only includes some parameters that the Commission has concluded exhibit uncertainty over measurement, including the beta and the market risk premium.

Where other regulators have referred to percentiles, and in Table 3.2 below and the tables in the submissions to the Commission, this tends to refer to the position within a range, assuming that the range is a uniform distribution.

[20] Although in practice there was no additional cash-flow allowance to cover potential insurance costs.
[21] NZCC (2013), 'Setting the customised price-quality path for Orion New Zealand Limited, Final reasons paper', November, paragraph C5.2.
[22] NZCC (2009), 'Revised Draft Guidelines, The Commerce Commission's Approach to Estimating the Cost of Capital', June.
[23] NZCC (2009), 'Revised Draft Guidelines, The Commerce Commission's Approach to Estimating the Cost of Capital', paragraph 240.

Figure 3.2 UK precedent: WACC ranges and point estimates



Note: CAA, Civil Aviation Authority; CC, Competition Commission; ORR, Office of Rail Regulation; Ofwat, Office of Water Services; Ofgem, Office of Gas and Electricity Markets. All values are shown on a nominal, vanilla basis (pre-tax cost of debt, post-tax cost of equity). All UK regulators (with the exception of Ofcom) use a real WACC; however, to enable comparison with New Zealand, the allowed real values have been converted into nominal using an appropriate inflation assumption. The Commission does not explicitly have a range for the WACC—the high and low values shown in the figure are based on the 95% confidence interval using the Commission's estimates of the standard error for the WACC.

Source: Various regulatory determinations, and Oxera analysis.

Figure 3.2 also highlights that, relative to UK regulators, the Commission's point estimate deviates from the midpoint quite considerably, at least when measured in percentage points of the WACC. This is useful to note since a different conclusion would be reached if a simple comparison of the percentiles were conducted.

Table 3.2 further compares where UK regulators have set the WACC from a range in percentile terms, and would appear to suggest that the Commission's choice of the extent to which it should deviate from the midpoint of the range is on average similar to the UK regulators, in respect of the assumed WACC within the price control (although not necessarily within the actual return on capital achieved, which will be affected by a wide range of factors).

Table 3.2 UK regulatory precedent: chosen percentile[1]

Regulator	Year	Sector/ company	Percentile in the range
UK ORR	2008	Network Rail access charges	63
UK CAA/CC	2008	Gatwick Airport	85
UK CAA/CC	2008	Heathrow Airport	86
UK CAA/CC	2009	Stansted Airport	80
UK Ofwat	2009	Water	56
UK Ofgem	2009	Electricity distribution	67
UK CC	2010	Bristol Water	100
UK Ofcom	2011	Wholesale broadband access	86
UK Ofgem	2012	Electricity transmission[2]	83
UK Ofgem	2012	Gas transmission[2]	67
UK Ofgem	2012	Gas distribution[2]	58
UK ORR	2013	Network Rail access charges	84
UK CAA	2014	Heathrow Airport	60
UK CAA	2014	Gatwick Airport	58
UK Ofwat	2014	Water(vertically integrated)	74
UK CAA	2014	Air traffic control[3]	26
UK CC	2014	Electricity transmission and distribution (Northern Ireland)	100
Average			73

Note: [1]The percentiles for UK precedent are calculated assuming a uniform distribution. This is because none of the UK regulators explicitly estimates the standard error for the WACC. [2] The WACC point estimate is applicable to the first year of the price control only (cost of debt indexed annually). [3] Draft decision at this stage.

Source: Regulatory determinations; Oxera.

However, the differences in the impact on a per-customer basis cannot be directly inferred from either of these comparisons, as they will depend on the relative sizes of the RABs and number of customers, and the ranges are derived in a different way.

3.6 Regulatory precedent—justifying an uplift on the WACC

In order to justify their point estimate, UK regulators often assume that the costs of setting the WACC too low are larger than the costs of setting it too high. However, the exact point estimate is typically chosen using judgement on a case-by-case basis. Moreover, the regulators will often take into account risks beyond those considered within the Commission's approach—in particular, the risks around the actual value of the risk-free rate achieved by the regulated businesses within the actual cost of capital.

There are also a number of examples of regulators explicitly taking into account the asymmetric costs of getting the WACC wrong when choosing a point estimate. The UK Competition Commission gave this argument significant consideration when making a recommendation to the CAA on the price controls for BAA's airports.

> If the WACC is set too high then the airports' shareholders will be over-rewarded and customers will pay more than they should. However, we consider it a necessary cost to airport users of ensuring that there are sufficient incentives for BAA to invest, because if the WACC is set too low, there may be underinvestment from BAA or potentially costly financial distress.
>
> ...Most importantly, we note that it is difficult for a regulator to reduce the risks of underinvestment within a regulatory period.

> Taking these factors into account, we concluded that the allowed WACC should be set close to the top of our range.[24]

However, the UK Competition Commission's recommendations were based on judgement and did not advocate using the same approach in each price control. In particular, the UK Competition Commission took into account how it estimated the individual WACC parameters and the relative levels of investment between the airports.

> In order to make recommendations to the CAA on the level of the price cap that should apply at Stansted, we needed to select a single point estimate from within our range. There were two main considerations that we believed should guide a regulator in this type of decision:
>
> (a) The first was that it was highly unlikely that the cost of capital lay at the very top or the very bottom of the estimated range. ...
>
> (b) The second was that there were asymmetric consequences from setting returns too high and too low. ...
>
> The conclusion that we drew from this is that it would have been wrong for us to select a value at the midpoint of between our upper and lower limits, or lower, but also that we would have to believe that very substantial costs would result from underinvestment in Q5 in order to justify choosing a point estimate at the very top end of the range.
>
> ...Ultimately, the estimate that we made was a matter of judgement, in which we balanced the likelihood of outcomes with their cost implications. Whilst we took the risk of underinvestment seriously, we were conscious in this review that our beta estimate was more likely to overstate than understate the riskiness of Stansted and, on this basis, we did not think it would be appropriate for us to go too high in the range. Furthermore, compared with Heathrow and Gatwick, the level of capex at Stansted in Q5 was forecast to be relatively modest, at approximately £125 million over the five years... This reduced the cost of underinvestment at Stansted compared with Heathrow and Gatwick.[25]

Similarly, in a recent decision on charges for wholesale broadband access, Ofcom noted the asymmetric loss function in relation to selecting specific point estimates of the individual parameters and the overall WACC range. It also gave some consideration to the specific investment characteristics of the telecoms industry:

> There are circumstances where we consider it is appropriate to err on the side of caution in relation to certain parameters. We had regard to the asymmetric loss function when choosing a point estimate for the [equity risk premium, ERP].
>
> …We accept TTG and Sky's arguments that the asymmetric loss function is more complicated for wholesale products which support downstream competition. This is because setting a WACC too high may impact investment by other communications providers (CPs). We understand the importance of encouraging efficient investment from both BT and downstream operators. However, we have regard to the level of investment made by the CPs.
>
> BT Group has invested over £2.5bn p.a. in capital expenditure over the period 2009-2011, compared to TTG's investment of around £100m p.a. over the same period. Whilst we accept that downstream investment is important, the relative scale of BT's investment profile means that the risks associated with setting the WACC too low may be greater than those of setting the WACC too high.[26]

[24] Competition Commission (2007), 'A report on the economic regulation of the London airports companies (Heathrow Airport Ltd and Gatwick Airport Ltd)', Cost of capital appendix, paragraphs 150–2.
[25] Competition Commission (2008), 'Stansted Airport Ltd Q5 price control review', Cost of capital appendix, paragraphs 115–7.
[26] Ofcom (2011), 'Charge control framework for WBA Market 1 services', paragraphs 6.188–91.

Similar considerations of the asymmetry of costs of over- and underinvestment can be found in regulatory deliberations in the energy sector in Australia. For example, in a recent report on the effectiveness of the regulatory framework in the electricity market, the Productivity Commission notes that, when setting allowed revenues, it is important to have regard to the fact that:[27]

> Under incentive regulation, under-remuneration is likely, ultimately, to lead to larger costs than over-remuneration of an equal magnitude. This is because the costs of underinvestment affect the long-run provision of reliable network services to consumers. In contrast, if the incentive regime were performing its role, any over-remuneration would not lead to overinvestment by a well-governed, profit-motivated network company. Rather it would result in slightly larger profits (which have lower efficiency costs), which the regulator could reduce in subsequent regulatory periods.

3.7 Conclusion

This section has reviewed a sample of the relevant regulatory precedent around the choice of percentile. The precedent demonstrates a consistent commitment from the regulators to assume a WACC above the midpoint, and therefore to seek to address the underinvestment problem.

However, the regulators are not consistent in the way that they address the approach, either across industries or across periods. The WACC is set based on judgement, and a review of the risks associated with an individual period. In addition, some regulators explicitly recognise risks outside the scope of the Commission's 75th percentile approach, such as the risks around the risk-free rate.

The approach taken by other regulators is different to the percentile approach applied by the Commission, and in theory may be more flexible. However, the Commission's approach has benefits in terms of providing greater certainty to investors over the returns that can be expected across the life of an asset.

A review of international precedent is therefore generally supportive of the Commission's approach to assume a WACC above the midpoint. However, given the differences in the estimation methodologies and regulatory frameworks, and the fact that international regulators typically rely mainly on judgement and qualitative evidence in arriving at a point estimate, it cannot be directly translated into a recommendation for a percentile to be used for electricity networks in New Zealand.

[27] Productivity Commission (2013), 'Electricity Network Regulatory Frameworks, Inquiry Report', Volume 1, No.62, 9 April, p. 31.

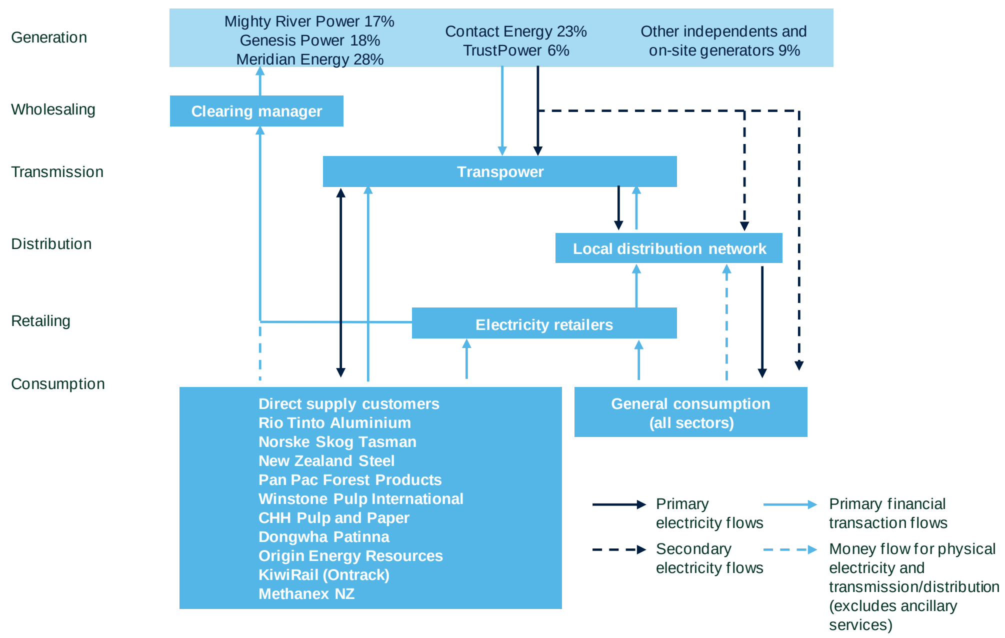
4 Financial consequences of setting the WACC too high or too low

This section considers the direct and indirect financial consequences of the choice of WACC percentile for the transmission and distribution companies. First, we consider the structure of the energy market and identify the parties that could be affected if the WACC is set too high. Based on this analysis, we provide an estimation of the scale of the direct and indirect effects of the choice of the WACC.

4.1 The electricity supply chain

Figure 4.1 gives an overview of the electricity supply chain in New Zealand.

Figure 4.1 New Zealand electricity supply chain



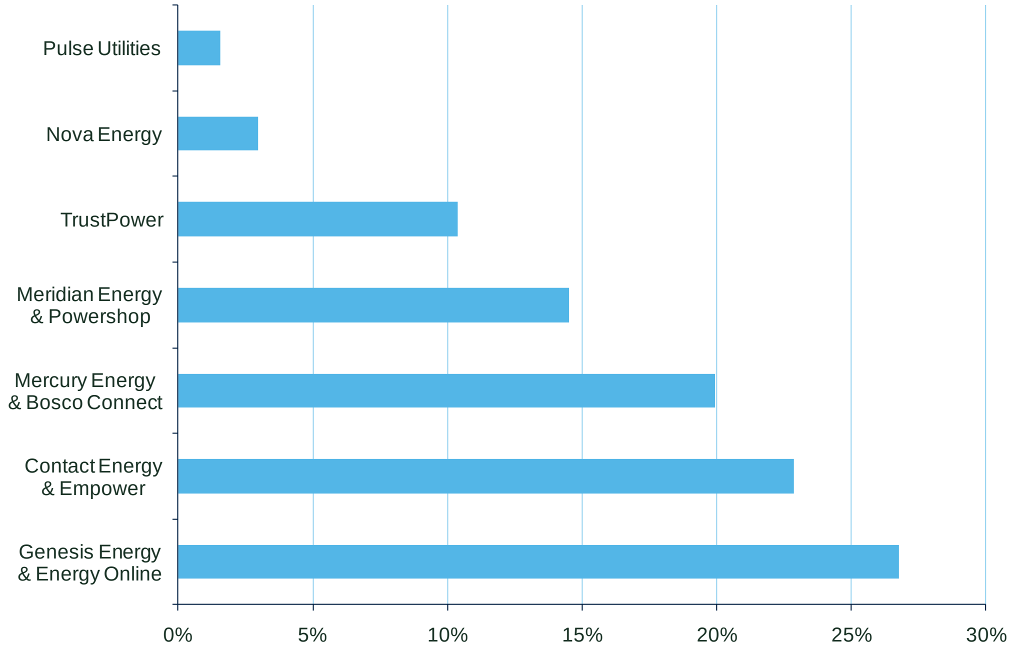
Source: Ministry of Business, Innovation and Employment (2013), 'Energy in New Zealand 2013', p. 61.

The electricity supply chain is made up of four main parts.

- **Generation**. Five major generating companies in New Zealand together provide around 92% of New Zealand's electricity generation: Meridian Energy (28%), Contact Energy (23%), Genesis Energy (18%), Mighty River Power (17%) and TrustPower (6%).
- **Transmission**. Transpower owns, operates, maintains and enhances the electricity transmission network in New Zealand. It conveys electricity from most of the major stations to local distribution lines and directly to a small number of major industrial users, such as Rio Tinto Aluminium and New Zealand Steel. Transpower is a state-owned enterprise.
- **Distribution**. There are 29 distribution companies in New Zealand, with a variety of ownership forms from publicly listed companies to local community-owned trusts. These companies convey electricity to users within their network areas. The largest distribution companies are Vector Limited and Powerco.

- **Retailing**. The electricity retail market is deemed to be competitive, with switching rates of around 20% a year. Electricity retailers include Contact Energy, Genesis Energy, Meridian Energy, Mercury Energy, TrustPower, Nova Energy and Pulse Utilities. The market shares of the electricity retailers are presented in Figure 4.2.

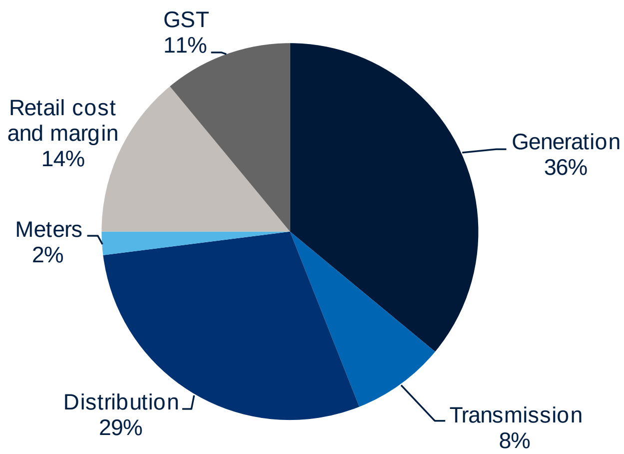
Figure 4.2 Market shares of major electricity retailers (as at December 2012)



Source: Ministry of Business, Innovation and Employment (2013), 'Energy in New Zealand 2013'.

The components of the electricity price paid by residential customers are presented in Figure 4.3. Generation (36%) accounts for the largest proportion of the end-user price, followed by distribution (29%). The figure shows that transmission costs are a much smaller proportion of the final price paid by end-customers.

Figure 4.3 Components of residential electricity price



Source: Electricity Authority (2011), 'Electricity in New Zealand', December, p. 25.

For non-residential customers, the breakdown of the price is likely to differ from that for residential customers. For example, the share of cost related to transmission will be higher—and the share of cost related to distribution lower—for large industrial users that are connected directly to the grid.

4.2 Direct effects

The clearest impact of setting the WACC at the 75th percentile is that the additional return earned by the transmission and distribution companies will feed through into higher network charges. The impact of this on downstream firms and end-customers can be determined by:

- the price effect—the increase in capital cost is equal to the value of the RAB multiplied by the additional WACC allowance. Depending on market conditions—i.e. the extent of 'pass-through'—the direct purchaser may be able to pass the additional costs on to its own customers;
- the demand effect—if higher charges are passed through to final prices, and if the tariff structure means that this increases the unit price of energy, consumers will typically respond by purchasing fewer units (depending on the level of price elasticity).

4.2.1 The price effect

The price effect depends on the size of the WACC range (with a smaller range giving a smaller effect) and the size of the asset base to which the WACC is applied.

Oxera understands that the distribution of the WACC has meant that adopting the 75th percentile of the WACC range has led to a point estimate that is approximately 0.7% higher than the midpoint of the range.

In the electricity sector, the RAB values are as follows.

- **Electricity transmission**. Transpower's RAB is forecast to grow to around NZ$4.6bn by the end of 2014/15.[28] Annual revenues are around NZ$950m.
- **Electricity distribution**. The combined asset value of the 29 distribution companies is in the region of NZ$9.5bn–NZ$10bn.[29] The three largest companies—Vector Limited (approximately NZ$2.5bn), Powerco (approximately NZ$1.4bn) and Orion (approximately NZ$800m)—have a combined asset value of over NZ$4.5bn. Combined annual revenues for the distribution companies are around NZ$2.5bn a year.

On this basis, the additional return for Transpower is around NZ$35m a year, while the (aggregate) additional return for the distribution companies is around NZ$70m a year. The combined effect is an additional NZ$105m a year.

Assuming that these costs are fully passed through to end-users, and using the breakdown of costs set out in Figure 4.3 (i.e. that transmission costs account for 8% and distribution costs account for 29% of final prices, respectively), average final prices for residential customers would be around 1.3% lower under the midpoint estimate than under the 75th percentile.[30] The change in price for non-

[28] Transpower (2013), '2015/16 to 2019/20 Transmission Revenue', 9 December, p. 1.
[29] Based on information from the New Zealand Commerce Commission's website and Oxera calculations.
[30] Based on the assumption that the reduction in transmission and distribution revenues of around 3.5% under the midpoint WACC scenario (relative to the 75th percentile scenario) would feed directly into lower final prices.

residential customers is likely to be larger, particularly for those users that are connected directly to the grid. Due to the lower transparency of pricing, it has not been possible to obtain a directly comparable breakdown of costs for non-residential customers in order to estimate the impact on the price charges to these customers. The analysis below assumes that a 1.3% increase in prices for such non-residential customers is the lower bound, while a 5.0% increase is the upper bound.[31]

The direct price effect results in a transfer of wealth from end-users to investors in the transmission and distribution companies. This could be considered a redistribution of wealth as opposed to an overall welfare loss, particularly where the business is not privately owned, as with Transpower. However, to the extent that one of the aims of the Commission in designing regulation is to protect end-users from overpricing, the transfer of wealth away from consumers could still be seen to be a welfare loss within the Commerce Commission's considerations (see Box 4.1).

Box 4.1 Welfare function

The total welfare (TW) function is given by:

$$TW = \alpha CS + (1-\alpha)PS$$

where CS is the consumer surplus, PS is the producer surplus and α is the weight given to each of these surpluses by society.

If one assumes that α is equal to 0.5 (i.e. consumer and producer surpluses are given equal weight) then a transfer of wealth from consumers to producers will have no impact on total welfare. A WACC uplift will have an impact on welfare only where it leads to a deadweight loss. Under a pure consumer welfare approach, on the other hand, it is assumed that α is equal to 1 and therefore that any reduction in consumer surplus is a welfare loss (even if there is an offsetting increase in producer surplus). In reality it would be reasonable to expect that the value of α which the Commission is expected to take into consideration in setting a price path lies between 0.5 and 1 (given its duties to protect customers from monopoly pricing). The consumer welfare approach is therefore a conservative approach to assessing the impact of a WACC uplift, and thus a lower estimate could be provided if a different approach were taken.

Source: Oxera.

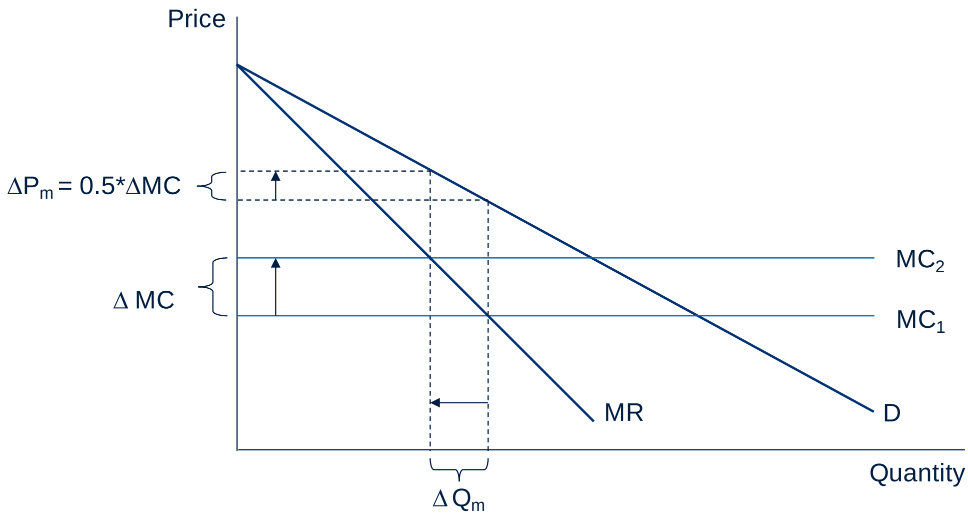
4.2.2 Is it realistic to assume 100% pass-through?

The impact of the choice of WACC percentile is determined by the extent to which the direct purchaser is able to pass on the additional costs to its own customers. There will be no effect on final customers if the downstream firm is unable to pass on any of the additional cost, or chooses not to. The level of pass-through to customers will influence the impact on the direct purchaser, but does not change the size of the impact, only at which point the impact occurs within the supply chain. With pass-through, the incidence of the choice of the WACC falls on end-users as opposed to the direct purchaser. This is a relevant consideration in understanding the impact on incentives across the supply chain.

[31] The 5% upper-bound assumption is based on a qualitative assessment of the likely maximum impact on non-residential tariffs.

Standard economic models suggest that the extent of pass-through will be determined by the structure of the downstream market. Figure 4.6 considers the situation in which the direct purchaser is a downstream monopolist. The monopolist maximises its profits by setting its price where the marginal cost (MC) is equal to the marginal revenue (MR). Under the assumption that the demand curve (D) is linear, the monopolist's marginal revenue curve is exactly twice as steep as the demand curve. If the price charged by the upstream firm is higher as a result of the WACC being set too high, the downstream monopolist's marginal cost curve will shift upwards. With linear demand, the monopolist's price will increase by exactly half the increase in cost. (In practice, a monopolist's demand curve is unlikely to be linear and the exact proportion of pass-through will be determined by the shape of the demand curve.)[32]

Figure 4.4 Cost pass-through by a downstream monopolist



Source: Oxera.

Where the downstream market is instead characterised by perfect competition, competitive pressures will mean that all firms will set their prices equal to marginal cost. Any increase in the marginal cost that is faced by all companies will result in a new market price equal to the higher marginal cost. Firms are unable to absorb any of the additional cost as to do so would require them to price below the new marginal cost (and therefore make a loss). As such, a perfectly competitive downstream firm will pass through the additional cost in full. In practice, the exact effect on companies and customers will depend on the supply and demand curves of the relevant markets.

Standard economic theory therefore dictates that a downstream monopolist will bear a greater cost from the WACC being set too high than would a firm in a more competitive downstream market. An oligopolistic market (under Cournot competition) produces a level of pass-through that is between the monopoly and perfectly competitive outcomes. Indeed, Ten Kate and Niels (2005) found that the price increase in an oligopolistic market will be equal to N/(N + 1) of the cost increase, where N is the number of firms in the market.[33]

[32] For example, with constant elasticity demand curves, the increase in price will actually be higher than the increase in cost.

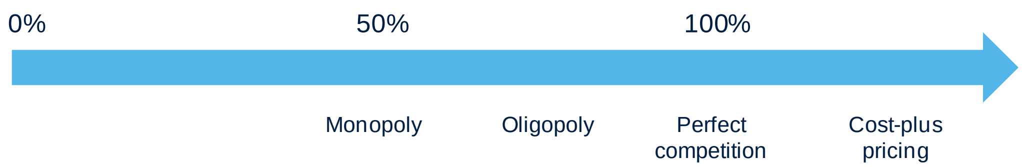
[33] Ten Kate and Niels assume Cournot oligopoly. Ten Kate, A. and Niels, G. (2005), 'To what extent are cost savings passed on to consumers? An oligopoly approach', *European Journal of Law and Economics*, **20**, 323–37.

However, there may be reasons why, in practice, the actual amount of pass-through deviates from the levels indicated by standard economic theory.

- **Cost-plus pricing.** One example is where companies in the downstream market employ cost-plus pricing, under which a company calculates the costs of its product and adds a fixed margin as a mark-up. For example, a company might observe that it has costs of NZ$100 and apply a mark-up of 10% to achieve a final price of NZ$110. If its input costs were to be NZ$10 greater as a result of the WACC being set 'too high' for the upstream seller, its cost-plus approach would result in it charging NZ$110 * 1.1 = NZ$121. In this instance, the company would actually increase its price by more than the increase in its costs—it raises prices by NZ$11 in response to a cost increase of NZ$10.[34]
- **Magnitude of the price increase**. In practice, the magnitude of the cost increase on the downstream firm's overall input costs may affect the extent of pass-through. For example, if the affected input cost makes up only a small proportion of the final product price, the company may be better able to absorb the cost than for large-cost items.

Figure 4.5 summarises the extent of pass-through under various market and pricing structures.

Figure 4.5 The extent of pass-through under different pricing structures



Source: Oxera.

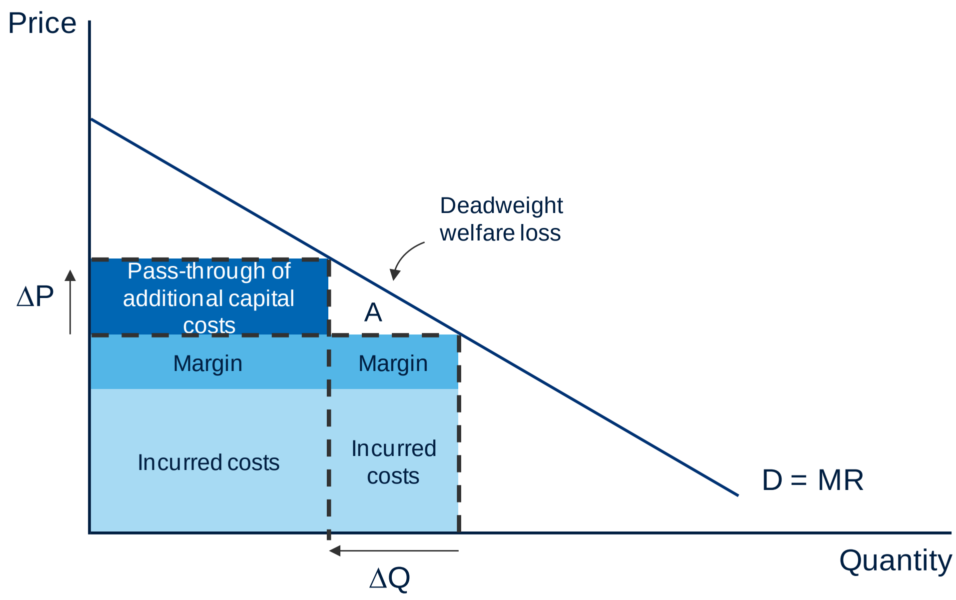
Given that the electricity retail market in New Zealand has been deemed to be competitive, it is not unreasonable to assume that a high proportion of any additional capital cost allowance for the transmission and distribution companies will be passed through to end-users.

4.2.3 The demand effect

Where there is some pass-through of the cost increases in the form of higher downstream prices, there is likely to be an impact on demand for the final product. Under all scenarios where the level of demand is affected by the level of price, the demand effect will create a deadweight welfare loss (equal to box A in Figure 4.6).

[34] Cost-plus pricing is generally likely to be linked to inelastic demand.

Figure 4.6 Deadweight welfare loss from the demand effect



Source: Oxera.

The size of this demand effect is determined by two factors:[35]

- the extent of pass-through by downstream firms;
- the (own-price) elasticity of demand for the product.

Therefore, to calculate the impact of setting the WACC too high on volumes sold by downstream firms, it is necessary to have an estimate of the elasticity of demand. The own-price elasticity of demand measures how sensitive demand for a product is to changes in that product's price. For example, an own-price elasticity of demand of –0.5 implies that a 1% increase in the price of the product will lead to a reduction in demand of 0.5%. The elasticity of demand for a product may differ in the short run and long run. For example, there may be factors that affect customers' ability to reduce their consumption of the product in the short run.

Table 4.1 summarises the results of academic studies that have sought to estimate the own-price elasticity of demand for household electricity. They have typically found that demand for electricity is relatively inelastic, at least in the short run. The demand effect is therefore likely to be relatively small.

[35] It should further be noted that the tariff structure is likely to have an effect on the size of the deadweight loss (e.g. greater use of fixed tariffs will likely reduce the deadweight loss).

Table 4.1 Estimates of the own-price elasticity of demand for household electricity

Study	Methodology	Estimate of own-price elasticity
Bohi and Zimmerman (1984)	Consensus estimates based on review of studies on energy demand	Short run (residential elec): –0.2 Long run (residential elec): –0.7
Baker et al (1989)	Translog model of energy demand for more than 80,000 UK households between 1972 and 1983	–0.75 (elec) –0.3 (natural gas)
Silk and Joutz (1997)	Error-correction model using annual data on US households from 1949 to 1993	Short run (elec): –0.25 Long run (elec): –0.50
Espey and Espey (2004)	Meta-analysis of 36 studies between 1971 and 2000	Short run (elec): –0.28 (median) Long run (elec): –0.81 (median)
Reiss and White (2005)	Generalised method-of-moments estimator using data on a large number of Californian households	–0.4 (elec)
Borenstein (2009)	Based on an increasing-block price schedule model and Californian data	0 to –0.12 (elec)
Fan and Hyndman (2011)	Based on log-linear model and South Australian data	–0.37 to –0.43 (elec)

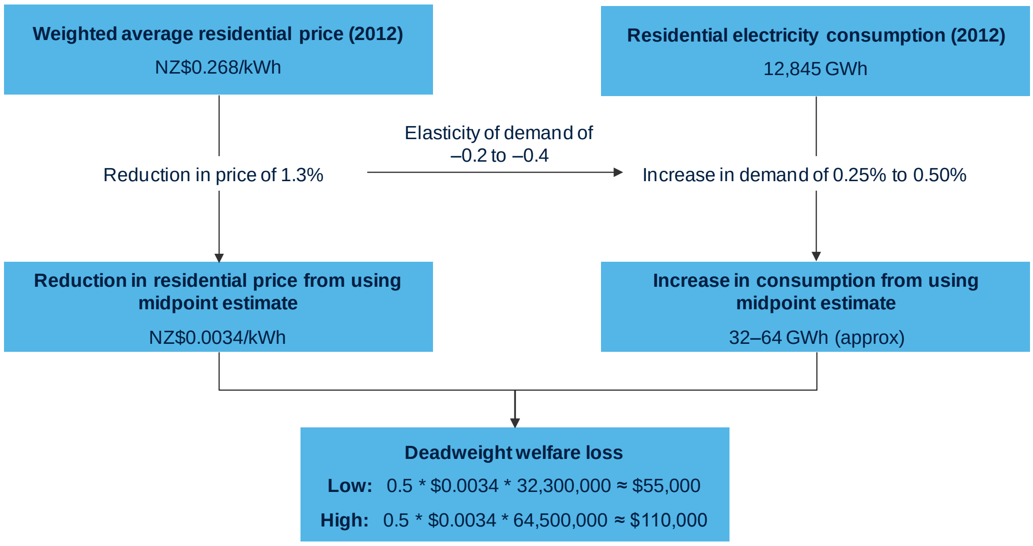
Source: Analysis reporduced from Politt, M. (2010), 'The Economics of Energy Demand', EPRG Spring Research Seminar, Cambridge, 14 May; Bernstein, M. and Griffin, J. (2005), 'Regional Differences in the Price-Elasticity of Demand For Energy', RAND Infrastructure, Safety and Environment; Borenstein, S. (2009), 'To what electricity Do Consumers Respond? Residential Demand Elasticity Under Increasing-Block Pricing', July 10; Fan, S. and Hyndman, R. (2011), 'The price elasticity of electricity demand in South Australia'.

As outlined in section 4.2.1, end prices to residential customers would be around 1.3% lower under the midpoint estimate than under the 75th percentile. With a price elasticity of demand of –0.2 to –0.4, this implies that final consumption would be around 0.25–0.5% higher if the midpoint WACC were used.

In 2012, residential electricity consumption was 12,845GWh with an average retail charge of 26.8 NZ cents per kWh. The elasticity of demand assumption suggests that there would have been an additional 32–64GWh of consumption if the WACC had been set at the 50th percentile. Under these assumptions, the welfare loss for residential customers as a result of the higher WACC would be small (approximately NZ$55,000–NZ$110,000).[36]

[36] This estimate is in the same order of magnitude as the estimate made by ASEC of the deadweight welfare loss. The ASEC report concludes that 'the maximum deadweight loss is between $174,000 and $214,000 per year.' See ASEC (2014), 'Selection of the WACC Percentile in the Context of Risks f aced by Electricity Distribution', p. 28.

Figure 4.7 Estimating the scale of the deadweight welfare loss for residential customers



Source: Oxera.

Estimates of the elasticity of electricity demand for commercial and industrial customers are typically in a range similar to the following.

- NIEIR (2007) estimated the elasticities of demand for commercial and industrial customers to be -0.35 and -0.38, respectively;
- Taylor et al. (2005) estimated a range for the elasticity of industrial electricity demand of -0.05 to -0.26;
- Beenstock et al. (1999) estimate the range for industrial demand to be -0.002 to -0.44.

Industrial users consumed 14,726GWh of electricity in 2012, while commercial electricity consumption was 9,131GWh. For example, based on a change in prices of 1.3% for these customers (i.e. the same increase in price as for residential customers), and assuming that this translated to unit prices, the deadweight welfare loss for non-residential customers associated with setting the WACC at the 75th percentile would be in the region of NZ$50,000 to NZ$100,000. [37] A 5% price increase for these customers could result in a combined deadweight welfare loss in the region of $750,000 to $1.5m. [38]

This indicates a wide range for the scale of the deadweight loss, and all these estimates are based on a range of assumptions. However, the scale of the effects is relatively small—in particular, by comparison to the price effect, the 75th percentile approach results in charges being over NZ$100m higher. Therefore, while the exact deadweight loss may be difficult to measure, we do not consider that it should have a material impact on the Commission's choice of percentile.

[37] This range is the combined effect on industrial and commercial customers. The bottom and top of the range relate to price elasticity of demand assumptions of –0.2 and –0.4, respectively.
[38] Furthermore, the tariff structure is likely to have an effect on the size of the deadweight loss (e.g. greater use of fixed tariffs will likely reduce the deadweight loss).

4.3 Indirect effects

This section considers two indirect effects from the prices being different to the competitive level:

- an investment effect, which could affect investment incentives across the supply chain;
- a competitive effect, which could affect the competitiveness of New Zealand-based companies that have high energy consumption and export a significant amount of their product.

4.3.1 Investment incentives across the value chain

Setting the WACC too high or too low for network businesses results in inefficient price signals being sent and could have the potential to distort investment incentives in other parts of the supply chain, and, potentially, for providers of substitute products.

If the WACC is set too high, the potential sources of distortions to investment incentives could be:

- incentives for the transmission and distribution companies to ‘gold-plate’, in order to benefit from the return being above the company’s actual cost of capital;
- diluted investment incentives for generation/production companies and downstream providers (if there is a demand effect);
- stronger incentives for investment by providers of substitute products.

The cost associated with distorted investment incentives in other parts of the supply chain is inherently difficult to quantify. However, in the electricity sector, the impact could be small for two reasons. First, electricity retailers are typically asset-light businesses with limited potential for increased investment expenditure. Second, there are limited potential substitutes for transmission and distribution, retailers are likely to be inelastic purchasers of electricity. The relatively small volume effect from an increase in transmission and distribution charges suggests that there is likely to be minimal impact on the size of investment in the upstream (generation) and downstream (retail) markets. As such, it is not included in the analysis.

More generally, the impact of the choice of WACC percentile on investment decisions is not straightforward, and is likely to differ on a project-by-project basis (see Box 4.2 below).

Box 4.2 Impact of the choice of WACC percentile on investment incentives

The decision by a direct or indirect purchaser of electricity transmission and distribution services to invest will depend on the return expected from that investment. Depending on what the investment is, the expected return may be affected by the choice of WACC percentile for the transmission and distribution companies.

- **The incentive to invest may be reduced as a result of the WACC being set at the higher percentile**. For example, assume that a downstream firm is considering making a capacity-enhancing investment but the higher transmission and distribution cost has lowered the profit the firm would make on the additional output. If the decision to go ahead would have been marginal with the midpoint WACC, the implementation of the 75th percentile approach might result in the firm deciding not to make the investment because the return would no longer be sufficient.
- **The incentive to invest may be strengthened**. For example, assume that a downstream firm is considering an investment in R&D to develop a product that uses less electricity. In this case, the higher price of electricity resulting from setting the WACC at the 75th percentile increases the benefits of the investment, and thus increases the likelihood of investment.
- **Investment incentives may be unaffected.** For example, assume that a large energy user is considering investing in a new product for which electricity is not an important input. Although the energy user's profits from its original business may be reduced as a result of using the 75th percentile, its decision to invest in the new product will only depend on the cost of the investment and the expected return, so the choice of percentile should have no impact on its investment incentives.

Source: Oxera

While all three scenarios are feasible, the impact of the choice of the WACC percentile will depend on whether the change in prices is sufficient to distort market conditions to actually drive a change in investment. In practice, the analysis suggests that the impact on investment incentives for industrial and commercial incentives is likely to be limited. The impact of any changes in electricity prices resulting from the WACC percentile on these users' cost bases is small in most instances (see Table 4.2).

Table 4.2 **Impact of an increase in electricity prices on input costs for different industries**

Industry	Approximate proportion of electricity costs to total input costs	Impact of an increase in electricity price of:	
		1%	5%
Agriculture, forestry and fishing support services	0.4%	Less than 0.01%	Less than 0.1%
Banking and financing	1.0%	0.01%	Less than 0.1%
Construction services	0.3%	Less than 0.01%	Less than 0.1%
Dairy cattle farming	3.7%	Less than 0.1%	Less than 0.25%
Dairy product manufacturing	0.3%	Less than 0.01%	Less than 0.1%
Meat and meat product manufacturing	1.6%	Less than 0.1%	Less than 0.1%
Non-residential property operation	7.1%	Less than 0.1%	Less than 0.5%
Petroleum and coal product manufacturing	0.6%	Less than 0.01%	Less than 0.1%
Primary metal and metal product manufacturing	16.6%	Less than 0.25%	Less than 0.85%
Pulp, paper and converted paper product manufacturing	10%	0.1%	0.5%
Sheep, beef, cattle and grain farming	1.2%	Less than 0.1%	Less than 0.1%
Supermarket and grocery stores	9.6%	Less than 0.1%	Less than 0.5%
Telecommunications services	0.6%	Less than 0.01%	Less than 0.1%
Wood product manufacturing	2.8%	Less than 0.1%	Less than 0.25%

Source: Oxera calculations based on Statistics New Zealand (2012), 'National Accounts input-output tables: Year ended March 2007', July.

There is, however, potential for the transmission and distribution companies to overinvest as the return they will earn on the investment could exceed their actual cost of capital. If this happens, customers pay for both the investment (through the depreciation charge) and the allowed return at the actual WACC percentile.

The potential for overinvestment is likely to be partly constrained by regulatory scrutiny of the companies' CAPEX plans. For Transpower, the level of CAPEX added to the RAB (and thus earns a return and depreciation allowance) is subject to ex ante approval by the Commission, with any excess CAPEX incurred during the regulatory period included in the RAB (through annual wash-ups) only where the Commission determines that it has been incurred efficiently. As a result, a well-functioning regulatory regime should ensure that—while there will be incentives to overinvest—the impact of setting the WACC at the 75th percentile on actual investment levels will be moderated.

The CAPEX allowance for the electricity distribution businesses, on the other hand, is currently not subject to a detailed ex ante review of their business plans and all investment is rolled into the RAB without ex post review to avoid asset stranding. As such, there is, arguably, greater likelihood that the choice of WACC will influence investment incentives for distribution companies than it will for Transpower.

4.3.2 Competitive distortions

A second potential indirect effect is for New Zealand-based companies to become less competitive than internal competitors. In order to estimate the scale of revenues which could be subject to a competitive impact, Oxera has focused on identifying sectors for which:

1. a large proportion of input costs is related to energy costs—where this is not the case, changes in energy prices could be expected to have a minimal impact on a company's competitiveness;

2. a large proportion of total revenues is derived from exports—where this is not the case, any change in energy prices should affect all companies in a (roughly) equal manner, and thus will have no impact on each one's competitiveness.

For this purpose, Oxera has used input–output matrices for the New Zealand economy (see Box 4.3).[39]

Box 4.3 Input–output tables

Input–output tables show the relationships between industries, including the inputs that are used by each industry in order to produce goods and service. The most recent input–output tables published by Statistics New Zealand were released in July 2012 and cover the year ended March 2007. The tables split the New Zealand economy into 106 industries and 205 products.

Source: Oxera based on Statistics New Zealand (2012), 'Using national accounts input-output tables', July.

The input–output tables suggest that the industries with the highest proportion of energy input costs are:

- primary metal and metal product manufacturing;
- pulp, paper and converted paper product manufacturing;
- supermarket and grocery stores.

For all other industry categorisations used in the tables, energy is a small proportion of total input costs, and thus any change in the price of electricity is expected to have a non-material impact on final prices.

The New Zealand input–output tables show that the first two of these industries had exports of around NZ$2.7bn and NZ$1.9bn in the year ended March 2007, respectively. Supermarkets and grocery stores had much smaller exports and the extent to which they compete internationally is assumed to be immaterial.

For the primary metal and metal product manufacturing and pulp, paper and converted paper product manufacturing industries, energy costs account for around 10–15% of total input costs. If setting the transmission and distribution WACCs at the 75th percentile were to result in a 1.3% increase in energy prices, this would lead to an increase of less than 0.25% in the end price of these products, or, if the price increases could not be passed through, to a 0.2% impact on profit margins. This will reduce surplus by an amount directly linked to the higher prices, but the impact on investment will be relatively small. Therefore, this also supports the conclusion that the direct price effects resulting from higher charges should be the primary focus of the Commission in determining the appropriate choice of percentile.

[39] Statistics New Zealand (2012), 'National Accounts input-output tables: Year ended March 2007', July.

We note the findings of Boardman, Greenberg, Vining and Weimer (2011) that the effects in secondary markets can be ignored under certain assumptions when conducting cost–benefit analysis.

> Fortunately, price changes in most secondary markets are likely to be small. Most pairs of goods are neither strong complements nor strong substitutes. Hence, large price changes in the primary markets are usually necessary to produce noticeable demand shifts in the secondary markets. Thus, even when secondary markets are distorted, ignoring these markets may result in relatively little bias to CBA [cost-benefit analysis].[40]

This further supports the conclusion from the analysis above, with both suggesting that the scale of such effects is unlikely to be material to the decision on an appropriate percentile for the WACC.

4.4 Conclusions

Setting the WACC at a level above the midpoint has a direct price effect and this may become material. However, the secondary effects appear to be small, relative to this direct price effect, in particular:

- given low price elasticity and the tariff structure, changes in distribution and transmission prices should have a limited impact on overall energy consumption;
- the impact on the international competitiveness of New Zealand-based companies is also likely to be small, relative to the direct effect;
- investment incentives across the supply chain are unlikely to be materially affected, with the greatest risk being of gold-plating, which should be mitigated through the wider regulatory framework (see section 7 for further explanation).

Table 4.3 outlines the approximate additional annual cost for New Zealand electricity customers as a result of the WACC being set at the 75th percentile, based on the RAB estimates identified in this section.

Table 4.3 Annual cost of setting WACC above midpoint (NZ$)

Percentile	Increase in WACC relative to midpoint	Approximate cost	Approximate increase in T&D revenues	Approximate increase in residential price
50%	0.0%	$0m		0%
55%	0.1%	$20m	0.7%	0.2%
60%	0.3%	$40m	1.3%	0.5%
65%	0.4%	$60m	2.0%	0.7%
70%	0.6%	$80m	2.7%	1.0%
75%	0.7%	$105m	3.5%	1.3%
80%	0.9%	$135m	4.4%	1.6%
85%	1.1%	$165m	5.4%	2.0%
90%	1.4%	$200m	6.7%	2.5%
95%	1.8%	$260m	8.6%	3.2%

Note: The figures, rounded to the nearest $5m, are based on RAB values of around NZ$4.7bn for Transpower and NZ$10bn for the electricity distribution companies.

Source: Oxera calculations.

[40] See Boardman, A., Greenberg, D. H., Vining, A. R. and Weimer, D. L. (2011), *Cost-Benefit Analysis: Concepts and Practice*, Prentice Hall, 4th edn, Chapter 5. Similar arguments are made in Mohring, H. (1993), 'Maximizing, measuring, and not double counting transportation-improvement benefits: A primer on closed- and open-economy cost-benefit analysis', *Transportation Research*, **27**:6, pp. 413–24.

5 Wider social and economic effects of setting the WACC too high or too low

5.1 What is a 'wider effect'?

The previous section discussed the size of potential financial effects from setting the WACC too high or too low. As noted in section 3, the effects of regulatory failure may not all be financial. The choice of the WACC may affect the performance of the networks, and this may have a 'cost' to customers.

The WACC is used to set both the Default Price Path and the Customised Price Path, effectively giving a target for the average rate of profit to be earned by companies.

In evaluating the wider social and economic effects of the regulatory framework, and the choice of the WACC, we focus on medium- to long-term network reliability. The reliability of an energy network is the key output for the users of the network. Continued uninterrupted delivery of power is the primary focus for users. As reliability decreases, the probability of network failure (which is the result of complete loss of reliability) increases. In its submission, Transpower notes the following:

> constraining capital clearly has the potential over the long run to lead to lower levels of reliability. While system reliability is clearly a very high priority for Transpower, decreasing the financial attractiveness of investing could bring about subtle changes in approach to grid planning.[41]

For business customers, this may lead to reduced production, and, ultimately, a financial cost. For residential customers, this 'cost' may be reflected in lower quality of service, which also has a 'cost' in terms of a reduced value to the consumer.

In this section we identify what a material wider effect might look like. In the context of energy, we focus on the link between underinvestment and reduced network reliability that might eventually lead to network failure. This effect is recognised in regulatory precedent and widely described as the factor that influences the choice of a point estimate of the WACC being set above the midpoint of the estimated range. The concept of network failure is in practice an extreme effect, but one that will have increasing probability as network reliability decreases.

In principle, therefore, to assess the appropriate choice of percentile, it is necessary to define both the relevant customer outcome (i.e. deterioration in network reliability), and the related regulatory decision (i.e. the choice of the WACC). Given that both are difficult to measure, and the latter is subject to fundamental uncertainty, these are unlikely ever to be measured in a statistically robust manner. However, performing an analysis of what can be established, and understanding the scale of these effects relative to the other impacts, will support the Commission in exercising its judgement on the appropriate percentile.

There is no single definition of network failure. A study by the American Society of Civil Engineers (ASCE) recognises the difficulty in defining precisely the 'typical' failure event:

[41] Transpower (2014), 'Further Work on the Cost of Capital Input Methodologies: Request for further evidence', 1 May.

> [t]he periods of time can be unpredictable in terms of frequency and length, but the end result is a loss of reliability in electricity supply which imposes direct costs to households and businesses.[42]

In this section, we create a simplified model of the impacts of such a loss in network reliability in order that these can be considered alongside the impact of direct effects.

5.2 Separating probabilities from cost estimates

To assess the wider economic and social costs that would be incurred as a result of an event that led to a material failure in network performance, it is useful to separate the components that make up this expected cost:

- the cost incurred by society given the occurrence of a failure event;
- the likelihood of a failure event.

The separation is helpful because while many studies assess the former, little (if any) research has been published on the latter. As a result, despite the difficulty in measuring and quantifying the expected cost of failure, it is possible to obtain an informed estimate of one of its key components, which, as explained later in the report, can then be a component of the analytical framework. The next sub-section provides more details on the cost of a failure event.

5.3 What is the cost of a loss in network reliability?

A concept often used to measure the cost of reduced network reliability is VoLL, which represents the amount that customers would be willing to pay to avoid disruptions in their electricity supply—an alternative interpretation is that of an insurance premium. In fact, the VoLL is most often used for residential electricity users. That is because, unlike businesses and industrial users, it is difficult to estimate a direct financial cost generated by an interruption in electricity supply for residential customers. In that context, it is useful to express the cost of failures within the electricity network according to the characteristics of the user (e.g. residential versus industrial, or urban versus rural), as well as the type of outage (e.g. time of the day, week or year), as detailed in Figure 5.1 below.

[42] ASCE (2011), 'Failure to Act: The economic impact of current investment trends in electricity infrastructure', p. 8.

Figure 5.1 Estimating the value of reliability

Customer characteristics

- residential
  - costs of network failure more intangible (e.g. delays in activities)
  - value typically estimated using surveys (e.g. 'how much would you pay to avoid power interruptions?')
- industrial, commercial, agriculture
  - costs more tangible than for residential users (e.g. lost sales, equipment damage, labour productivity)
  - costs highest in construction and manufacturing sectors
- rural vs. urban

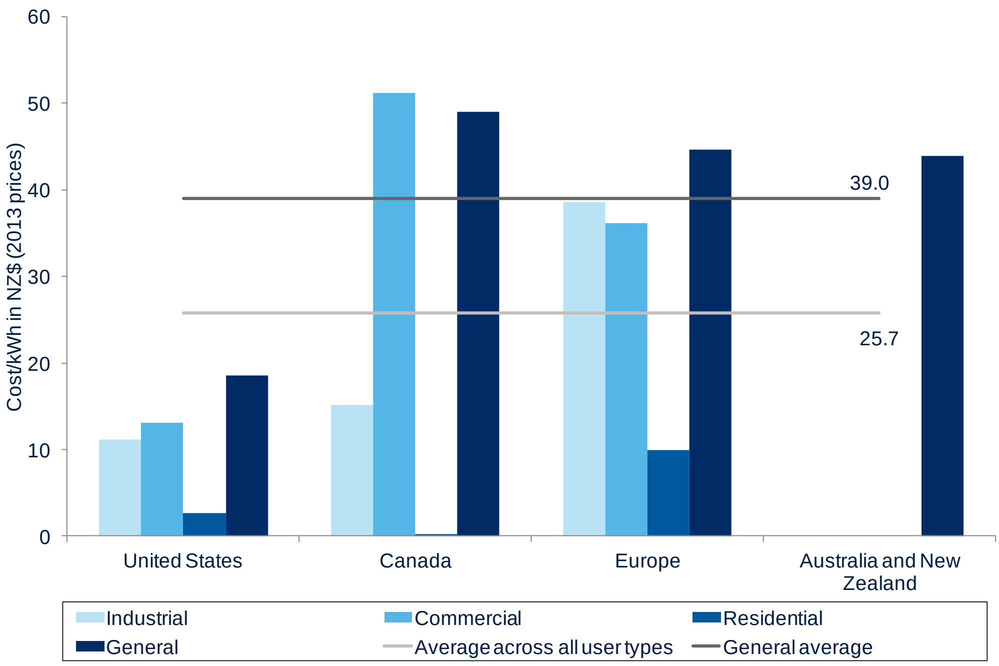
Type of outage

- **time of the day**: daytime outages tend to be more costly than evening or nighttime ones
- **time of the week**: weekday outages tend to be more costly than weekend ones
- **time of the year**: the mild variation in temperature between summer and winter in New Zealand suggests little difference in costs between various seasons
- **cost of restoring power**: certain types of power outage (e.g. hurricanes) imply higher operating costs incurred by energy companies to restore power

Source: Hickling, R., (2010), 'Value of customer reliability'; Sullivan et al. (2009), 'Estimated Value of Service Reliability for Electric Utility Customers in the United States .

A wide range of academic and organisational studies has sought to quantify the cost of a network failure for different regions of the world (see Figure 5.2).

Figure 5.2 Summary of studies on cost of power outages



Note: 'General' refers to studies where the costs of outages are not broken down by sector of usage. 'Average across all user types' includes 'general', as well as results for industrial, commercial and residential users. The costs of power outages are calculated as an average across available studies over time in each geographic area . The value of expected unserved energy in New Zealand was $21.5/kWh. The stated value in Australia was significantly higher, resulting in the stated average of around $40/kWh.

Source: Oxera analysis based on various academic studies.

As shown in Figure 5.2, these studies show a range for the cost of network failure across different countries, which appears to have been found to be lowest in the USA, and highest in Australia. The estimate for New Zealand, at just over $20/kWh, is slightly below the average across all regions. It is important to stress that the wide range of estimates observed across studies is possibly more a function of the difficulty in accurately inferring the cost of network failure than in systematic geographical or technological differences. However, averaging across studies and geographies over time may present an indicative estimate of such costs.

Given that the VoLL for New Zealand seems typical of that for other countries, it is reasonable to use estimates from studies of international outage costs as a first-order proxy to approximate the total cost implied by a power outage in New Zealand. This is not intended to provide a detailed estimate of costs, but is intended to provide an illustration of the scale of the potential effects of underinvestment.

Table 5.1 provides estimates of the cost to economies of network failure from a range of academic studies in the United States. The values provided reflect estimates of the economic costs of the various outages, both actual and projected. The analysis is illustrative of the potential cost to the New Zealand economy of a hypothetical network failure of a comparable size. These studies have primarily been focussed upon annualised amounts, ie. what could be the annualised cost of material outage events resulting from under-investment, prior to the effects being remedied.

Table 5.1 Summary of studies into economic cost of power outages

Study	Country	Event period (year)	Cost of outage (US$ bn)	GDP in year of study year (US$ bn) [1]	Cost (% of GDP)	NZ GDP in 2013 (NZ$ bn)	Implied cost of outages in NZ (NZ$ bn)[2]
Annual studies (i.e. studies of equivalent annualised effect)							
ASCE 2013	USA	2012–20	55	15,500	0.4	211	0.7
ASCE 2013	USA	2020–40	97	15,500	0.6	211	1.3
LaCommare et al. 2004	USA	2004	79	12,300	0.6	211	1.4
EPRI 2001	USA	2001	119–188	10,600	1.1–1.8	211	2.4–3.7
Swaminathan and Sen, 1998	USA	1998	39	9,100	0.4	211	0.9
Weather related outages only							
Campbell, 2012	USA	2012	25-55	16,200	0.15-0.4	211	0.3 - 0.7
Specific event							
Ontario Incident Analysis, 2006	Canada (Ontario)	2003	n/a	n/a	1.4	211	3.0
Reichl et al, 2013[3]	Austria	2013	2.3	417.6	0.6	211	1.3

Note: [1] GDP is reported in current prices. [2] Based on the same proportion of GDP as in country of occurrence [3] Assessment of the impact of a 48-hour outage.

Source: Oxera analysis, based on various academic studies: ASCE (2011), 'Failure to Act: The economic impact of current investment trends in electricity infrastructure'; Campbell, R. J. (2012), 'Weather-Related Power Outages and Electric System Resiliency', Congressional Research Service, 28 August; LaCommare, K., Eto, J. (2004), 'Understanding the cost of power interruptions to U.S. electricity consumers'. EPRI (2001), 'The Cost of Power Disturbances to Industrial & Digital Economy Companies'.Wyman, M. (2008), 'Power Failure: Addressing the Causes of Underinvestment, Inefficiencyand Governance Problems in Ontario's Electricity Sector', May; Reichl, J., Schmidthaler, M and Friedrich, S. (2013), 'Power Outage Cost Evaluation: Reasoning, Methods and an Application', Journal of Scientific Research & Reports, 2:1, 249-276; Swaminathan, S., and Sen, R. K. (1998), 'Review of Power Quality Applications of Energy Storage Systems', Sandia National Laboratories, July. Data from World Bank and Statistics New Zealand

(2013), 'Regional Gross Domestic Product', March, available at http://www.stats.govt.nz/browse_for_stats/economic_indicators/NationalAccounts/RegionalGDP_HOTPYeMar13.aspx; last accessed 15 May 2014.

The results of the annual studies illustrated in Figure 5.1., all of which are based in the USA indicate that network failure has a negative impact on the US economy of between 0.4% and 1.8% each year. If equivalent levels of network failure occurred in New Zealand, this would cost the economy between NZ$0.7bn and NZ$3.7bn annually.

Alternatively, a single extreme incident of network failure, such as that which occurred in New York and Ontario, Canada in August 2003 (and lasted between 7 and 48 hours, depending on area) has been estimated to cost a local economy a one-off cost equivalent to as much as 1.4% of its annual GDP. If an equivalent failure were to occur in New Zealand, it could cost the economy an estimated NZ$3bn within the relevant period of the impact. This is likely to represent a relatively extreme example of the type of impact which could occur from under-investment, but is nevertheless representative of a specific case of such an impact. Moreover, Reichl et al (2013) estimate that the cost of a 48-hour power outage in Austria would be around 0.6% of its annual GDP.[43] The equivalent cost in New Zealand would be around NZ$1.3bn.

On the whole, for the purposes of this report, a cost in the order of NZ$1–NZ$3bn is considered to indicate the scale of the cost of network outages that could occur as a result of underinvestment. Specifically, this is likely to represent an estimate of the scale of the annualised impact of such underinvestment, should it lead to increased network outages, or the potential size of a severe one-off effect. The exact size and length of a series of events is beyond the scope of this assessment, but this scale should be a suitable reference point for the Commission in considering the choice of percentile. This appears to be broadly consistent with recent evidence on the VoLL from the Electricity Authority, although this evidence also demonstrated that the cost would vary significantly for different customer groups, demonstrating that the actual cost would be heavily linked to the most likely nature of any event that could happen in New Zealand.[44]

The next section examines whether such a failure event might indeed be caused by a regulator's decision on the allowed rate of return for regulated networks.

5.4 Can a low WACC lead to network failure?

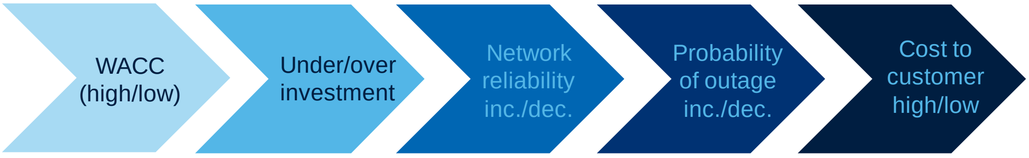
To assess the link between the allowed WACC and the occurrence of network failure, it is useful to consider separately the following.

- Is there a link between the WACC and investment?
- Is there a link between investment and network failure?

Figure 5.3 illustrates the flow of the proposed argument.

[43] Reichl, J., Schmidthaler, M and Friedrich, S. (2013), 'Power Outage Cost Evaluation: Reasoning, Methods and an Application', *Journal of Scientific Research & Reports*, **2**:1, 249-276.
[44] See Electricity Authority (2012), 'Investigation into the value of lost load in New Zealand – Summary of findings'.

Figure 5.3 Proposed link between WACC and cost to end-users



Source: Oxera analysis.

Each of these points is examined further below.

5.4.1 Is there a link between the WACC and investment?

According to finance theory, a firm will invest only in projects that offer an expected return equal or above their cost of capital. This is also the case in a regulatory context, where 'some kind of guarantee about the rate-of-return on assets is inevitable if the concerns about sub-optimal investment are to be alleviated'.[45]

However, the WACC is not just applied to new investment. We consider the significance of the impact of the WACC for different parts of the asset base. In practice, these point to a need for a consistent regulatory approach in order to minimise the risks of distortions from a WACC that is too low.

- **New (but uncommitted) investment**. Much of the rationale for the WACC being set above current levels draws on the 'option' that the company has to not invest, should the WACC in the price control be below the WACC of the company. This could point to the need to adjust for new investment only. However, the short-term risk on new investment is, in any case, likely to be high, and the short-term required return is potentially higher than the WACC. The WACC therefore works as an incentive to invest if it is applied consistently over the asset life, during the higher-risk investment periods and the operation phase. Nevertheless, if the investor perceives that the long-term WACC has risen above the assumed WACC, the option to wait and reduce investment may be exercised.
- **Existing assets**. In theory, the existing asset base is low risk, and could be argued to command no premium. Recognising this, theories have been proposed which no longer apply the WACC to existing assets, but seek to apply a debt rate.[46] In practice, however, as described above, if the correct WACC is applied over the asset life, this will appropriately reward investors for the investment and operational risks.
- **Commitments during price control**. Once commitments have been made, there is no need for a further premium. However, equally, to agree to commitments, the asset owner will need sufficient return expectation to accept the review in the first place and forgo the option to delay investment. The allowed return on such committed investment could be assessed in line with that of existing assets if the regulator is bounded by a duty to finance, which would further reduce the risk that the investor suffers future losses on the investment. In the absence of such financing duty, the required return on committed investment might arguably be closer to that on new (but uncommitted) investment: but, as explained above, this is arguably in line with

[45] Cowan, S. (2002), 'Price-cap Regulation', *Swedish Economic Policy Review*, **9.**
[46] See, for example, the discussion on the 'split cost of capital' in Helm, D. (2009), 'Infrastructure investment, the cost of capital, and regulation: an assessment', *Oxford Review of Economic Policy*, **25**:3, pp. 307–26.

that of existing assets given the necessity to adopt a 'whole-life' approach to assessing investment risk.

- **Anticipated but uncommitted investment**. Even if a commitment structure were used to deter underinvestment, the asset owner might, if the WACC is too low, seek to reduce the level of investment over time, and rely on operating costs where feasible.

- **Innovation**. Although technological innovation might be less relevant in the electricity distribution and transmission sectors than in other sectors, notably telecommunications, there are also risks around not making any allowance for investment in new technology (e.g. smart grids, renewable energy). Given that it is for the companies, rather than the Commission, to determine the level and nature of innovation, this is another area where the Commission should potentially be cautious in deterring investment.

On the whole, the exercise of considering the various aspects of the asset base and types of investment (according to their level of commitment) is helpful in that it highlights the importance of setting the allowed WACC in a consistent manner based on a whole-life approach, which is akin to taking a long-term view of the asset risks.

It is also important to consider this link (between WACC and investment) within the broader context of the regulatory framework. Several studies argue that the mere presence of price regulation will lead to underinvestment, for example:

> the firm chooses to 'under-invest' (relative to the competitive benchmark) when constrained by a price cap is that, given demand uncertainty, it takes account of possible future adverse market movements[47]
>
> even low deviations from optimal price capping can have an impact on the volume and timing of investment decisions of regulated companies[48]
>
> the FCC has set too low a regulated price for telecommunications services from new investment, and the result will be a decrease in new investment in telecommunications services and network infrastructure below economically efficient levels[49]

The impact of regulation on investment is also likely to be linked to on the distance between the regulated price cap and the counterfactual of an 'unconstrained' market price. According to Nagel and Rammerstorfer (2008), only large deviations from unconstrained price would lead to underinvestment.[50] In the case of electricity networks, this differential is likely to be significant.

Such findings could imply that even a high WACC percentile might not offset the broader disincentive effect that is generated by the existence of price caps for electricity network charges in the first place.

Certain features of regulation, such as incentive mechanisms, can mitigate these investment 'disincentive' effects. For example, Roques and Savva (2006) claim that 'underinvestment effects are considerably weaker where the regulatory

[47] Dobbs, I. (2004), 'Intertemporal Price Cap Regulation under Uncertainty', *The Economic Journal,* **114**, pp. 421–40.
[48] Nagel, T. and Rammerstorfer, M. (2008), 'Investment Decisions under Market Concentration and Price Regulation', available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=100912
[49] Hausman, J. (1997), 'Valuing the Effect of Regulation on New Services in Telecommunications', *Brookings Papers: Microeconomics*.
[50] The authors find that a price cap that is 10% below unconstrained price levels leads to only a 1% underinvestment, while a price cap that is 35% too low leads to a 34% underinvestment. See Nagel, T. and Rammerstorfer, M. (2008), 'Investment Decisions under Market Concentration and Price Regulation', available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=100912

regime includes incentive mechanisms, rather than pure price caps.'[51] Regulatory frameworks built around a set of predetermined outputs or outcome targets generate tangible incentives for firms to optimise their operating and investment decisions. In such cases, the potential costs of earning a 'low' allowed WACC on investment would be at least partly (or even fully) offset by the potential benefits from reaching the targets specified by the various incentives mechanisms. Furthermore, in cases where a reduction in investment is expected to lead to lower performance against these incentives, the company would be likely to consider alternative solutions (for instance, OPEX alternatives) to maintain a desired level of performance against the regulatory outputs or outcomes.

This section has summarised the potential sources of evidence to support a link between the WACC, an underinvestment problem, in particular to the extent that the nature of any underinvestment problem will be to increase the risk of events such as those highlighted in section 5.3 above. The evidence reviewed in this section highlights that:

- any impact of underinvestment is more likely to be noticeable in the long term, hence the direct link between WACC and underinvestment is harder to observe and quantify;
- the imposition of price caps, considered in isolation, can lead to sub-optimal investment decisions as firms seek to increase short-term cash flows;
- other parts of the regulatory framework (for instance, incentive mechanisms) can play an important role in mitigating the underinvestment problem.

Hence, in summary, it appears that in regulated markets, particularly those where the regulation is the primary driver of price, the level of allowed return will distort investment incentives, and therefore a low return will increase the risks around underinvestment.

We discuss the practical implications in more detail in section 7, and the extent to which the risk of underinvestment is mitigated, or in some cases enhanced, by the wider regulatory framework. In this section we focus on the nature and scale of the events that could occur as a result of the underinvestment which might be the result of such regulatory failure.

5.4.2 Is there a link between investment and an increase in network outages?

The obvious answer is yes: a network that is left to depreciate without adequate maintenance and without investment in replacing ageing assets is bound to become less reliable (and more prone to failure) over time. In a regulatory setting, the existence of an implicit contract between the regulator and the company implies that although investment may fluctuate in the short term, deviations from long term investment 'promises' are unlikely to be such that network reliability is materially affected.

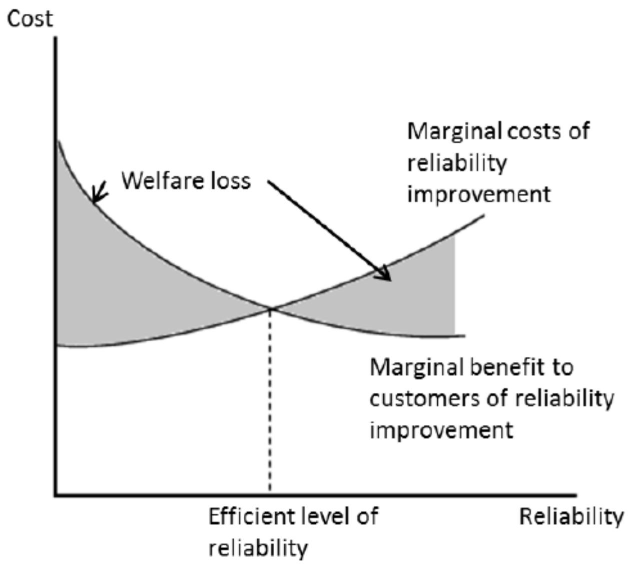
The link between investment and network failure is harder to establish as part of an analytical framework, mainly because it depends on the actual state of the network with and without investment. This will vary not only across sectors but also across companies within a given sector. Even within a given network, the

[51] Roques, S. and Savva, N. (2006), 'Price Cap Regulation and Investment Incentives under Demand Uncertainty', working paper, available at http://www.eprg.group.cam.ac.uk/wp-content/uploads/2014/01/eprg0616.pdf

quality of the infrastructure would be unlikely to be standardised at all connection points.

The state of a network determines the incremental benefits (in terms of reliability) from additional investment. As illustrated in Figure 5.3, the reliability benefits of additional investment are likely to be greatest in less well-maintained networks, while for networks that are already highly reliable, the marginal gains in reliability are likely to be considerably smaller.

Figure 5.4 The cost of reliability



Source: Australian Government (2013), 'Electricity Network Regulation', Chapter 14: Building a reliability framework in order to benchmark', 26 June, p. 534.

Table 5.2 summarises five major network failures that have been directly linked to prolonged periods of underinvestment.

Table 5.2 Network failures related to underinvestment

Network failure	Summary of event and causes
South Africa (2008–14)	Eskom, South Africa's largest private utility which provides 95% of the nation's electricity has imposed widespread blackouts since 2008. As a consequence of decades of underinvestment and a lack of capitalisation, exacerbated by lack of political impetus, the current capacity is inadequate to meet South Africa's growing power needs threatening economic growth. The need to swiftly upgrade the infrastructure has seen average tariffs rise 200% in the last five years
Northern and Eastern India (2012)	In what was termed as the largest ever power failure in the Indian subcontinent, nearly 600m people were left without electricity supply. The primary reason for the collapse of entire regional grids was due to overloaded transmission lines. The Planning Commission had earlier pointed out the shortages in core equipment availability (boilers, turbines and generators), bottlenecks in mining and transporting coals and delays in investment decisions that had resulted from consistent underinvestment over the past six decades
Nigeria (2013–2014)	Between April 2013 and June 2014, Nigeria recorded 28 system failures, 22 were total and 6 were partial. The failure to build a new infrastructure over the years and inadequate operation and maintenance network resulted in a weak transmission system. According to the Presidential Task Force on Power, in 2011 the country registered the biggest gap between supply and demand for electricity in the world. The underinvestment in the power sector has resulted due to the centralised ownership structure where the federal government operates as a vertically integrated investor in generation, transmission, distribution, procurement, construction, operation and maintenance
New York, U.S.A (2012)	The southern part of Manhattan was without power for almost a week due to failure of a major sub-station hub in the electrical grid. Nobel laureate Professor Michael Spence identified that lack of investments in resilience, redundancy, and integrity of these systems was the key factor for the network failure
Ontario, Canada (2003)	In August 2003, a large power outage struck North America. A tree branch disrupting a power line in Ohio led to 50m people being left without power, highlighting the ageing and weak electrical system. The lack of investment in the network and generation assets was linked to the government constraining the market and imposing regulation on retail and wholesale prices as a result of the market liberalisation in 2002

Source: Marais, J. (2013), 'Can SA's Eskom keep the lights on?', *The Africa Report*, 6 May; *BBC News* (2014), 'Power restored in South Africa as energy emergency ends', 6 March; *The Economic Times*, 'Northern and Eastern grids collapse : Biggest power failure in India', 31 July 2012; Biswas A., (2013), 'India: Policy Darkness in the Power Sector', January; Opara S. (2014), 'Power: 28 system failures recorded in 16 months', *Punch*, 1 June; Presidential Task Force on Power (2010), 'Roadmap for power sector reform', August; Spence, M. (2012), 'Underinvestment in Resilience', November 8th; Wyman, M. (2008), 'Power Failure: Addressing the Causes of Underinvestment, Inefficiencyand Governance Problems in Ontario's Electricity Sector', May.

As evidenced above, the threat of underinvestment causing network outages with significant costs is not just limited to emerging markets trying to bridge the gap between supply and demand, but is also found in developed economies where networks with sufficient capacity can fail due to resiliency issues, and the regulatory framework can be one of the causes of such failure.

5.5 Summary

The existing body of literature is consistent with the presence of a link between the parameters used to set price caps (including the allowed WACC) and wider social and economic costs related to potential or actual network outages.

This link is difficult to measure precisely partly because it is hard to untangle the effects of the existence of a price cap from other factors that might lead to underinvestment and eventually (possibly) a failure event. In addition, it is possible to implement other regulatory mechanisms that will reduce the strength of the link to the WACC percentile, such as incentive mechanisms linked to clearly specified output or outcome targets.

In terms of the cost of failure events, the evidence reviewed in this section suggests that an appropriate illustrative estimate of the scale of the effect is likely to be of the order of NZ$1– NZ$3bn if there is persistent underinvestment. This implies that a regulatory intervention that reduces the probability of failure by 1% would lower the expected cost of failure events by an amount of the scale of NZ$10m–NZ$30m. While there will be uncertainty around the true impact of any regulatory intervention, this provides useful supporting evidence of the scale of the potential benefits to be assessed against the costs of allowing a higher percentile for the WACC.

6 The level of risk and uncertainty around the WACC

In coming to a view on the appropriate percentile, it is important to understand both the scale of the impacts of the WACC being set too high or too low and the likelihood of those events. This section outlines the actual size of the risks associated with the choice of WACC. This technical analysis is then considered alongside the impacts identified in the previous section, when coming to a series of options and recommendations for the Commission.

6.1 The Commission's approach to the level of uncertainty over the WACC

Figure 6.1 illustrates the level of uncertainty over the WACC, based on the Commission's methodology. The Commission's approach assumes that certain WACC parameters, which cannot be observed directly from the financial markets, have a measurable uncertainty over their actual values. The range is estimated as a normal distribution, or 'bell curve'. This recognises that there is no strict limitation on the extent to which the WACC could differ to expectations, but the probability of a small error is greater than the probability of a larger error. The assumptions used by the Commission within the cost of capital for electricity (distribution and transmission) within the current IMs are summarised in Table 6.1.

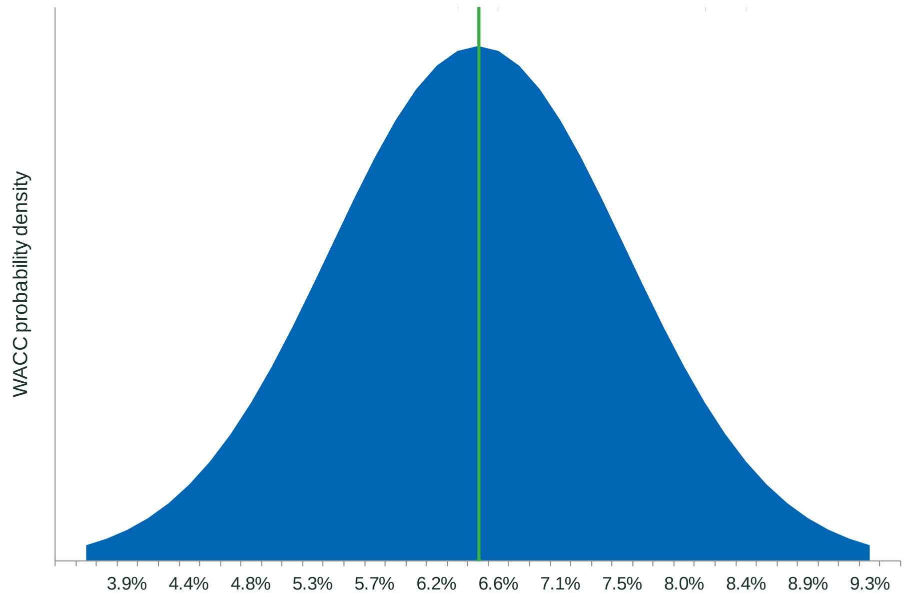
Table 6.1 The Commission's assumptions for the cost of capital for EDBs and Transpower

Parameter	Point estimate	Standard deviation
Leverage	44%	0
Risk-free rate	4.64%	0%
Debt premium	2.0%	0.15%
Debt issuance cost	0.35%	0
Asset beta	0.34	0.13
Equity beta	0.61	0.23
TAMRP	7.1%	1.5%
Corporate tax rate	28.4%	0
Investor tax rate	28.2%	0
WACC (post-tax)	6.49%	

Source: Commerce Commission (2010) 'Input Methodologies (electricity distribution and gas pipeline services): Reasons Paper', p. 167.

Figure 6.1 illustrates the impact of these assumptions. Based on a central estimate for the WACC of 6.5%, there is a probability around 3% that the Commission could be as much as 2% 'wrong' in its central estimate in either direction—i.e. that the true WACC could be either above 8.5% or below 4.5%. The probability that the WACC is actually as low as 3% or as high as 10% is so small that it can be discounted.

Figure 6.1 WACC uncertainty based on the Commission approach



Source: Oxera analysis, based on Commerce Commission (2010) 'Input Methodologies (electricity distribution and gas pipeline services): Reasons Paper', December.

The impact of this uncertainty is that investors may make losses on investment in the network. If the assumed WACC is lower than the actual WACC, investors effectively see a reduction in the value of their assets from investment. However, given this assumption around the size of the uncertainty, the size of the potential loss for investors will fall as the percentile increases.

Figure 6.1 is based on the Commission's methodology as summarised in Table 6.1. This reflects that, at the point in time when the Commission determines the WACC, it may be 'wrong' due to the difficulty in measuring the parameters, and, in particular, the beta. It does not reflect that, in addition, the WACC may change over time. We discuss this further in section 6.3 below.

6.2 Measuring the risk to investors: the 'probability of loss'

This section illustrates, for an investor in a New Zealand electricity network, the size and the impact of this uncertainty on the investor, in terms of the 'probability of loss'. If the WACC is set at the midpoint, there is by definition a half chance (50%) that the actual WACC at the start of the period is above the assumed WACC. There is also a 17% chance that the differential between actual and assumed WACC represents a 1% shortfall, and a 3% chance that the differential in WACC is as much as a 2% shortfall. Moreover, as considered further below, the movement of WACC parameters over time is likely to magnify the uncertainty over the IM period.

The probability of loss is therefore a relevant concept for the underinvestment problem'. Investors will require a certain level of return or 'hurdle rate', below which they will become more likely to reduce investment.

Box 6.1 The 'probability of loss' approach

One hypothesis is that the underinvestment problem will be caused by the **size of the differential between the actual and assumed WACC**. If some trigger is breached for this differential, investors will have the incentive to minimise investment.

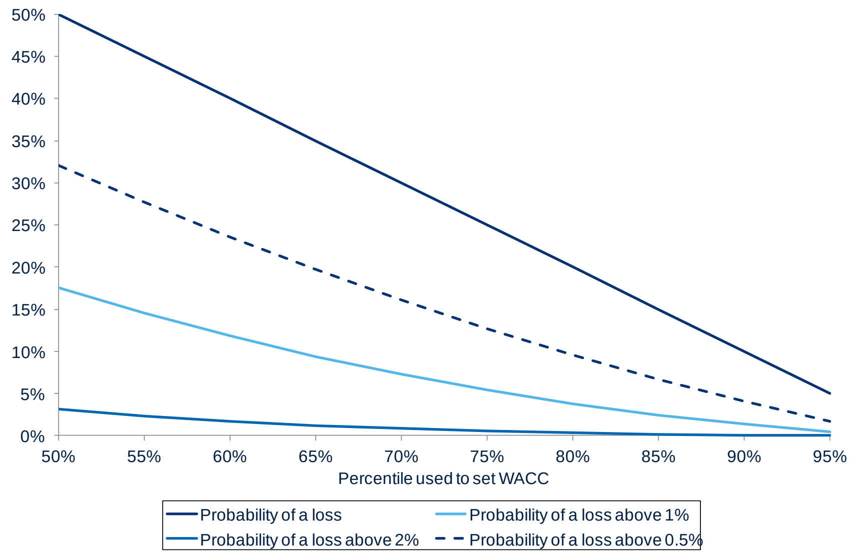
In reality this trigger is unlikely to be as low as 0%, given the difficulty in measuring the WACC, which makes a very small difference both comparable to a 'rounding error' and small in the context of the potential for the WACC to be re-set over the life of the assets. However, the assumption is that, at the trigger level, investment will be minimised, and the risks associated with the underinvestment problem will arise in practice.

The **'probability of loss' approach** therefore assumes that the decision on the percentile should be informed by the probabilities of certain triggers being met, and it is for the Commission to decide which trigger to apply—i.e. whether to assume that a 0.5%, 1% or 2% shortfall is the best assumption for the level at which the underinvestment problem is likely to arise.

The actual differential that will affect electricity companies' investment behaviour will depend on a wide range of factors, including the strength of perceived risks from quality incentives. However, for example, a 1% differential would potentially mean an upfront loss of over 10% on any investment made, which will provide clear disincentives to the companies, potentially greater than those that arise from short-term regulatory measures.

Figure 6.2 illustrates these risks in practice. As the percentile used to set the WACC increases, the probability of any relevant 'trigger' for underinvestment being met will reduce, as will the size of any loss. At the 75th percentile, the risk that the actual WACC is above the estimated WACC is 25%, but the probability that the differential is as high as 2% is only 0.6%.

Figure 6.2 The 'probability of loss' for different triggers, given the choice of WACC percentile



Note: Based on the Commission's approach to measurement uncertainty only.

Source: Oxera analysis, based on Commerce Commission (2010) 'Input Methodologies (electricity distribution and gas pipeline services): Reasons Paper', December.

Another way of characterising the risk to investors is the 'expected loss'

The analysis above shows the probability of any loss for investors based on a certain level of trigger for the differential between actual and assumed cost of capital. In other words, the 'probability of loss' analysis calculates the likelihood that the WACC will be higher than the assumed WACC, but does not consider the size of the difference between these two measures.

The use of the probability of loss in coming to a conclusion on the percentile would therefore reflect an assumption that underinvestment will occur if a trigger is met, and otherwise there will be no underinvestment.

However, in assessing the need to compensate investors for a higher WACC, not only the probability of a loss, but also the scale of it could be considered. This would be more appropriate if the level of underinvestment is likely to be linked to the size of any differential, or in assessing the value of the protection (or insurance) provided against the underinvestment problem by increasing the percentile.

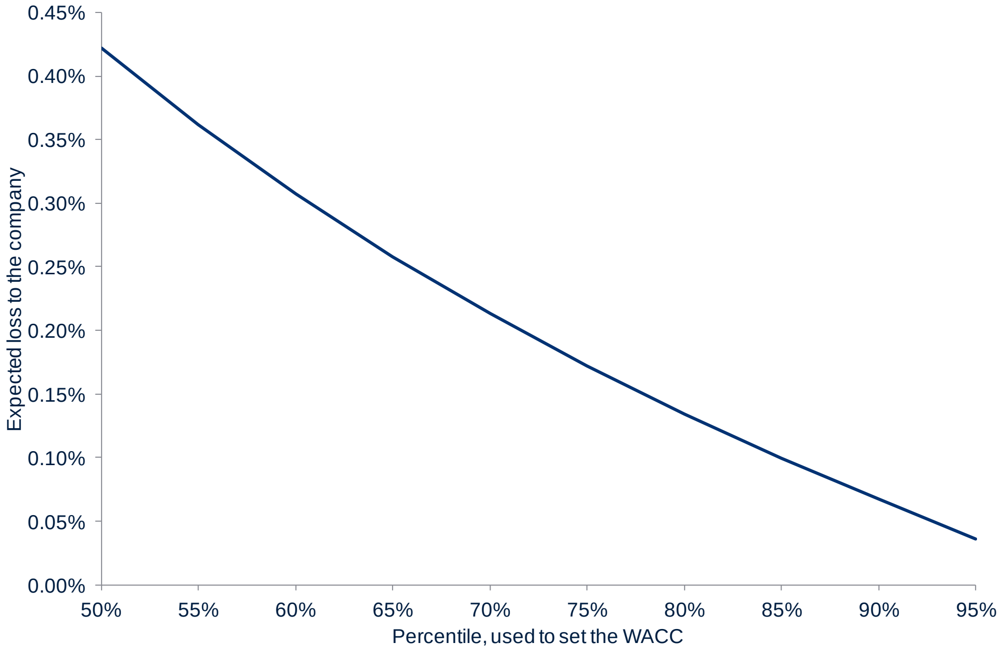
In assessing the value of this protection, we consider the concept of the 'expected loss' for different choices of the percentile. The expected loss represents the average of all potential losses, weighted by probability. To understand the concept of expected loss, consider a simple example:

- the probability of loss is 50%, with a 50% chance of a profit
- there is a 30% probability of a 0.5% loss; and
- there is a 20% probability of a 1% loss

In this example, the 'expected loss' is 0.35% = 0.5%*30%+1%*20%. In common terms, the 0.35% represents the cost of insuring against loss. By paying a 0.35% premium, all these losses could be covered.

Figure 6.3 illustrates this for electricity companies based on the assumed distribution for the WACC explained in Figure 6.1 above. This assumes that there is no underinvestment, and that companies will invest regardless of the WACC level.

Figure 6.3 Expected losses for electricity companies if there is no option for underinvestment



Source: Oxera analysis, based on Commerce Commission (2010) 'Input Methodologies (electricity distribution and gas pipeline services): Reasons Paper', December.

On average, the regulated business can expect a 0.42% loss if the WACC is set at the 50th percentile, and this falls to 0.17% at the 75th percentile.

This is again potentially relevant to the level of compensation required by the investor, and the amount that customers should potentially be willing to pay. As described above, the expected loss could be comparable to the 'insurance' premium that customers would be required to pay to insure the companies against any losses. In theory, the cost of insuring against the downside risk identified by the Commission should only be 0.42% (as a WACC adjustment) under the use 50th percentile. This would fall to 0.17% at the 75th percentile.

Box 6.2 The 'expected loss' approach

Another hypothesis is that the underinvestment problem will be caused by the WACC differential identified in Box 6.1 above, and that this could be offset by customers paying an 'insurance premium' to cover against this risk, via an uplift to the WACC.

The **'expected loss' approach** would therefore consider the value to customers of reducing the downside risk for the investor, assuming that investors will seek to underinvest to offset the risk of value reduction, and that the underinvestment problem will increase with a higher differential.[52] The 'expected loss' represents the size of downside risk for investors. As long as the WACC is at or above the 50th percentile, this will be offset by 'expected profits' in cases where the actual WACC is below the assumed WACC. The relevance of the expected loss is that it represents a notional 'insurance premium' to offset the underinvestment problem.

Figure 6.2 illustrates the scale of the 'expected loss' under different percentiles. The impact of the use of the 75th percentile is to reduce expected losses by 0.25%, from 0.42% in the case of the 50th percentile, to 0.17% in the case of the 75th.

In principle, one approach to managing the underinvestment problem could be to provide investors with compensation for expected loss in return for a commitment to investment, even where that investment is not NPV-positive.

However, as discussed in section 5, under the typical regulatory framework, including that in New Zealand, in practice the 'option' to underinvest is likely to still exist, and therefore customers cannot eliminate the underinvestment problem. If customers seek to pay an 'insurance premium', this may reduce but not eliminate the risk of underinvestment.

The next section proposes an approach based on the estimation of the probability of loss for investors in electricity networks in New Zealand. This approach appears to be more consistent with the regulatory framework in New Zealand, which seeks to place some constraints on investment, but also provides some flexibility to design a suitable long-term investment programme. In practice, both values may be relevant, as the correct approach may depend on whether the Commission believes that there will in practice be a 'trigger' for underinvestment (resulting in a probability of loss approach) or a gradual increase in underinvestment with losses, which can be reasonably covered through an expected loss approach.

6.3 The difference between 'risk' and 'uncertainty'

The previous section considered the approach to measuring risk around the WACC, based on the Commission's approach to measuring the standard error of the WACC. In practice, the actual WACC and the assumed WACC will diverge for two reasons. The measures will be different to reflect both the difficulty in measuring the WACC in the first place and the differential between the measured WACC and the actual WACC, which will change over time given changes in market conditions. These can be characterised as:

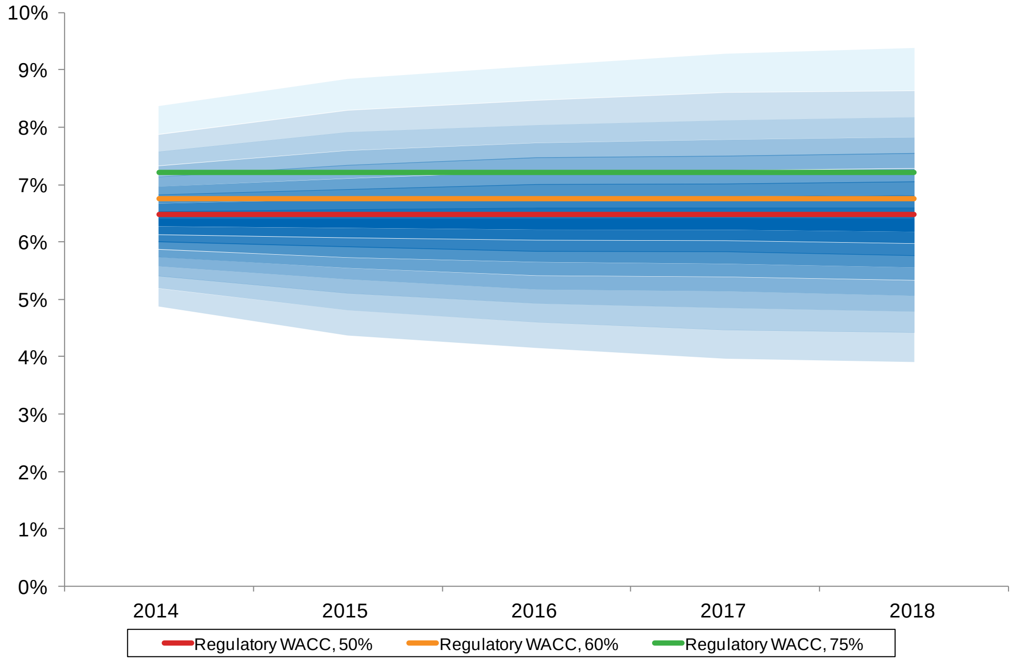
[52] This analysis focuses on the size of downside scenarios, and does not explicitly reflect that there may also be an 'expected profit' for the investor, in the scenarios where investment creates value. The combination of the expected profit and expected loss will create the net expected profit.

- **‘risk’, or changes in market conditions**. Risk is generally the term applied in this context to measurable, known reasons why the WACC will change over time. The simplest example is that the cost of debt, including the risk-free rate, will change over time within the financial markets. The range over which it changes can be estimated from historical data or, in some cases, from market prices for different products[53]. As a result of these changes, the WACC which investors actually require will be different to that estimated at the start of the period;
- **‘uncertainty’, or measurement error**. Uncertainty is the term applied when an input to a calculation cannot be ascertained with certainty, and there is clear evidence as to why not. This is the case with the beta. The beta is a ‘known unknown’, and can be estimated only with a certain degree of accuracy. The standard error applied by the Commission is a measure of the range of uncertainty. The term ‘fundamental uncertainty’ is generally applied to a specific form of uncertainty, where not only can a statistic not be measured accurately, but there is no reliable method even to estimate that figure, or the range around the actual figure. Sources of fundamental uncertainty include the actual probability that a low WACC will lead to underinvestment.[54]

The difference between risk and uncertainty is a relevant consideration in the selection of a percentile for the WACC. The presence of uncertainty (including fundamental uncertainty) is likely to be the reason why many regulators have tended to ‘aim high’ on a case-by-case basis. Both influence the range by which actual and assumed WACC may diverge, as illustrated in Figure 6.4. However, in the view of the Commission, the presence of risk such as that around the risk-free rate does not justify an uplift to the WACC estimate, as companies and investors are expected to manage risk themselves, as they would within a competitive market.

[53] For example, analysis of option prices can be used to determine the market’s view of forward-looking risks in different financial measures, including the risk-free rate.
[54] There may be precedent and/or judgement which can support measurement. The probability of another volcano and consequent ash cloud next year may be subject to fundamental uncertainty, but is not zero, and unlikely to be more than 50%. In assessing fundamental uncertainty, it is necessary to use judgement to refine the range.

Figure 6.4 Risk to the WACC—the combination of risk and uncertainty



Note: 'Regulatory WACC, 50%' corresponds to the midpoint estimate of the WACC—in this case, 6.49%, as given in Table 6.1. 'Regulatory, WACC, 75%' corresponds to the 75th percentile of WACC estimate, which equals 7.22%. 'Regulatory WACC, 60%' reflects the equivalent value if the Commission had selected the 60th percentile.
Source : Oxera analysis, based on Commerce Commission (2010) 'Input Methodologies (electricity distribution and gas pipeline services): Reasons Paper', December.

The Commission's approach is designed to compensate for uncertainty only, not risk. It explicitly assumes zero risk for other factors, including the risk-free rate. This approach assumes that these risks are best managed by the company, rather than through additional costs to customers. This does mean that the Commission's approach will necessarily understate the actual range of uncertainty faced by the regulated business. For example, using this approach, the actual WACC has a 5% chance of being 1.70% or more above the assumed WACC. If the additional risk associated with the risk-free rate risk is also reflected, this would increase from 1.70% to 2.1%. The effect is material, but does not change the broad scale of the probability of loss.

The risk around the risk-free rate is, when considering the nature of the underinvestment problem described in section 2, an 'in-flight' effect that influences the size of the underinvestment problem only within a regulatory period. The Commission's approach assumes that this could be addressed at the time of any future review. Therefore, the Commission considers this risk to be less important—especially given that the form of the price control already provides incentives to manage investment through a fixed price level over the period. We discuss this further in the next section.

6.4 Summary

This section has considered the scale of risks around the WACC. We find that:

- the risks of pre-specified downside events, which could have an impact on investment incentives, are measurable, and can be assessed for different choices of WACC. This can be measured through the 'probability of loss' or the 'expected loss';

- the impact of measuring the probability of loss is to demonstrate that there is a material probability, for example under the 50th percentile, that investors will not invest unless absolutely forced to, as they will be destroying value in the short and medium term;
- it is not feasible to identify a specific point that will definitively trigger underinvestment, but it is likely to be linked to a material differential between the assumed and actual WACC. Our assessment is that a range of 0.5–1% is a plausible starting point for this differential;
- the Commission's approach of focusing on uncertainty over the WACC (measurement error) may, under some circumstances, not reflect the total in-period risks of underinvestment, as other factors, such as the risk-free rate, will also vary over time.

7 Assessment and recommendations

This section considers the choice of a percentile for the Commission, drawing together the various streams of analysis within our report.

7.1 Recap—why use a percentile?

The Commission assumes, in using a percentile at all, that the WACC is uncertain, and that the uncertainty surrounding the WACC is broadly measurable. In coming to practical recommendations, it is important to consider what this uncertainty means in practice. It does not mean that investors have a 'better' idea of the required return than the Commission. It refers to the uncertainty around investors' actual equilibrium requirements in the future, based on market evidence in the past. Investors' actual requirements will depend on the market for capital and risk, the sources of capital and the alternatives for that capital. In practice, the required return will depend on many complex factors that may not be known with certainty at the time when the price control is established. As highlighted in the Northington Report, [55] it has been observed that prices for infrastructure assets have in some cases risen above the asset values. This is characterised in the finance literature as the asset having a 'q-value' above 1—i.e. that the value of an asset is higher than its replacement cost.

This can be taken to imply that the actual WACC required by investors appears to be below that assumed by many regulators. However, there is no guarantee that this will continue in the future. The range of values that can be identified for infrastructure assets demonstrates that investors do not share common views on the 'right' level of the WACC, either for different assets or for the same assets over time.

The use of a percentile by the Commission is not the only approach to addressing uncertainty in the WACC, and is in practice not used in the same way by other regulators. In section 3 we considered the following options for setting the WACC percentile too high or too low:

- Option 1: midpoint (P50) of the range;
- Option 2: 'aim up' using judgement in each period;
- Option 3: formulaic 'aim up', based on a specified percentile (the Commission approach);
- Option 4: 'aim up' based on a calculation other than a standard percentile (e.g. a premium on new investment only).

The Commission's approach is to use Option 3—i.e. a defined formula for the choice of the WACC above the midpoint. Our analysis indicates that, alongside the other measures applied by the Commission, this approach should be effective in mitigating the underinvestment problem. For example:

- there is a material asymmetric risk if the underinvestment problem were to be realised, and therefore the choice of a percentile above the 50th is likely to be appropriate if the choice of a higher percentile reduces the underinvestment problem;

[55] Northington Partners (2013), 'Transpower New Zealand Limited', December.

- any underinvestment problem is likely to relate to medium-term expectations around investment returns over the life of the asset. As such, an approach that provides medium-term certainty would be more likely to resolve such an underinvestment problem than one that sets a premium on a case-by-case basis for each review period;
- applying a premium to new investment only, or reassessing the premium to reflect the investment risk in each period, is therefore less likely to provide sufficient certainty of returns, but may well introduce unnecessary complexity.

In this section, we adopt the Commission's approach, and consider what percentile is most likely to balance the benefits and costs of setting the WACC above the 50th percentile. We do not consider a percentile below the 50th, as this would not appear to take into account the asymmetric risks of setting the WACC too low. Even if these risks could be completely managed by the regulatory regime, this would suggest that a 50th percentile would be most appropriate.[56]

We consider this problem using the logical framework outlined in section 2, which is aligned to the duties of the Commission. The questions are:

- what is the nature of the underinvestment problem?
- what is the potential size of the impact if the underinvestment problem were the occur?
- how is this resolved by setting the WACC at a percentile above the 50th percentile?
- how does this compare to the costs to consumers of setting the WACC above the 50th percentile?

In reaching a recommended approach, we have also continued to assume that the Commission continues with other aspects of its regulatory framework:

- **the approach to defining the WACC will otherwise remain the same as that under the current IMs**. We have assumed that the Commission correctly estimates the standard errors which define the 75th percentile, and that the CAPM assumptions underlying the 75th percentile hold in practice;
- **the wider regulatory framework also remains unchanged**, including the combination of quality incentives and asset stewardship incentives that are designed to offset any underinvestment problem;
- **the WACC percentile does not cover asymmetric risk**. Consistent with the IMs, we assume that asymmetric risk is **not** reflected in the choice of WACC percentile; and
- **the approach to defining the breadth of the distribution excludes other risks such as the risk-free rate**. As discussed below, there is likely to be some interaction between the overall risk of underinvestment, and the other factors excluded from the calculation such as the risk-free rate, which will also vary over time.

[56] A scenario could be constructed in which the company has the benefit of asymmetric information, and is therefore able to earn an average return above the WACC. However, given the regulator's duties, a WACC below the 50th percentile would be inconsistent with the need to allow the financing costs of efficient investment, and therefore this risk should be managed within the regulatory regime rather than through a lower WACC.

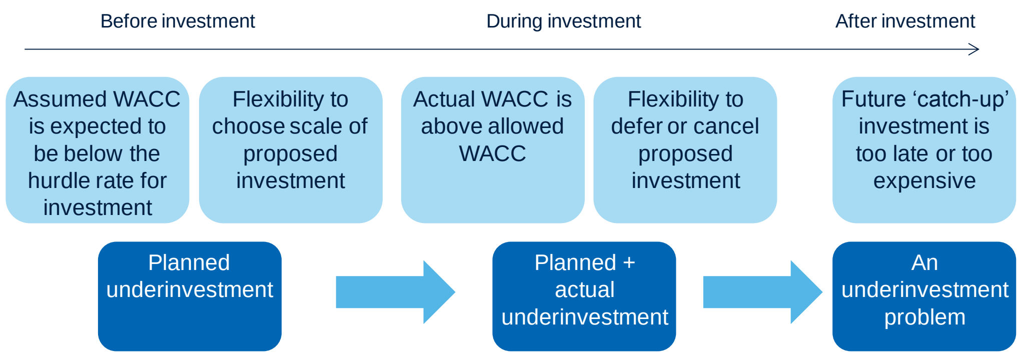
7.2 What is the nature of the underinvestment problem for electricity in New Zealand?

This section recaps the analysis within the report to identify the best way to define the underinvestment problem. This problem is summarised across the investment cycle in Figure 7.1, and means both that there is a level of underinvestment, and that it is sufficient to result in a problem. Within our analytical framework, this specifically means that the impact of underinvestment on the network is significant, and results in adverse social and economic effects for the users of the network.

This underinvestment problem can occur in three phases:

- **at the planning stage**—if the WACC is expected to be above the 50th percentile, the company can be expected to have stronger incentives to identify and design new investment schemes that will deliver benefits for customers and therefore will be permitted by the regulator. This will include both the level of ongoing investment in the reliability of the network, and the incentive to design new schemes and/or innovative new approaches that will strengthen the longer-term resilience and reliability of the network;
- **during the price control**—under a regulatory framework with fixed returns across the period, such as that within New Zealand, there is always a theoretical incentive to underinvest during the price control once revenues have been allowed. However, this incentive is strongest when there are limited benefits to investment at any stage (i.e. where the NPV of investment is zero or close to zero), or where the costs of short-term quality failure are low relative to the value of the option to defer investment;
- **after the price control**—the underinvestment will turn into an underinvestment problem if it cannot be resolved at the next review period.

Figure 7.1 What is the underinvestment problem?



Source: Oxera.

Figure 7.1 illustrates that an underinvestment problem occurs when the following conditions coincide:

- **there is flexibility to choose the level of investment** and the company has the ability to reflect the level of the WACC (actual and assumed) in its decision on the appropriate level of investment;
- **the level of the assumed WACC is below, or is expected to be below, the company's view of the actual WACC,** and therefore the perceived NPV of capital investment is negative;

- **the impact of deferring investment cannot be adequately recovered after the period**. Underinvestment only translates into an underinvestment problem if the impact of any shortfall in investment cannot be readily rectified after the period.

From a financial perspective, this potential underinvestment can be presented as a rational investment decision—the optimal level and mix of investment will be affected by the expected return on investment at each point in the investment cycle, and the ability to trade off investment, for example against maintenance costs.

This is illustrated in Table 7.1 for the types of expenditure incurred by the electricity companies. The table considers the ways in which underinvestment may arise owing to the asymmetric information problem, and the flexibility for the company to choose the level of investment.

Table 7.1 Identifying the underinvestment problem

Type of spend	Incentives—the level of planned investment	Incentives—the level of actual investment (regardless of the WACC)	Protection against underinvestment through the regulatory framework including minimum standards/service quality	Summary: what is the nature of the underinvestment problem caused by a low WACC?
Maintaining the reliability of the current network: capital maintenance and renewals	Maximise forecast cost requirements in order to increase the potential for outperformance If assumed WACC is expected to be below the actual WACC, there could be an incentive to maximise OPEX and minimise CAPEX within plan assumptions	Make as large savings as possible in order to retain excess profit, unless higher penalties from service quality. If CAPEX and OPEX are incentivised together then shared incentive with OPEX (below)	Underinvestment may be constrained by need to meet quality standards, depending on how quickly stripping out maintenance spend will lead to failure to deliver minimum standards, and how the level of quality penalties will compare with the costs from a low WACC	A low WACC reduces the likelihood that the company will want CAPEX in the RAB—i.e. a higher WACC effectively allows the company to gain from some of the wider economic benefits, and therefore the value of the option to defer investment will be reduced. However, the risk of underinvestment can be mitigated by quality incentives and by regulatory approaches to CAPEX/OPEX trade-offs
Making the network 'better' and more resilient over the medium term: growth investment/innovative investment	Maximise forecast cost assumptions in order to increase the potential for outperformance. Where the WACC is higher, stronger incentive to identify schemes to improve the quality and reliability of the network, which will deliver benefits for customers and positive returns for investors	In theory, make as large savings as possible in order to retain excess profit, but likely to be mitigated by (reputational) impact on allowed investment in future periods	Potential for medium-term investment to be below socially optimal levels unless well-designed asset stewardship indicators and/or if minimum standards/service quality indicators capture need for long-term development of the network Overinvestment risk mitigated by Commission's ability to scrutinise proposed schemes to moderate the level of 'bids' for high CAPEX and to avoid 'gold-plating'	A policy to set the WACC at a higher level and consistently over the investment cycle increases the incentive on the company to identify credible investment schemes to improve the network. A low WACC means that schemes will not be identified and there will be a bias towards OPEX and renewals
Operating the network: ongoing operating costs	Maximise cost assumptions in order to increase the potential for outperformance	Make as large savings as possible in order to retain excess profit	Customer-facing service indicators should prevent too great a reduction in OPEX	If the WACC is too low, the company may have stronger incentives to reduce OPEX in order to meet a target return

Source: Oxera

Table 7.1 suggests that the underinvestment problem is likely to result from:

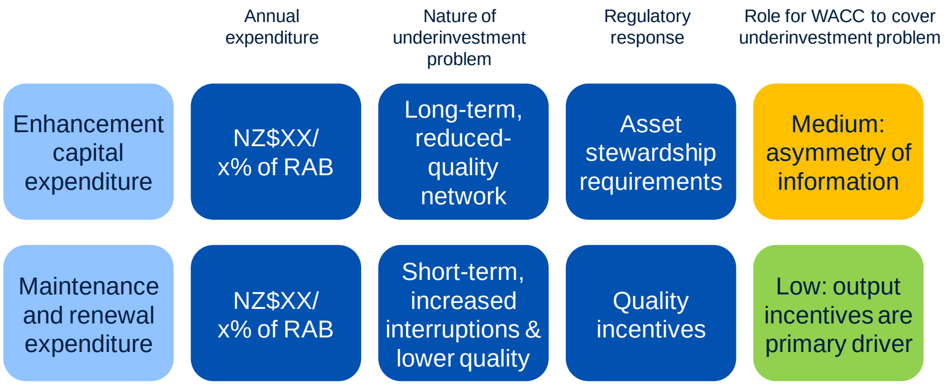
- a low WACC resulting in weak incentives to develop new CAPEX schemes to develop and enhance the network. As long as the WACC is around the midpoint, and new investments are NPV-neutral at the actual WACC, there will be limited incentive to develop innovative (and potentially above-average-risk) investment programmes to enhance the longer-term reliability of the network;
- a bias towards OPEX rather than CAPEX in maintaining the network;
- the natural incentive to invest less than the regulator's assumptions within the price control period, which will be strengthened the lower the benefit from investing relative to that from deferring investment. This will vary over the period and according to the strength of quality incentives, but the strength of the incentive to defer will be higher, the lower is the WACC.

In the context of electricity distribution and transmission, the nature of the investment that might be at risk from a low WACC might not necessarily mean a better service for customers in the short term. For example, in telecommunications, underinvestment may mean a continuation of lower-value services for customers, as opposed to the development of new and potentially more speculative technology to improve the customer experience. In electricity distribution and transmission, the primary output of the electricity network is continued operation (and the primary risk associated with underinvestment is an increasing gap between actual network quality and the socially and economically optimal level of network quality). Therefore, the primary source of the underinvestment problem is likely to be medium- to long-term investment risk within electricity networks.

If the WACC is lower, there will be an incentive to reduce capital maintenance investment relative to OPEX. This may be in part managed through the use of output and quality incentives, including incentive schemes that reflect the role of CAPEX/OPEX trade-offs, or schemes which mitigate the impact of timing issues, such as the Commission's incremental rolling incentive scheme (IRIS).

The next step in the analysis is to convert this underinvestment problem into the proposed analytical framework. This is illustrated in Figure 7.2.

Figure 7.2 What is the role of the WACC in resolving the underinvestment problem?



Note: The actual size of enhancement and maintenance expenditure will vary by firm, but the figure is intended to illustrate that the relative size of the efficient level of these types of expenditure will affect the potential size of the underinvestment problem.

Source: Oxera.

Figures 7.1 and 7.2 illustrate the nature of the link between the level of the WACC, and the underinvestment problem. Within the context of the New Zealand electricity networks, this will be (or could be) in part addressed by the following mitigations:

- the underinvestment problem on maintenance/renewals expenditure can also be through output requirements, and through a consistent approach to setting incentives for OPEX and CAPEX (and trade-offs between them);
- the underinvestment problem on longer-term investment is partly managed through asset stewardship requirements;
- the underinvestment problem can be partly mitigated in the longer term by adjusting the WACC if additional evidence emerges that it is being set 'too low'. However, depending on the way in which the evidence emerges, this could then risk undermining the principle of using a consistent WACC percentile in the first place.

However, there remains an underinvestment problem that could potentially be resolved through the choice of WACC percentile, as:

- the regulator does not determine the appropriate investment plan for the business, and there is asymmetric information between the network operators and the Commission in how to determine a longer-term plan;
- the investment strategy identified will be biased by investors' expectations of the size of longer-term returns they can expect;
- if underinvestment persists, unit costs are likely to rise over time, service quality will worsen, and the risks associated with the potentially material wider costs of poor quality and interruptions to service will increase.

Oxera's framework is therefore designed to provide evidence to the Commission on what percentile level is likely to provide the best balance between the risks and benefits.

7.3 Application of the analytical framework

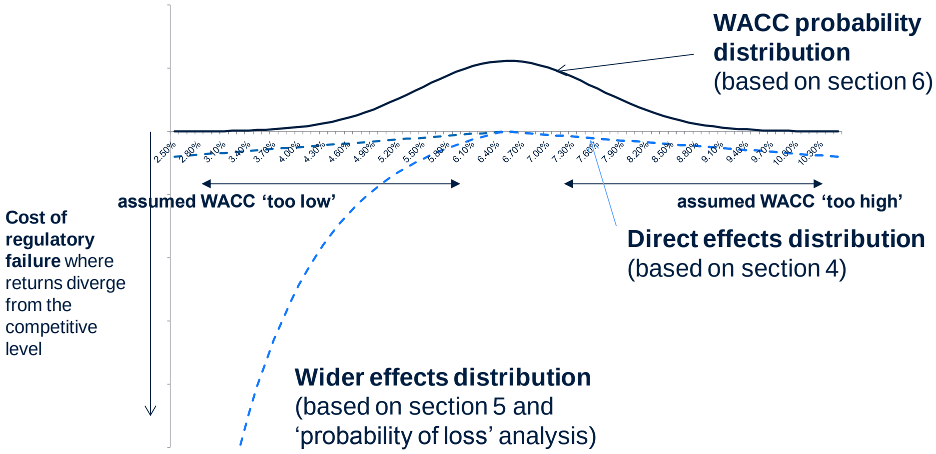
Returning to the analytical framework described in section 2, and reflecting the sources of the underinvestment problem identified above, we propose that the Commission consider the following factors when comparing WACC percentile options.

We draw primarily on a 'probability of loss' approach, as this is likely to be more aligned with the practical situation faced by investors in seeking to optimise their level of network investment.

The approach is consistent with the 'social loss' approach outlined by Dobbs, van Zijl and others, but gives weight to the practical issues involved in estimating the parameters within the social loss analysis. We focus on the impacts of the choice of WACC which can be directly related to the regulator's duties. Since there is no single answer to some of the parameters within the analysis, our approach provides a range of measures. This will then provide evidence to support the Commission in reaching a view on the appropriate percentile.

The analysis in this report illustrates that the Commission will always need to exercise judgement in setting the percentile. There is a fundamental uncertainty about the exact probability that a particular percentile will lead, in the medium term, to costly network outages. However, we also agree with the approach taken by Dobbs and van Zijl, among others, and that this form of social loss analysis needs to be objectively considered as far as there is evidence to do so, in reaching that judgement. Returning to our illustration of these effects from section 2, we have now established estimates of the scale of the various effects.

Figure 7.3 Practical application of the social loss framework



Source: Oxera.

This combined approach, while recognising the limitations of the analysis, should be more effective in demonstrating that the Commission has considered the evidence available specific to the case, and that the choice of percentile is therefore based on a proper consideration of the economic effects.

The flow of the economic effects that the Commission is seeking to address when choosing a WACC to resolve the underinvestment problem is set out in Table 7.2.

Table 7.2 What is the series of events which result in an underinvestment problem?

Step	Reference	Approach and calculation
Question 1: What is the size of the underinvestment problem?		
The WACC is set 'too low'	Section 6	There is uncertainty about investors' actual WACC, and certain WACC inputs are not measureable. We calculate the 'probability of loss'—i.e. the probability of certain values for the size of the differential between the assumed and the actual WACC
The firm has a reduced incentive to invest	Section 6	The greater the differential between assumed and actual WACC, the stronger the incentive to underinvest. This requires judgement, but we assume that a 0.5–1% differential will be sufficient to trigger the electricity businesses to seek to minimise the level of investment
The reduced investment leads to failures within the network	Section 5	The short-term effects are mitigated by quality incentives. The longer any differential exists, the greater the risk of network failure. In practice, it is likely to be the planning of enhancements to the network that represents the greatest risk, and this is likely to be a multi-period effect
The network failure has costly wider social and economic effects	Section 5	The size of wider economic effects of network failure are inherently difficult to estimate; however, evidence from actual events and analysis of potential events in other countries suggests that a severe outage event resulting from underinvestment could result in a cost with an annualised economic value equivalent to over NZ$1bn.
Question 2: What are the costs of implementing a higher percentile?		
Customers pay higher prices	Section 4	The direct impact is that customers will pay higher prices—as much as $200m with the 90th percentile

Source: Oxera.

This form of analysis cannot provide complete assurance that a particular choice of percentile is most appropriate, as the probability of a shortfall in the WACC leading to an underinvestment problem is not known with certainty. However, it is instructive in understanding the relationship between the benefits of avoiding underinvestment, the probability that investor financing costs will actually be above the assumed WACC under different options, and the costs to customers (including the indirect costs) of applying that percentile. The output is illustrated in Table 7.3.

Table 7.3 Outputs of Oxera's analysis—the relationship between the probability of loss and the underinvestment problem

Step	**Identifying the WACC percentile**	**Measuring the direct and indirect costs**	**Defining the size of the underinvestment problem**		**Measuring the benefit—what is the additional protection against the underinvestment problem?**			
Rationale:	Apply the Commission's approach to determining the WACC percentile	What are customers paying to protect against the underinvestment problem?	Gross (not probability-weighted) costs of WACC too low (NZ$bn)		What is the reduction in the probability of loss for different measures? We assume that a sustained 0.5–1% differential between the actual and assumed WACC is likely to be sufficient to be a trigger for underinvestment			
Source:	Oxera analysis of the Commission's IMs	See section 4: primary driver is WACC (actual percentile — 50th) * RAB	See section 5: primary source of evidence is GDP-equivalent impact of network failure in US economies (actual and projected, equivalent annualised effect during period of failure)		See section 6: for a choice of estimated WACC, given the Commission's assumption of a normal distribution, what is the probability that the actual WACC will be above the estimated WACC, by differing amounts?			
						Probability of		
Percentile	**WACC impact**	**Low**	**Low**	**High**	**>0% loss**	**>0.5% loss**	**>1% loss**	**>2% loss**
50%	0.00%	0	1,000	3,000	50%	32.1%	17.6%	3.1%
55%	0.13%	20	1,000	3,000	45%	27.7%	14.5%	2.3%
60%	0.27%	40	1,000	3,000	40%	23.6%	11.8%	1.7%
65%	0.41%	61	1,000	3,000	35%	19.7%	9.4%	1.2%
70%	0.56%	83	1,000	3,000	30%	16.1%	7.3%	0.8%
75%	0.72%	107	1,000	3,000	25%	12.7%	5.4%	0.6%
80%	0.90%	133	1,000	3,000	20%	9.6%	3.8%	0.3%
85%	1.11%	164	1,000	3,000	15%	6.7%	2.5%	0.2%
90%	1.38%	203	1,000	3,000	10%	4.0%	1.3%	0.1%
95%	1.77%	261	1,000	3,000	5%	1.7%	0.5%	0.0%

Source: Oxera.

Table 7.3 does not in itself answer the question around the choice of percentile, but does provide important evidence about the choices made by the Commission.

Box 7.1 Example: illustrating the impact of choosing the 75th percentile

For example, in assessing the 75th percentile option, it is instructive to understand the impact relative to both the counterfactual of the midpoint and the choice of a lower percentile (here, the 70th percentile).

- The cost is 0.72% of WACC, equivalent to over NZ$100m, which equates to around 3% higher charges, or around 1.3% higher end prices to residential consumers.
- The probability of the true WACC being 0.5% above the assumed WACC is 12.7%, which compares to a 32.1% probability at the 50th percentile. The equivalent comparison for a 1% differential is 5.4% relative to 17.6% at the 50th percentile. Therefore, for a NZ$100m annual higher cost, there is a 20% reduction in the probability of 0.5% loss, and a 10% reduction in the probability of a 1.0% loss.
- Even if this is considered to 'better' balance the risks of regulatory failure than the midpoint, it is also relevant to assess the comparison of this 75th percentile to the 70th percentile. In this incremental comparison, the 75th percentile represents a 0.16% higher WACC or NZ$24m higher cost per year, in return for a 3.4%/1.9% reduction in the probability of a shortfall in the WACC of 0.5%/1% respectively.
- Therefore, if the Commission considered that this change in the 'probability of loss' could be directly comparable to the reduction in probability of an equivalent NZ$1bn annualised cost of a severe network outage, the cost of $24m would compare to a saving of $34m/$19m in the expected cost of failure (i.e. a 3.4% or 1.9% reduction in the likelihood of a NZ$1bn event)—i.e. the two effects would be of comparable scale.

Source: Oxera analysis.

As discussed above, there is an uncertainty surrounding the nature of the exact comparison between the probability of loss and the reduced risk of network reliability and, in the longer term, of loss load. However, the comparison is instructive in understanding the scale of benefits and costs associated with the choice of percentile.

In addition, as the percentile increases, the cost of each 5th percentile rises, and the benefit in incremental protection falls—hence justifying the likelihood that there is an optimal percentile to manage the underinvestment problem. Appendix 1 considers this theoretical comparison further. The rest of this section considers practical recommendations for the Commission.

7.4 Recommendations for the choice of the WACC percentile

This report has assessed the economic effects of choosing a percentile for the WACC, in particular the ability of a choice of the WACC to reduce the risk of underinvestment leading to network instability, and, ultimately, the risk of costly failures within the network which have wider social and economic effects. This section draws together the analysis, to provide support to the Commission in coming to a conclusion based on the evidence available.

Based on the analysis in this report, we conclude that the following are likely to be the key factors for the Commission in deciding on the appropriate percentile for electricity distribution and transmission businesses:

- **the level of confidence in the quality and asset stewardship regulation to mitigate the underinvestment problem**. Oxera's analysis is based on the assumption that there will be an underinvestment problem should the WACC be set 'too low'. This is consistent with the views of other regulators, the asymmetric information problem, and the natural incentives within the New Zealand regulatory regime more generally to underinvest. It is unlikely that the Commission (or any regulator) can design a regime that fully addresses all these issues;
- **the legal framework appears to suggest that the Commission should give weight to the underinvestment problem**. The Commission has a duty to provide incentives to electricity businesses to invest, upgrade and innovate. As with other regulators, this indicates that the legal framework requires the Commission to give particular weight to the risk of underinvestment. This is consistent with the views expressed by the Commission's experts at the time that the IMs were designed;
- **the WACC range identified by the Commission is designed to address longer-term risk (measurement error) and will underestimate short-term volatility between the assumed and actual WACC**. The in-period risk could therefore be greater than identified by the Commission;
- **however, the underinvestment problem will be most strongly felt to the extent that it persists over multiple periods**. The Commission's approach to regulation is relatively prescriptive within-period and the direct levers are being strengthened. As with any price cap framework, the Commission can revisit the framework should the approach by the companies within a period be strongly indicative of regulatory failure or of a shift towards negative outcomes if this is inconsistent with the specified aims of that framework. The underinvestment problem is therefore more likely to be realised in practice if the overall framework is inconsistent with investment incentives into the medium to long term. Shorter-term risks, including risks around capital maintenance incentives, will be more likely to be manageable through quality regulation and potentially through the regulation of CAPEX/OPEX trade-offs;
- **the case for a high percentile is therefore largely related to the longer-term benefits of promoting investment and innovation in improving the medium- to long-term resilience and performance of the networks.** Our interpretation is that the strongest case for a higher percentile relates to the need to ensure that longer-term incentives are preserved, and this is most likely to be realised where the actual WACC is, and is expected to remain, above the assumed WACC over multiple periods.

Table 7.4 illustrates how the choices of percentile might be interpreted in the context of these conclusions.

Table 7.4 Alternative approaches to defining the percentile

Choice of percentile	Probability of loss (0.5–1%)	Increase in charges (relative to 50th percentile)	Rationale
50th	18–32%	$0m	Choosing the 50th percentile would imply the greatest confidence that the underinvestment problem could be mitigated by regulatory measures other than the WACC. There would be no value created for the businesses by investment. In addition, there is an almost one-in-five chance of a shortfall of 1% between the actual and assumed WACC. This would be likely to result in underinvestment, and the potential costs of this are material—we discussed in section 5 that a major network outage could have an equivalent annualised economic cost of NZ$1bn or more. There is also no expectation that the differential would be resolved under this approach, and so the incentive to invest would remain low. This approach would be appropriate only if the Commission considered that it could confidently determine and impose a socially optimal investment level.
60th	12–24%	$40m	Choosing the 60th percentile still implies reasonable confidence that the underinvestment can be mitigated through other regulatory measures, such as the capital/operating cost incentive schemes. The annual cost to customers of NZ$40m represents less than 5% of the potential size of the risk mitigated, on the assumption that the eventual impact of underinvestment could have an annualised economic cost of at least $1bn. The incentives to invest, while stronger, remain moderate, with the WACC premium being around 0.25%.
70th	7–16%	$83m	The 70% percentile reduces the probability of a 1% shortfall between actual and assumed WACC below 10%. The cost, at over NZ$80m, is increasing towards 10% of the NZ$1bn estimate of the potential scale of annualised economic cost of a severe outage event. This implies that the cost paid by customers through the WACC is becoming comparable to the size of this estimate of the impact of a network failure resulting from an underinvestment problem over two periods for the IMs.
80th	4–10%	$133m	The 80th percentile would represent a prudent approach. The cost is around $133m a year, or potentially equivalent to the impact of one severe event within a seven-year IM period. The reduction in risk is significant. In choosing this level of protection, the Commission would be giving less weight to the intention of asset stewardship and quality obligations to offset some of the risk of the underinvestment problem which is designed to minimise the risk of an underinvestment problem within the regulatory period.
90th	1–4%	$203m	The 90th percentile would be a highly conservative choice. Arguably, the risk of underinvestment would be nearly eliminated, as the probability of a material differential between the actual and estimated WACC would be very low. However, the annual cost of $200m a year would be close to insuring against the potential risk of an event with equivalent economic cost of NZ$1bn every five years. At this level of WACC, the risk of gold-plating the network would also start to become material.

Source: Oxera.

Table 7.4 represents an overview of the considerations faced by the Commission. As discussed above, there remains a fundamental uncertainty about the exact size of some of the effects. However, this level of evidence is proportionate to the complexity and impact of the choice of percentile. The nature of the evidence implies that the approach to setting the percentile will need to retain an element of judgement, but this analysis should support an outcome more closely linked to the nature of the underinvestment problem that the WACC percentile is seeking to address.

Based on the analytical framework, and assuming a continuation of the current IMs, which require a percentile, we therefore propose the following.

- **The 50th percentile is likely to be too low**. At the 50th percentile, the incentives to invest will be relatively low, as new investment adds no value to the business. The potential costs of underinvestment are material. Evidence from actual events and analysis of potential events in other countries suggests that a severe outage event resulting from underinvestment could result in a cost with an annualised economic value equivalent to over NZ$1bn. Some premium for customers to reduce these costs appears reasonable and proportionate.

- **The 90th percentile is likely to be too high**. Even at the 80th percentile, the cost of protection appears relatively high compared with the level of benefits, given the wider measures put in place by the Commission.

- **The proposed form of economic impact analysis has limitations, but some of these relate to points of fundamental uncertainty, rather than points that can be readily addressed by further analysis**. It will be difficult to identify a probability that a particular value for the assumed WACC directly results in underinvestment. However, it is instinctively consistent with the workings of financial markets and the competition for capital that a shortfall of 0.5–1% (or more) is likely to increase the risk of triggering a rebalancing of medium-term investment plans, and a move by investors towards deferring investment as far as possible.

- **Any premium should be applied to all RAB assets and applied consistently**, as the expected whole-life return on assets should be the relevant test for investors. This also strongly points to the New Zealand approach of providing certainty over the need for a premium, rather than a case-by-case basis, as applied more generally by other regulators.

Given the specific circumstances of electricity transmission and distribution, some recognition of the need for investment is likely to be appropriate in setting the WACC. Based on the Commission’s approach, and considering the specific need for investment in electricity distribution and transmission, a point estimate around the 60th or 70th percentile appears to provide a suitable balance between the costs and benefits of the approach of setting a higher percentile in mitigating the risks associated with the underinvestment problem, and should therefore achieve the intended benefits of the WACC percentile approach.

An 80th percentile approach would be more conservative, and would imply that customers are paying as much for protection within a seven-year IM period as our analysis indicates could be the potential annualised cost of material outages. Given that the Commission has other regulatory measures in place to offset the risk of underinvestment, and is strengthening these measures, this appears to be a potentially excessive level of protection.

We would expect the exact choice of a percentile by the Commission to reflect these considerations, and the Commission's view on the desirability of taking into account other factors that are not explicitly reflected in the current approach to defining the percentile, but which might nevertheless point to a cautious approach in setting the percentile either high or low. These could include, as an example, the risks not currently reflected within the percentile, such as the risk of model error or the incremental risks within regulatory periods around parameters such as the risk-free rate.

Oxera understands that, under the approach within the IMs, the Commission considers that this can be managed by the electricity companies. Nevertheless, this will only exacerbate the underinvestment problem, and could therefore lead the Commission to err on the side of caution when choosing a percentile.

A1 Illustrative scenarios of the rationale for the selection of a particular percentile

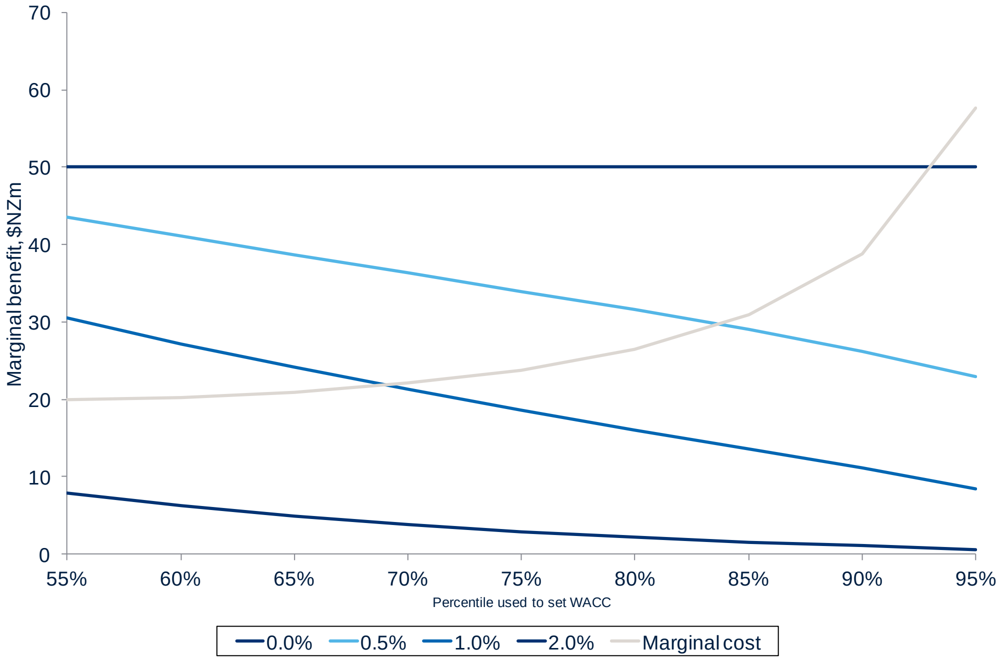
A1.1 Incremental effects—increasing the percentile

Table 7.3 illustrates that, for each incremental 5th percentile in the WACC distribution, the cost to customers increases. If the size of the underinvestment problem is measured by the probability of a shortfall between the actual and assumed WACC, then the rate at which this problem is mitigated by a higher percentile also reduces, the further the percentile is from the 50th.

This is further illustrated in Figure A1.1. The graph plots the costs and benefits associated with different choices for the percentile, where the benefit is measured as the reduction in probability of a shortfall in the WACC of 0%, 0.5%, 1% or 2%, as a NZ$m equivalent amount, if that were to correspondingly reduce the risk of underinvestment, and that underinvestment were to lead to a NZ$1 billion effect.

This scenario is consistent with the analysis within section 5 and discussed further above.

Figure A1.1 Illustration of benefits and costs of each additional 5th percentile

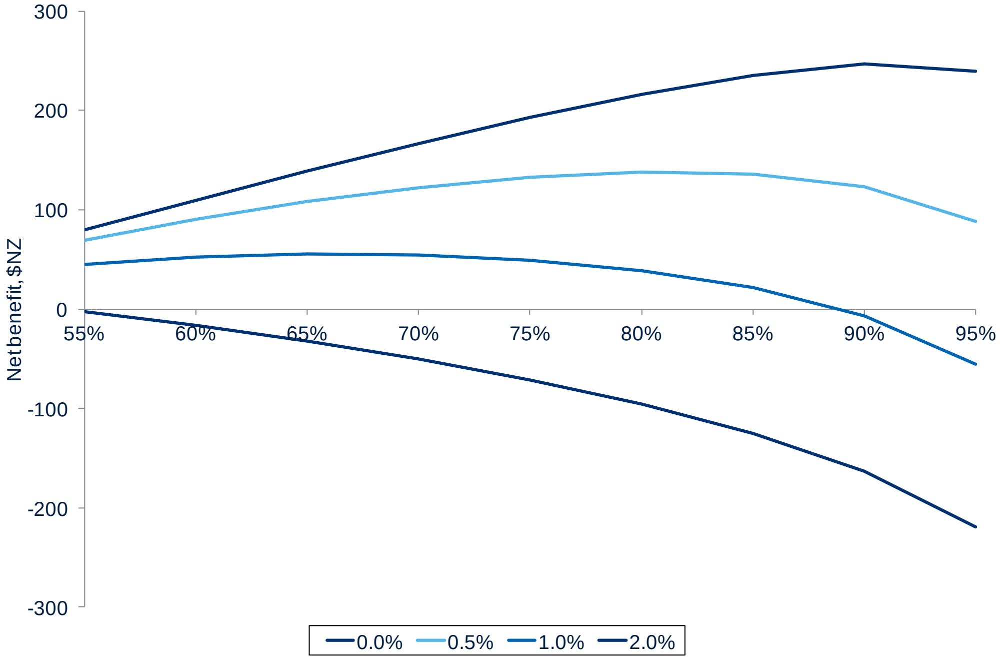


Note: Each marginal benefit line is based on the assumption that a trigger for underinvestment is a shortfall of 0%, 0.5%, 1% or 2% between actual and assumed WACC, with the impact of underinvestment being assumed to be NZ$1 billion

Source: Oxera analysis of data described in sections 4-7 above

The uncertainty over the assumptions in Figure A1.1 has been discussed in sections 4 and 5. Nevertheless, the impact demonstrated is consistent with the objectives of the Commission in setting the 75th percentile, and Figure A1.1. shows that there is likely to be a point at which the incremental benefits of protection and the incremental costs to users are balanced. Figure A1.2 shows this in terms of the total benefit and cost. The peak of the graph represents, for the relevant set of assumptions, the point at which the benefits of protection best offset the financial costs through higher prices.

Figure A1.2 Illustration of total benefits and costs for each choice of percentile



Note: Each marginal benefit line is based on the assumption that a trigger for underinvestment is a shortfall of 0%, 0.5%, 1% or 2% between actual and assumed WACC, with an impact of underinvestment assumed to be NZ$1bn.

Source: Oxera analysis of data described in sections 4–7 above.

Figures A1.1 and A1.2 demonstrate that, regardless of the level of analysis, some judgement will be required on the percentile, as there is no certainty over the link between the shortfall between the actual and assumed WACC and the underinvestment problem. However, the figures provide additional context for the Commission in coming to its decision.

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