A submission on Prof Ian Dobbs' comments on our implementation of his loss function model

A REPORT PREPARED FOR TRANSPOWER NEW ZEALAND

September 2014

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Figures

Tables

Executive summary

In August 2014, we produced a report (our August report) on behalf of Transpower, which implemented Professor Ian Dobbs' loss function model (the model) within a New Zealand context.[1] The model was based upon a study by Professor Dobbs published in the *Journal of Regulatory Economics*.[2]

On 19 September 2014 the Commerce Commission (the Commission) published, and invited submissions from interested parties on, a report by Professor Dobbs entitled *Proposed amendment to the WACC percentile for the allowed rate of return: Comments on the application of the Dobbs [2011] model* (Professor Dobbs' report). Professor Dobbs' report comments on our implementation of his model.

Transpower has asked us to consider Professor Dobbs' report, provide our views on it and, where appropriate, respond to concerns or issues raised by Professor Dobbs over how we have implemented his model.

Overall, we consider that Professor Dobbs' report is a thoughtful and helpful analysis of our work, and raises a number of points and challenges that are worthy of further consideration. Given the very limited time to develop this submission, we have focussed on the most substantive of the issues raised by Professor Dobbs. In addressing these issues, we have undertaken some further modelling work. Our key finding is that after addressing the recommendations made by Professor Dobbs, the optimal WACC percentile predicted by the model remains well above the 75th percentile currently employed by the Commission, and is very robust to variations in input assumptions within the bounds of plausibility.

Whilst we consider that the evidence provided by the model is robust and is supportive of a WACC percentile at least as high the 75th percentile, we recognise that more work could be done in future to refine the model and to validate and test some of the inputs used. This additional work was not possible within the time available. Towards the end of this executive summary, we identify a few areas that could be worthwhile exploring in due course. The key issues raised by Professor Dobbs that we have focussed on are the following:

- The 'goodness of fit' of the model (i.e. its applicability to the electricity sector).
- The value of a loss function model framework to assist the Commission's decision making.

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1 Frontier Economics, *Application of a loss function simulation model to New Zealand, A report prepared for Transpower*, August 2014.

2 Dobbs, I.M., "Modeling welfare loss asymmetries arising from uncertainty in the regulatory cost of finance", *Journal of Regulatory Economics* (2011) Volume 39, pp.1-28.

- The appropriate welfare standard to assume when implementing the model.
- The need for some further modelling and sensitivity analysis.

Goodness of fit

Professor Dobbs noted that the model was developed originally for application to the telecommunications sector, where technology progresses relatively quickly and, due to the deployment of new products and services over time, it is generally easy to distinguish between 'existing' and 'new' demand.

Notwithstanding that the model was developed with another sector in mind, we do not see any compelling reasons why the model could not be applied to electricity networks. Many of the underlying assumptions of the model — e.g. that the supplier is a monopolist; and that the supplier has limited freedom over the timing of certain investments, and more discretion over the timing of other investments — seem to apply well to electricity networks.

In addition, Professor Dobbs noted that the model is not a peak-load pricing model. We have accounted for this when performing the additional modelling reported in this submission by taking a highly conservative approach to estimating the value customers place on additional network capacity.

The value of a loss function model framework to assist the Commission's decision making

Professor Dobbs expresses reservations about using the estimates of the optimal WACC percentile from the model in a mechanistic way. He suggests that "precise quantitative predictions of the model should be regarded as indicative at best".

We agree the model has limitations (i.e. it does not reflect all real-world features perfectly), and that it should not be used mechanistically by the Commission to choose the WACC percentile. However, we do consider that the model, applied to a New Zealand context, provides:

- a very helpful framework to analyse systematically the welfare trade-offs the Commission faces when determining an appropriate allowed rate of return;
- a means for laying out and testing the effects of various assumptions;
- useful directional evidence on the optimal WACC percentile; and
- an indication of whether the Commission's proposed WACC percentile is likely to be too generous or too conservative.

In our view, the use of the model and its insights would enhance significantly the Commission's decision-making; it would be better to take account of the evidence provided by the model than to discount it and rely on purely theoretical arguments and/or the modelling work undertaken by Oxera.[3] We think the model should be used to inform, but not to dictate, the Commission's choice of the optimal WACC percentile.

The appropriate welfare standard

Professor Dobbs notes correctly that the optimal WACC percentile predicted by the model can depend on whether a total welfare standard or a consumer welfare standard is adopted. We agree with both Professor Dobbs and Dr Lally that there is no good economic reason to favour consumer welfare over producer welfare (and there is certainly no sound reason to ignore producer welfare altogether). Indeed, for the reasons described by Professor Dobbs, a policy that discriminates in favour of consumer welfare may undermine investors' confidence in the regulatory framework and lead to perverse outcomes that would ultimately harm consumers.

Need for further modelling and sensitivity analysis

Professor Dobbs' main concern about our implementation of the Dobbs (2011) model is that we may have adopted too high a maximum willingness-to-pay assumption when calibrating the electricity demand function. He suggests that our specification of demand is likely to exaggerate significantly the loss of welfare that arises when new investment does not occur, and may exaggerate the extent of uplift of the allowed rate of return above the mean of the WACC distribution.

Professor Dobbs recommends that the model be respecified using a linear demand function, in part to address what he considers to be weaknesses associated with the use of a constant elasticity (iso-elastic) demand curve when demand is assumed to be inelastic. We have implemented Professor Dobbs' recommendation and find that under the base case scenario the optimal WACC percentile is equivalent to the **93rd** percentile — still well above the 75th percentile the Commission presently employs.

In addition to trying an alternative demand function, Professor Dobbs recommends two further pieces of sensitivity testing. Specifically, Professor Dobbs suggested evaluating the impact on the optimal WACC percentile of:

- allowing the assumed elasticity of demand to differ as between new and sunk investments; and
- varying the parameter used to allocate network price changes to the fixed and variable components of the retail tariffs faced by consumers.

[3] We note that the High Court also cautioned against relying on purely conceptual reasoning, and urged the Commission to explore loss function modelling of the kind we have presented.

The sections that follow elaborate on these points in greater detail and section 4 presents the results of the modelling and sensitivity analysis.

Issues for further investigation

We think that the loss function modelling we have presented, including the additional analysis we have undertaken to address the recommendations made by Professor Dobbs, provides the Commission with robust evidence to inform its decision on the appropriate WACC percentile.

We recognise that there are a number of possible avenues for further investigation that could be pursued in due course. However, we consider these avenues are more likely to represent refinements to the model rather than major overhauls and are not needed in order for the Commission to rely on our modelling results when making a decision on WACC percentile. We note that the model is not intended for use with a consumer surplus criterion, as it does not allow for a negative investment response by suppliers to such a policy.

Future avenues of investigation could include, for example:

- Seeking to understand better the characteristics of user demand for electricity and the value of continuous supply. This work could focus on investigating the appropriate 'shape' of the demand curve (for different types of consumers), as well as estimating/validating empirically the short-run and long-run elasticities of demand for electricity. This empirical work could involve, for example, discrete choice modelling of electricity consumers' stated and revealed preferences. This work could also seek to develop more nuanced ways of estimating the welfare at stake (e.g. the area under the demand curve under the existing model) than simply assuming that network investment avoids the costs of customers needing to invest in independent/distributed generation.
- Further work could be done to validate and test certain input parameters, such as the assumed growth rate in demand served by new investment. We note that in those areas where the evidence available on input parameters is presently limited, we have tried to adopt conservative (i.e. in the sense of tending towards producing low WACC percentiles) input assumptions.
- As we noted in our August report, the model does not take account of the possibility that network augmentation may, in addition to avoiding unmet demand for energy, increase the economic efficiency of dispatch by facilitating the export of energy from regions with cheaper generation resources and by reducing physical transmission losses. Some work could be done to investigate the magnitude of these market benefits from 'economic investments'.
- It may be worthwhile investigating whether alternative WACC distributions would be more appropriate than the normal distribution assumed in the

model. If other plausible distributions can be identified, the effect of applying those distributions could be investigated.

- Different sensitivities of network investment to allowed regulated returns below the firm's true WACC could be considered. This would involve asking to what extent (and under what circumstances) an allowed rate of return set below a firm's true WACC would actually discourage network investment.[4]

4 This would go to Professor Dobbs' point about the reasonableness of the assumption that regulated suppliers respond to incentives to invest (see Professor Dobbs' report, section 3.3).

1 Introduction

1 In August 2014, we produced a report (our August report) on behalf of Transpower, which implemented Professor Ian Dobbs' loss function model (the model) within a New Zealand context.[5] The model was based upon a study by Professor Dobbs published in the *Journal of Regulatory Economics*.[6]

2 On 19 September 2014 the Commerce Commission (the Commission) published, and invited submissions from interested parties on, a report by Professor Dobbs entitled *Proposed amendment to the WACC percentile for the allowed rate of return: Comments on the application of the Dobbs [2011] model* (Professor Dobbs' report). Professor Dobbs' report comments on our implementation of the model.

3 Transpower has asked us to consider Professor Dobbs' report, provide our views on it and, where appropriate, respond to concerns or issues raised by Professor Dobbs over how we have implemented the model.

4 The key issues raised by Professor Dobbs that we have focussed on are the following:

- The 'goodness of fit' of the model (i.e. its applicability to the electricity sector).
- The value of a loss function model framework to assist the Commission's decision making.
- The appropriate welfare standard to assume when implementing the model and when determining an appropriate allowed rate of return more generally.
- The need for some further modelling and sensitivity analysis.

5 The remainder of this report is organised as follows:

- Section 2 considers how the model could be used by Commission in its deliberations.
- Section 3 sets out in more detail our views on the appropriate welfare standard when evaluating the optimal WACC percentile.
- Section 4 presents the results of further modelling work recommended by Professor Dobbs.

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5 Frontier Economics, *Application of a loss function simulation model to New Zealand, A report prepared for Transpower*, August 2014.

6 Dobbs, I.M., "Modeling welfare loss asymmetries arising from uncertainty in the regulatory cost of finance", *Journal of Regulatory Economics* (2011) Volume 39, pp.1-28.

2 Use of the Dobbs model by the Commission

2.1 'Goodness of fit' of the model

6 Professor Dobbs comments briefly on the 'goodness of fit' of his model for electricity networks. He makes three specific points:

- Firstly, he raises a question as to the applicability of the model to the electricity sector.
- Secondly, he notes that the model assumes an obligation to supply in respect of 'existing demand', which may not apply as unambiguously to Transpower.
- Finally, he notes that his model is not a 'peak-load' pricing model, in that it does not distinguish between investment to meet a constant increment of demand and investment to meet short-term excursions of demand or supply-side contingencies.

7 We address briefly each of these points.

2.1.1 Applicability of the model to the electricity sector

8 Professor Dobbs notes that his model was developed originally with a view towards application to the telecommunications sector. In the telecommunications sector, technology evolves relatively rapidly and new services are developed and rolled out from time to time. By contrast, technological progress in the electricity sector tends to be slower, and 'new' demand is relatively indistinguishable from 'existing' demand.

9 Although Professor Dobbs does not say so explicitly, the implication is that technological progress, and the ongoing development of new services, provides the impetus for 'new' demand in the model.

10 We note that Professor Dobbs did not advise that the model is unsuitable for application to the electricity sector. In our view, there is no compelling reason why the model should not be applied to the electricity sector. Technological progress is not the only driver of new demand. New demand for electricity can arise, for instance, with population growth, the geographical expansion of urban areas, and growth in industrial and economic activity.

11 Finally, as Professor Dobbs notes, "the model assumes essentially a monopoly provider of these services".[7] This is a correct description of regulated electricity networks in New Zealand.

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[7] Professor Dobbs' report, para. 10.

2.1.2 Assumption of obligation to supply

12 Professor Dobbs notes his model assumes that the service provider is obliged to meet increases in demand for existing services and, as such, investing to meet such incremental needs does not constitute 'new demand'.

13 However, to the extent regulated suppliers retain some discretion over the timing and/or level of investment to meet load growth from existing customers, it would likely be the case that the optimal WACC in respect of category 1 (existing) investment is higher than Professor Dobbs found in his 2011 paper. Professor Dobbs makes this observation himself.[8]

14 A report prepared by Castalia for Transpower details how Transpower and EDBs have a significant degree of discretion over timing of investment; even for reliability. For example:

> Transpower needs to invest to meet regulatory standards, and has limited ability or incentive to avoid investment if doing so would directly compromise regulated reliability standards. However, investments in reliability only form part of the capital that Transpower spends. Other investments that help to promote the efficient operation of the grid and/or electricity system can be deferred or avoided, for example economic investments.
>
> The ability to defer expenditure also exists for other regulated suppliers. This is because regulated businesses do not face pressure from other suppliers to maintain efficient expenditure levels that exists in workably competitive markets. Instead regulators seek to promote outcomes that are consistent with workably competitive markets by requiring regulated suppliers to meet quality standards. However, those standards will always be incomplete—creating an ability to defer expenditure that would be most efficiently spent today.[9]

2.1.3 Peak-load nature of the demand for electricity

15 Professor Dobbs suggested that customers may have different valuations for *overall electricity* supply (which may be capped by the cost of by-pass), as compared to what he refers to as *reliability* (which appears to mean consumers' willingness-to-pay to avoid short-term interruptions of power at certain times).

16 We do not disagree with this point. In undertaking additional modelling, for the purposes of developing this submission, we adopted a highly conservative assumption that all consumer demand – whether for overall supply or reliability – is capped at either the P-intercept of the linear demand function or at $500/MWh, depending on whether by-pass opportunities were being modelled explicitly.

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8 Professor Dobbs' report, para.11.

9 Castalia, *The Rational Response of a Regulated Transmission Company to a Low WACC*, 1 May 2014

2.2 The value of a loss function model framework to assist the Commission's decision making

17 Professor Dobbs cautions the Commission, correctly in our view, against using the results from the model in a purely mechanistic way. We agree the model has limitations and does not reflect all real-world features perfectly. But then, no economic model does. Therefore, the optimal WACC percentile predicted by the model should not be viewed by the Commission as 'the' correct WACC percentile to apply.

18 However, we do consider that the model, applied to a New Zealand context, can enhance significantly the Commission's review of the WACC percentile used for price control by providing:

- a very helpful framework to analyse systematically the welfare trade-offs the Commission faces when determining an appropriate allowed rate of return;
- a means for laying out and testing the effects of various assumptions;
- useful directional evidence on the optimal WACC percentile; and
- an indication of whether the Commission's proposed WACC percentile is likely to be too generous or too conservative.

19 In our view, it would be better to take account of the evidence provided by the model than to discount it and rely on purely theoretical arguments and/or Oxera's modelling. The High Court, in its judgment, cautioned against relying on purely conceptual reasoning, and urged the Commission to explore loss function modelling of the kind we have presented.

20 There are good reasons for this. As the Commission has recognised, the appropriate choice of WACC percentile involves the weighing of welfare consequences of setting the allowed rate of return too high or too low. This is a complex problem. Whilst one might form conjectures based on theoretical considerations, it is necessary to test these systematically to avoid drawing mistaken inferences.

21 For instance, as Professor Dobbs notes, switching from a constant elasticity demand function to a linear demand function would reduce the consumer surplus lost.[10] Based on this, one may draw an *a priori* inference that a large reduction in lost consumer surplus would lower significantly the optimal WACC percentile. Indeed, Professor Dobbs himself suggests this may be the case.[11] However, that inference turns out to be incorrect, as we show in section 4.1.

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10 Professor Dobbs' report, para. 67.

11 Professor Dobbs' report, para. 74.

22 Without a formal model, not only might it be easy to draw the wrong conclusions, it would also be difficult to test those conclusions.

23 For these reasons we think the model should be used to inform, but not to dictate, the Commission's choice of the optimal WACC percentile.

3 The appropriate welfare standard

3.1 Implications of weighing consumer surplus more than producer surplus

24 As explained in our August report to Transpower, we consider that it would be inappropriate for the Commission to place greater weight on consumer welfare than on producer welfare in determining the appropriate WACC percentile.

25 As noted by Professor Dobbs in his report, given that for existing network assets consumer surplus is strictly decreasing in the network tariff and hence in the choice of the allowed WACC, the optimal solution under a pure consumer surplus criterion would be to reduce the allowed rate of return on sunk assets to zero.[12] We and Dr Lally have previously made the same point.

26 Providing a regulated firm with no return on its sunk assets, or deriving a uniform firm-wide allowed return based on the notion that the firm should receive a zero return on its sunk assets, would effectively prevent regulated suppliers from fully recovering their efficient costs. This, in turn, would deter regulated suppliers from making investments, or investing in an efficient manner.

27 As noted in our August report, the regulatory objective in section 52A of the *Commerce Act* 1986 refers to promoting the long-term interests of consumers "...by promoting outcomes that are consistent with outcomes produced in competitive markets..." (p.8).

28 A competitive market can only operate at a stable equilibrium if firms are able to recover their efficient costs. If firms in a competitive market cannot recover their efficient costs, they will exit the market (or refrain from investing) until prices rise sufficiently for an equilibrium in which efficient costs can be recovered is restored. This suggests that ignoring the welfare of producers would not be consistent with the regulatory objective.

3.2 The regulatory compact

29 Professor Dobbs' reasoning for why it would be inappropriate to provide a zero return on sunk assets, which we agree with, was as follows:[13]

> This is simply the age old conundrum – that all new investment once made becomes sunk and hence potentially exploitable by the regulator. The regulatory 'compact' is about building trust that the regulator will not (after investment) exploit the sudden shift in bargaining power as new assets revert to being sunk assets. Continuing to

[12] Professor Dobbs' report, para. 20.

[13] Professor Dobbs' report, para 20.

> offer an adequate return on investment on sunk assets is crucial to the 'compact' – without it, firms would not trust the regulator not to subsequently exploit the 'now sunk' new investment and hence would not invest at all. In terms of the model, moving from putting equal weight on consumer surplus and profits to a position in which there is increased weight on consumer surplus is effectively putting some weight on being able to exploit sunk assets.

30 This strongly suggests it would be invalid to use Professor Dobbs' loss function model in conjunction with a consumer surplus criterion rather than a total surplus criterion. Such an application would be inconsistent with the behavioural underpinnings of the model and disqualify the integrity of any results so obtained.

31 Spiller and Tommasi (2008) explain the temptation for regulators to exploit utilities' sunk assets as follows:[14]

> ...the fact that a large component of infrastructure is sunk, implies that once the investment is undertaken the operator will be willing to continue operating as long as operating revenues exceed operating costs. Since operating costs do not include a return on sunk investments (but only on the alternative value of these assets), the operating company will be willing to operate even if prices are below total average costs.

32 As a result, regulators may exploit infrastructure businesses' sunk assets without necessarily, in the short-term, degrading the quantity or quality of service provision. However, over the long-term, such a policy would be unsustainable as it would seriously undermine the incentives of regulated suppliers to make the investments that deliver services to customers.

33 Spiller and Tommasi go as far as saying:[15]

> ...we contend that the overarching problem driving the regulation of utilities, whether public or private, and thus the issues politicians have to deal with, is how to limit governmental opportunism, understood as the incentives politicians have to expropriate – once investments are made – the utilities' quasi rents,[16] whether under private or public ownership, so as to garner political support.

3.3 Foundations of the regulatory compact

34 There is a considerable body of literature that traces the basis for economic regulation to the difficulties encountered by infrastructure providers and customers in negotiating long-term contracts for the development and use of

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14 Spiller, P.T. and M. Tommasi, "The Application of Regulation: An Application to Public Utilities", chapter 20 in *Handbook of New Institutional Economics*, Menard, C. and M.M. Shirley (Eds), (2008) Springer-Verlag, pp.515-543, p.519.

15 Spiller and Tommasi (2008), pp.517-518.

16 In this context, 'quasi rents' should not be regarded as illegitimate super-normal profits, but as providing a return on capital invested in sunk assets.

long-lived, immobile and low alternative-value assets. Gomez-Ibanez (2003) explains:[17]

> It is hard for an infrastructure company to avoid investments in durable and immobile facilities or for its customers to avoid investments specific to their communities. The company's facilities cannot be transported to other locations if the local customers, or the government representing those customers, insist on price reductions. And the customers can't easily relocate if the infrastructure company decides to raise prices...
>
> As in the more general procurement problem, one way to protect against opportunism is to sign a long-term contract before making the relationship-specific investments...
>
> Government regulation can be viewed as a substitute for private contracts, used when it is too costly or difficult for the companies and customers to reach individual agreements. In effect, the government contracts with the infrastructure company on the customers' behalf.

35 Joskow (1991) describes the stylised features of the regulatory compact as follows:[18]

- The regulated firm is granted an exclusive franchise to provide a service to consumers in a certain area at a price to be determined by a regulatory agency.
- To fulfil its obligations to serve, the utility must make substantial investments in long-lived assets that are highly immobile and have little value in alternative uses (i.e. once made, the investments are sunk).
- Interruptions in service are very costly to consumers and utilities are expected to provide sufficient capacity to keep the probability of interruptions low (ideally balancing benefits and costs).
- Individual customers have no long-term contractual obligations to take service from the utility and may increase or decrease demand at will.
- The regulatory agency has a dual responsibility to protect consumers from excessive rates, as well as to enable the regulated firm to recover at least its efficient costs.
- Thus, while the utility does not have a long-term contract with any individual customers, it has an implicit long-term take-or-pay contract with customers as a group through the operation of economic regulation.

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17 Gomez-Ibanez, J.A., *Regulating Infrastructure, Monopoly, Contracts, and Discretion*, (2003) Harvard University Press, p.10.

18 Joskow, P.L., "The Role of Transaction Cost Economics in Antitrust and Public Utility Regulatory Policies", *Journal of Law, Economics & Organization*, Volume 7, Special Issue (1991), pp.53-83, pp.67-68.

3.4 Breakdown of the compact

36 Joskow observes that the combination of franchise-specific sunk investments and franchise exclusivity gives the regulatory agency (or more generally the political process to which it responds) potential power to 'hold up' the utility. Once a public utility has made sunk investments in facilities, it is open to being held up by regulators trying to keep prices as low as possible.

37 However, it is difficult to see how a rational, forward-looking supplier would observe such opportunistic behaviour by the regulator and continue to invest as though the regulator is likely to remain faithful to the regulatory compact in future.[19]

38 If, as a result of these incentives, there is a break-down of the regulatory compact, Joskow notes that:[20]

> ...firms would not find least-cost investments viable and would either decline to supply or supply inefficiently in response to regulatory rules that treat different types of costs asymmetrically for rate-making purpose.

39 Therefore, violation of the regulatory compact is likely to yield inefficiency – either in the form of under-investment or in the form of piecemeal investment that involves smaller sunk costs but does not minimise overall costs – to the long-term detriment of consumers. This point, which we agree with, is made by Professor Dobbs in his report.

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19 In section 3.3 of Professor Dobbs' report, he entertains the idea that a regulator might consider regulatory policies under the assumption that regulated suppliers will not respond rationally to incentives. In our view, it is very difficult to justify a regulatory framework on the basis of such an assumption. Indeed, the whole system of **incentive regulation** is predicated on the notion that firms do respond to incentives. To do away with that assumption would be to do away with incentive regulation itself.

20 Joskow (1991), p.68.

4 Further modelling and sensitivity testing

40 Professor Dobbs recommended three pieces of further modelling and sensitivity testing that would be worthwhile to undertake. These were:

- Applying a linear demand function in place of the iso-elastic demand function used in his original model and in the model we implemented.
- Allowing the demand elasticity assumption to vary by category of investment.
- Performing sensitivity analyses on the extent of pass-through of network costs to electricity retail tariffs.

41 In order to assist the Commission with its deliberations, we have addressed each of these suggestions by Professor Dobbs.

4.1 Specification of the demand function

42 Professor Dobbs makes a number of points regarding the specification of the demand function for electricity that we have assumed. Firstly, he notes that demand does not 'choke off' suddenly as we have assumed; rather, it is more likely that demand would attenuate smoothly towards zero as price approaches the choke price. Secondly, if there is a choke price, it is unlikely to be as high as we have assumed in our modelling.

43 Professor Dobbs' underlying concern when raising these points is that predicted welfare losses arising from under-investment may be highly sensitive to the form of the demand function assumed. This, in turn, could have a material impact on the optimal WACC percentile.

44 Professor Dobbs notes that both Dr Lally and NZIER consider a linear demand specification to be more realistic, and recommends some modelling be done under this assumption. He demonstrates that, under a linear demand assumption, the maximum willingness to pay for electricity (i.e. the P-intercept of the demand curve) would be considerably lower than the choke prices we assumed on the basis of Value of Lost Load (VoLL) estimates for New Zealand.

45 This section presents our modelling results based on a linear demand function specification. We acknowledge that we do not know the true form of the demand function for electricity in New Zealand.[21] In reality, it is likely that both a constant elasticity of demand function and a linear demand function are imperfect representations of the actual demand for electricity.

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21 In reality, we only observe price and demand data not too far away from the current level. Extrapolating the shape of demand curve further away from what we can empirically observe inevitably involves a large amount of uncertainty.

46 Whilst Professor Dobbs suggested that the assumption of a constant elasticity of demand function would likely *overstate* the welfare losses associated with under-investment in electricity networks, our view is that adoption of a linear demand function would likely *understate* the welfare losses.

47 To illustrate why a linear demand function is likely to understate the benefits attributable to electricity networks, consider that in our base case scenario, the linear demand function extends from the 2012 average retail price of approximately $186/MWh to intercept the P-axis at around $800/MWh. At least in the short term, even $800/MWh is likely to understate the amount consumers would be willing to pay for electricity supply. As noted in our previous report, for network planning purposes, much higher (i.e. VoLL) figures are used to represent the value of supply to consumers.

48 As Professor Dobbs calculated in Table 4 of his report, using the 2012 price and demand level, the base case with linear demand implies the consumer surplus from the electricity sector is about $12.2 billion. It would seem implausible that if New Zealand were to run without any grid-supplied electricity for the full duration of 2012/13, the adverse welfare impact would be as low as 5.8% of its total GDP for that year.[22]

49 Even in the long-term, when some consumers may be willing to consider by-passing the existing network by investing in distributed generation, the use of a linear demand function with a P-intercept of $800/MWh implies that demand is highly elastic at prices well below this level. Given that the minimum levelised cost of by-pass is likely to be in the vicinity of $600/MWh, it seems unrealistic that the elasticity implied by a linear demand function at a price of $500/MWh would be -1.62 in the base case.[23] This would mean that if retail prices rose from, say, $500/MWh to $550/MWh, customers would reduce their total expenditures on electricity, *despite being unable to source power from elsewhere at a lower price*.

50 Nevertheless, in response to Professor Dobbs' suggestions, we present revised modelling results using linear demand functions. The linear demand specification implies willingness to pay and total surplus at the low end of any plausible range and, as Professor Dobbs' report pointed out, leads to a lower optimal WACC value. Since the values of other inputs span the range of plausibility in the context of electricity network industry, we consider results from linear demand lie on (or beyond, as in some sensitivities) the lower bound of the optimal WACC percentile predicted by the model.

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22 Professor Dobbs notes, at para. 62 of his report, that New Zealand GDP in 2012/13 was approximately $212 billion.

23 To do this, one needs to first construct the linear demand curve. See below on how this may be done. The implied elasticity on the linear demand at any price then can be computed using the following formula: $\epsilon = \frac{\partial Q}{\partial P}\frac{P}{Q}$.

4.1.1 Application of a linear demand function

51 At time t, the linear demand function for category i takes the form:[24]

$$Q_{t,i} = e^{\alpha_i t}(a_i + b_i P_i)$$

where α is the growth rate of demand. As in our August report, we take the volume-weighted average retail price and demand at the end of calendar year 2012 as the starting point of the model, and will suppress the subscript i and t for the sake of simplifying the notation.

52 As suggested by Professor Dobbs, we construct the linear demand curve by finding the implied slope of the demand function at the starting point. The elasticity of demand is defined as:

$$\epsilon = \frac{\partial Q}{\partial P}\frac{P}{Q}$$

53 The slope of the demand function at the starting point is

$$b = \epsilon \frac{Q_0}{P_0}$$

where (P_0, Q_0) denotes the starting point of the demand curve.

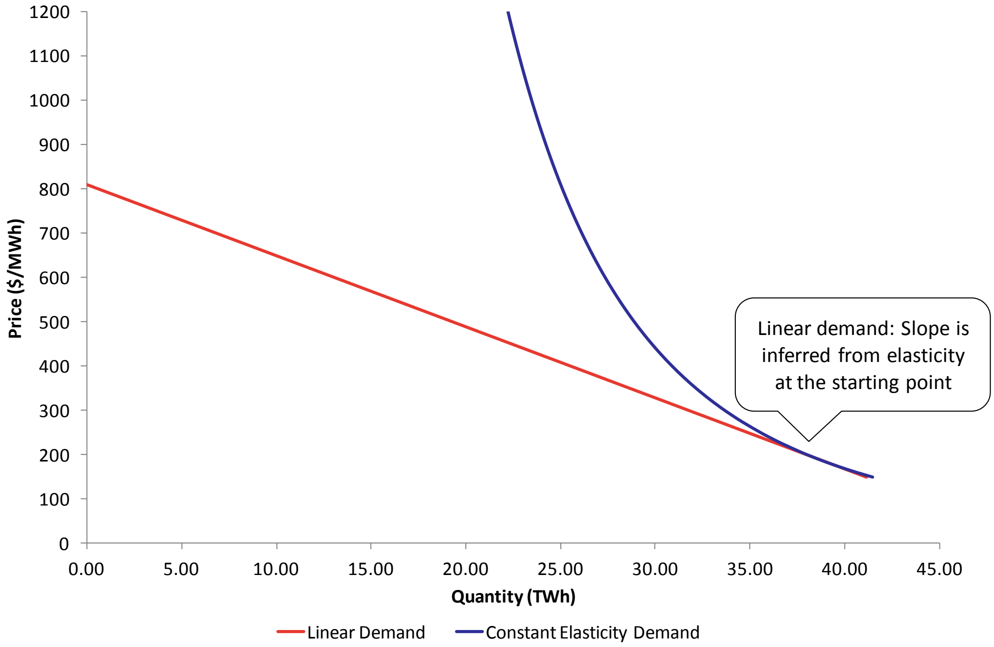
54 It is then straightforward to calculate the intercept between the demand function and the P-axis, which is the maximum willingness to pay, as follows:

$$P_{\max} = \frac{(Q_0 - bP_0)}{-b}$$

55 An example of a linear demand function is illustrated in Figure 1.

24 We adopt this convention so that the negative slope is actually implied by the value of b.

Figure 1: Illustration of linear and constant elasticity demand functions



Source: Frontier Economics

4.1.2 Scenarios modelled

56 Here we show the results of three main scenarios from our August report. The base case in our original report consists of inputs most likely to be representative of the New Zealand electricity network industry. In addition, we examined a range of plausible alternative input values in scenarios 1 and 2.

57 The base case scenario inputs from our August report are reproduced in Table 1. We have modified the relevant assumptions in relation to demand to reflect the linear demand function modelled here.[25]

25 The originally assumed maximum willingness to pay does not apply here as the demand function will be naturally capped out by its point of intercept along the P-axis.

Table 1: Base case assumptions

Parameter	Base case assumption
Retail price (starting point on demand curve)	$186.77/MWh
Demand served by existing investment (at starting point on demand curve)	38.85 TWh
Demand served by new investment **(at starting point on demand curve)**	1% of existing = 0.39 TWh
Elasticity of demand at the starting points (existing and new)	-0.3
Demand growth (existing)	0 %
Demand growth (new)	1%
Transmission price (at starting point)	$21.96/MWh
Distribution Price (at starting point)	$44.69/MWh
WACC distribution	Normal truncated at ± 4 std dev
WACC mean	6.83%
WACC standard deviation	1.067%
Network fixed cost component	70%
Annual depreciation	2.5%
Regulatory length	5 years

Source: Frontier Economics

58 The input assumptions under scenarios 1 and 2 that are different from the base case are presented in Table 2.

Table 2: Scenario 1 and 2 alternative inputs

Parameter	Scenario 1	Scenario 2
Demand served by new investment **(at starting point on demand curve)**	1.5% of existing =0.58 TWh	0.5% of existing =0.19 TWh
Elasticity of demand at the starting point (existing and new)	-0.1	-0.7
Network fixed cost component	65%	75%

Source: Frontier Economics

Further modelling and sensitivity testing

59 Table 3 shows the slope and maximum willingness to pay for the three scenarios considered. In this section, we keep elasticity the same for new and existing demand *within* each scenario; in a subsequent section we relax this assumption.

60 It is then straightforward to verify that the intercept on the P-axis is the same for existing and new demand curve for each scenario.

Table 3: Slope and maximum willingness to pay

Scenario	Elasticity at start point	Slope of existing demand (b), $\Delta MWh/\Delta\$$	Slope of new demand (b), $\Delta MWh/\Delta\$$	Intercept at P-axis/Max WTP (a), $/MWh
Base case	-0.3	-62,399	-624	809
Scenario 1	-0.1	- 20,800	-312	2,054
Scenario 2	-0.7	-145,598	-728	454

Source: Frontier Economics

61 For completeness, we have included scenario 2 from our original report in the current modelling. However, we emphasise that using linear demand under scenario 2 implies an implausibly low value of electricity – well below any plausible cost of by-passing the grid. In addition, every 1 cent/KWh increase in average retail price will lead to a reduction in annual consumption by more than 1.45 TWh, or 3.7% of the 2012 consumption level. Further, Table 4 of Professor Dobbs' submission shows the implied consumer surplus in scenario 2 under linear demand is $5.2 billion in 2012. It is difficult to imagine that if New Zealand did not have any grid-supplied electricity, the welfare loss would represent a mere 2.5% of its total GDP.

62 In later sections, we present further sensitivities suggested by Professor Dobbs in his report. In particular, we investigate the effect of assuming:

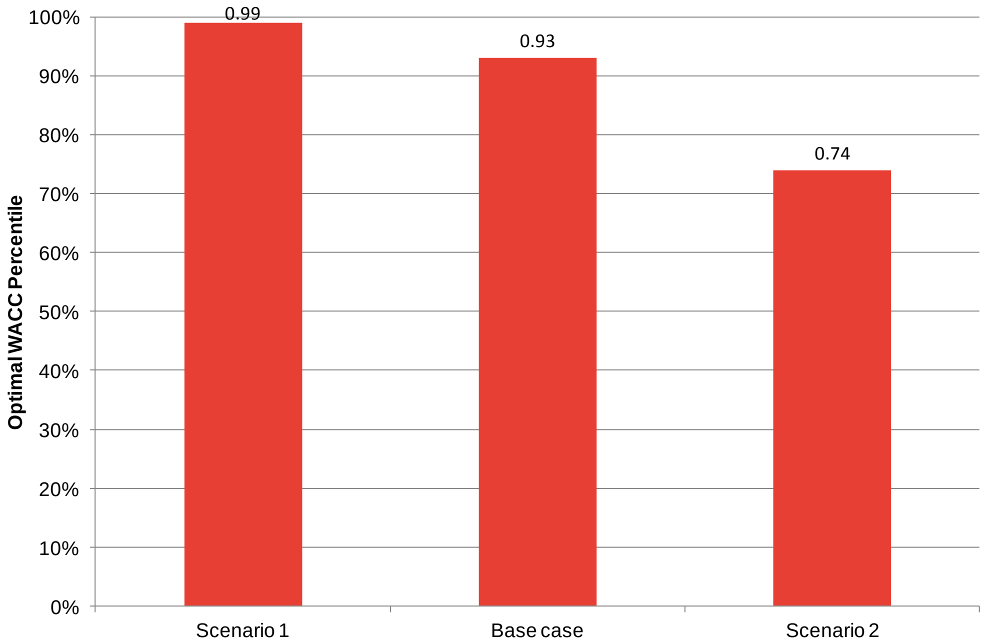
- new demand is more elastic than is existing demand; and
- a maximum willingness to pay lower than the point of interception between the linear demand curve and the P-axis.

4.1.3 Results under a linear demand specification

63 The optimal WACC percentiles with a linear demand specification, under the three scenarios considered, are presented in Figure 2. Although the linear demand specification leads to a lower optimal WACC percentile under the base case and scenario 2, vis-à-vis the results in our August report, the optimal WACC percentile under the base case remains high, i.e. at the **93rd percentile**.

64 Even under scenario 2, with an implausibly low welfare level associated with electricity, the optimal WACC percentile is the 74th percentile, i.e. higher than proposed by the Commission in its Draft Decision.

Figure 2: Optimal WACC percentiles



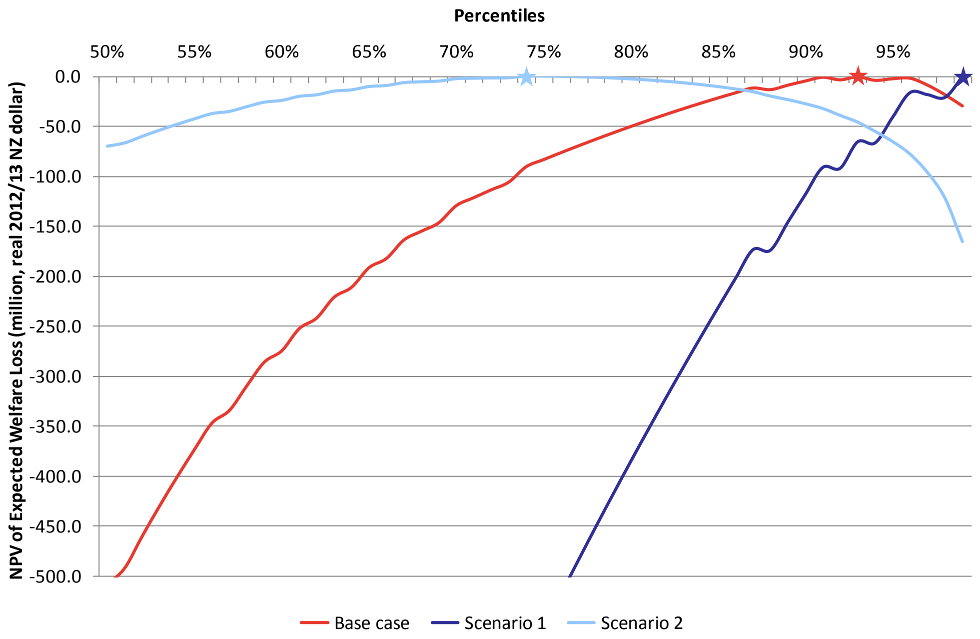
Source: Frontier Economics

65 As recommended in Professor Dobbs' report, we have calculated the expected welfare loss when moving away from the optimal WACC in each scenario – see Figure 3 and Table 4 below.[26] The markers in Figure 3 indicate the optimal WACC percentile under each scenario.

---

26 The actual loss amount can be "jagged" when moving from one percentile to the next. We have commented on this in footnote 36 of our August report. This is due to the "lumpiness" introduced by the mathematical approximation.

Figure 3: NPV of expected welfare losses



Source: Frontier Economics.

Notes: Global maxima are indicated.

Table 4: NPV of expected welfare loss ($ millions)

Percentile	Base case (Optimal WACC at 93rd percentile)	Scenario 1 (Optimal WACC at 99th percentile)	Scenario 2 (Optimal WACC at 74th percentile)
50%	-508.4	-2,508.6	-70.1
55%	-373.1	-1,896.6	-42.7
60%	-274.3	-1,446.6	-24.3
65%	-191.1	-1,064.1	-10.5
70%	-129.0	-773.8	-2.6
75%	-82.9	-552.4	-0.1
80%	-49.7	-384.8	-2.9
85%	-21.1	-231.0	-10.6
90%	-4.2	-117.8	-27.7
95%	-1.9	-40.6	-65.4
99%	-29.1	0.0	-165.5

Source: Frontier Economics

66 Note that the mathematical setup of the model involves infinite horizons with continuous timing. Therefore the figures presented below show the Net Present Value (NPV) of the expected welfare loss over an infinite horizon. It is not a trivial exercise to annualise the losses as neither the instantaneous welfare in the model nor the WACC are stationary.[27]

67 Under the base case, the NPV of the expected welfare loss increases sharply as one moves further away from the optimum, i.e. the 93rd percentile. The expected loss is roughly $83 million if the 75th percentile is adopted, $191 million if the 65th percentile is adopted, and over $500 million if the 50th percentile is adopted. Even in scenario 2, adoption of the 50th percentile leads to an expected NPV loss to society of $70 million, relative to choosing optimum, i.e. the 74th percentile.

4.1.4 Explanation of results under linear demand

68 Professor Dobbs suggested that if the model were run under a linear demand specification "it is likely that the predicted optimal percentile figure will be considerably lower than that under Frontier's base case ($20,000) or even supposedly conservative case ($10,000)".[28]

69 However, our further modelling shows that whilst the optimal WACC percentile is lower than under our original demand specification, it is not significantly lower; the optimal WACC percentile under our base case is significantly greater than the 75th percentile that the Commission presently employs.

70 Professor Dobbs' conjecture was based on the intuition that compared to the constant elasticity specification, a linear demand function would lead to a smaller total surplus attributable to the electricity network. Consequently, he suggested that the implied loss of welfare due to delayed investment would be lower under a linear demand specification than under an iso-elastic demand specification.

71 While delayed investment under a linear demand specification is indeed associated with a smaller welfare loss than with iso-elastic demand, this does not necessarily lead to a substantial reduction in the optimal WACC percentile. Although linear demand implies a smaller total surplus lost when investment is delayed, the optimal WACC is determined by the overall trade-off between the avoided loss in total surplus and the increased deadweight loss.

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27 It may be possible to use some approximate discount factor for these purposes. For example, since this exercise involves an assessment of overall welfare to society under different regulatory approaches, it may be appropriate to employ an estimate of the social rate of time preference as the discount rate when annualising the societal losses. However, given that estimates of social rates of time preference can be contentious, we have not attempted to annualise the losses here.

28 Professor Dobbs' report, para. 74.

72 To see this more clearly, one can start by considering total welfare predicted by the model at the 99th percentile, and examining the welfare gain or loss if the WACC percentile chosen by the regulator were lowered incrementally.

73 Figure 4 and Figure 5 provide such illustrations for the base case scenario under a constant elasticity demand specification and a linear demand specification, respectively. We plot changes in NPV of welfare under the two demand specifications on different charts because the absolute levels of welfare under each are very different, and so are difficult to represent clearly on a common scale.

74 The charts show that as the WACC percentile is reduced from the 99th percentile, expected welfare under existing demand (denoted by the red curve) increases because of the expected deadweight loss (i.e. from the possibility that the regulated price is set too high) declines. However, the welfare change under new demand (denoted by the dark blue curve) is dominated by the increased probability of delayed new investment and hence falls as the WACC percentile is reduced. Although a reduction in price also lowers the deadweight loss under new demand *if new investment does occur,* this marginal effect is very small compared to the total surplus at stake.[29] Total welfare (i.e. the light blue curve) is given by summing the red and dark blue welfare curves.

75 In the case of constant elasticity demand (Figure 4), the optimal WACC percentile (denoted by the star on the total welfare curve) corresponds to the 99th percentile. Any reduction from the 99th percentile causes an overall reduction in welfare due to the very large total surplus at stake. When demand is linear, moving below the 99th percentile initially increases the total welfare. However, this effect is reversed at the 93rd percentile (which, as shown earlier, is the optimal WACC percentile predicted by the model). Below this point, the potential lost welfare in relation to new demand overwhelms the avoided deadweight loss in relation to existing demand; the net effect (denoted by the light blue curve) is that total welfare declines.

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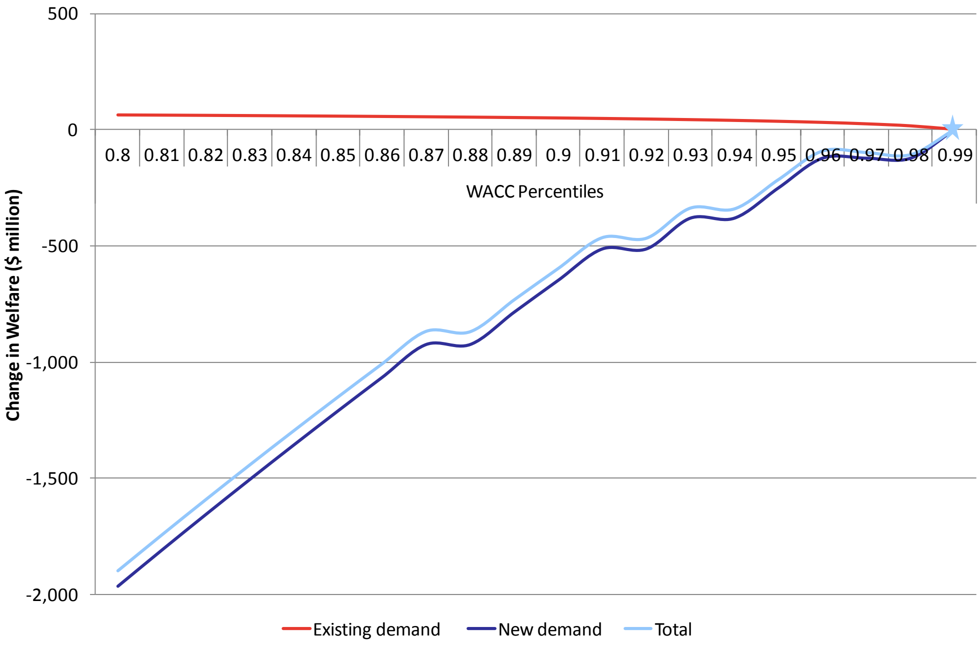
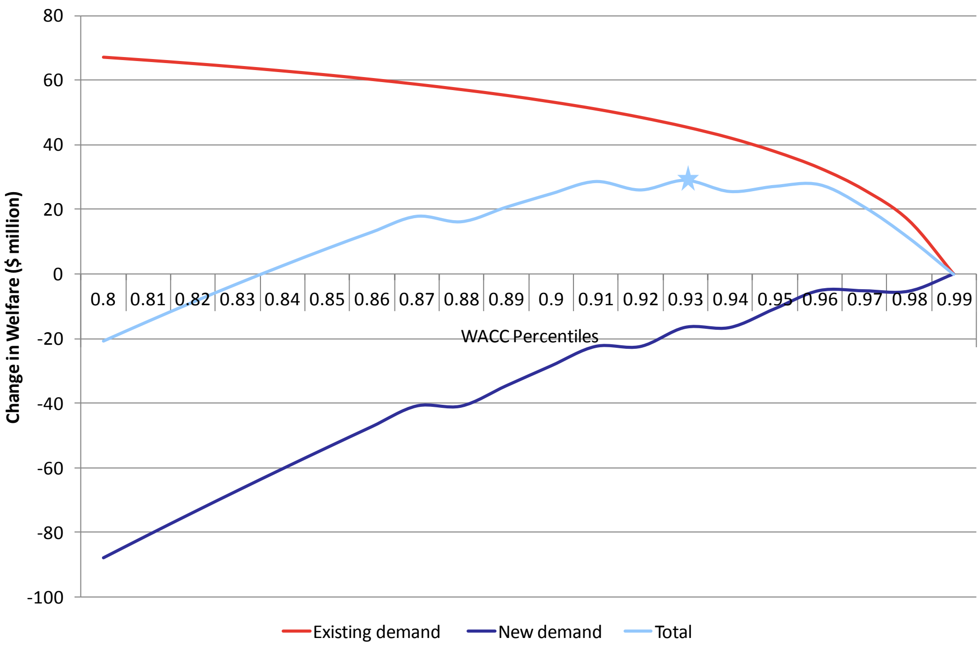
29 Readers may notice the "kinks" in the welfare curves for new demand. As mentioned in the footnote 36 of our August report, sometimes the probability of investment can remain unchanged when the allowed rate of return increases by just one or two percentiles. When this happens, increasing the WACC percentile slightly reduces the welfare under new demand due to the larger deadweight loss when investment actually takes place.

Figure 4: Welfare change ($m) relative to 99th percentile – constant elasticity demand



Source: Frontier Economics

Figure 5: Welfare change ($m) relative to 99th percentile – linear demand



Source: Frontier Economics

Further modelling and sensitivity testing

4.1.5 By-pass option

76 Professor Dobbs raised the question of whether even the linear demand specification has a realistic 'choke point' (i.e. P-intercept). Assuming a demand elasticity of -0.3, the P-intercept under linear demand is $809/MWh. We consider that most electricity customers in New Zealand would struggle to by-pass the existing network at a levelised cost below this figure.

77 Nevertheless, based on basic desktop research, it may be possible to conceive of customers installing diesel generators with levelised costs of as little as $500/MWh – comprising:

- $450/MWh for fuel (based on an optimal load factor[30] and a diesel cost of $1.50/litre[31] producing 3.33 kWh/litre); and
- $50/MWh for capital and operating and maintenance costs.[32]

78 Note that many estimates of by-pass costs, particularly for smaller customers, are significantly higher.[33]

79 We have investigated the effect of capping the linear demand function at the by-pass cost of $500/MWh. Figure 6 illustrates the shape of the demand function with a binding cap. The result of is shown in Figure 7. Note the cap does not bind for scenario 2. The optimal WACC percentile for the base case under such cap corresponds to the 91st percentile.

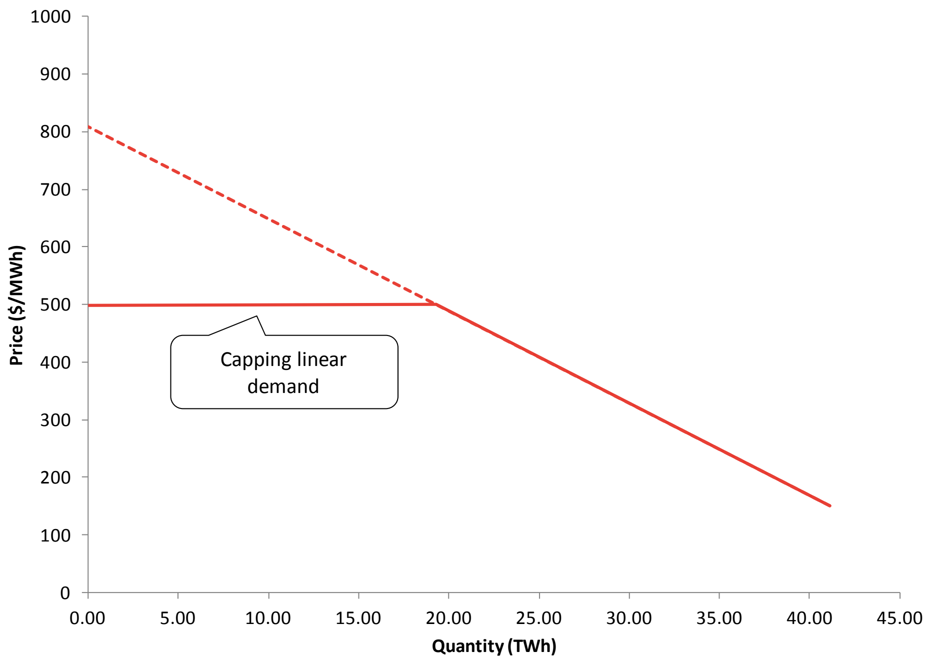
30 Based on efficiency of a 20 kW diesel unit operating at 100% load factor, producing 20 kWh with 1.6 US gallons (6 litres) of fuel: see the Diesel Service and Supply website (accessed 25 September 2014). This results in 3.33 kWh per litre. At a diesel cost of $1.50/litre, operating cost is 45c/kWh.

31 See Stockdale, M., September 2014 petrol and diesel prices, AA Motoring, 17 September 2014: (accessed 25 September 2014).

32 Based on capital cost of approximately $2,500 for a (small) 4 kW diesel unit, amortised at a 7% discount rate over 10 years. See CSIRO, *Modelling the Future Grid Forum Scenarios*, December 2013, Table 11, p.41.

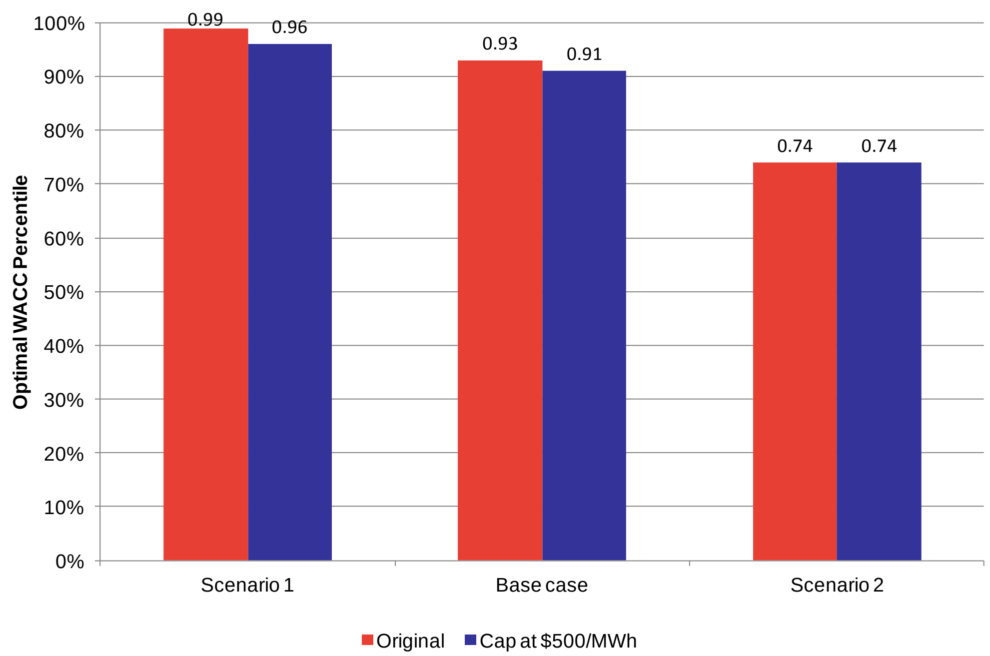
33 For example, the IT Power report for the South Australian Department of Manufacturing, *Innovation, Trade, Resources and Energy, Data Collection of Diesel Generators in South Australia*, September 2013, p.26, middle chart.

Figure 6: Capping the linear demand function



Source: Frontier Economics

Figure 7: Sensitivity – Capping linear demand



Source: Frontier Economics

Further modelling and sensitivity testing

4.2 Allowing the elasticity assumption to vary by investment category

80 Professor Dobbs also suggested using different elasticities for new and existing demand. Whilst the costs of by-passing the network are likely to be broadly similar regardless of the source of demand, there are plausible reasons why incremental demand might be more responsive to prices than existing demand.

81 'Existing' electricity demand could be characterised as reflecting demand for basic appliances such as lighting, cooking and some space heating, uses for which consumers could be unwilling to reduce their power usage even if faced with higher tariffs. Conversely, 'new' demand could be characterised as reflecting demand for more discretionary functions, such as air-conditioning or higher heating comfort levels. Demand for such uses could be more sensitive to higher electricity network tariffs. 'New' demand could also represent demand from customers in new housing or business developments, which could potentially have access to lower by-pass costs (e.g. such as through the use of integrated solar PV) than customers in existing developed areas.

82 Therefore, we investigated two sensitivities to test the effect of more elastic new demand. In the first sensitivity, we assume the elasticity of new demand is -0.7 at the starting point. This assumption, whilst plausible, is at the high end of accepted estimates of the long-run elasticity of demand.[34] In the second sensitivity test, we assume the elasticity of new demand is -1.5, which is well beyond any credible estimate of the long run elasticity of electricity consumption that we are aware of. The linear demand specification is maintained in this sensitivity analysis.

83 Note that at an elasticity of -1.5, the implied slope of the new demand curve for the base case is -3120ΔMWh/Δ$, and the intercept along the P-axis is $311/MWh. The optimal WACC percentile results are presented in Figure 8. (By construction, the result for scenario 2 only changes when new demand elasticity is -1.5.)

84 With an elasticity of -0.7 for new demand, the optimal WACC for the base case is at the 87th percentile. Even with the use of an implausibly high elasticity assumption of -1.5 for new demand, the optimal WACC percentile for the base case remains high, i.e. at the 83rd percentile.

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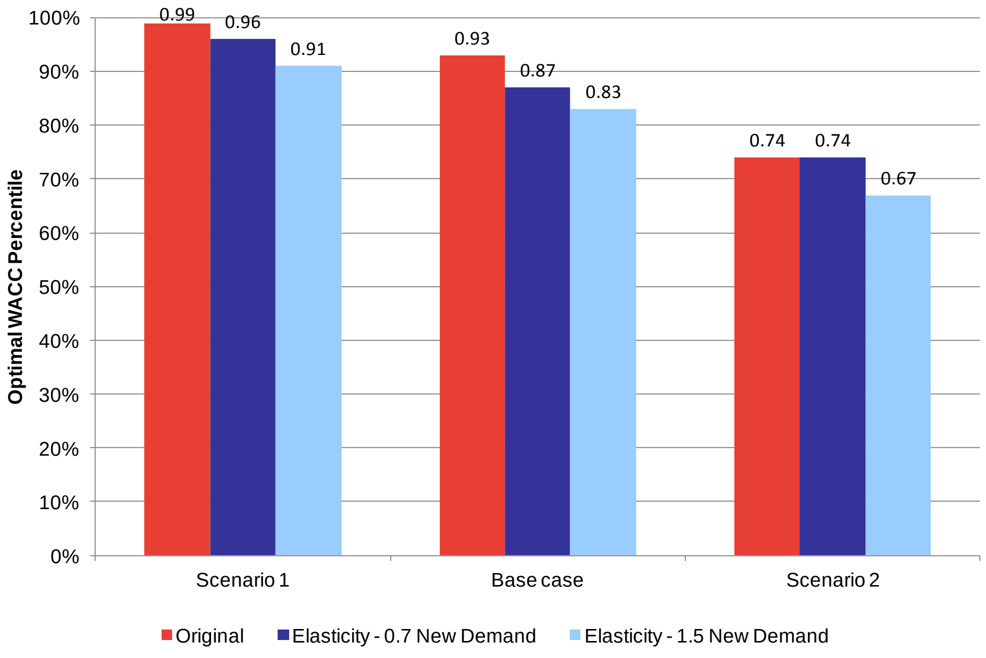
[34] Productivity Commission (2011), *Carbon Emission Policies in Key Economies, Research Report*, 9 June, *Appendix L, Demand-side analysis for electricity*, Box L.2., p.4.

Figure 8: Sensitivity – more elastic new demand



Source: Frontier Economics

4.3 Extent of assumed pass-through of price changes

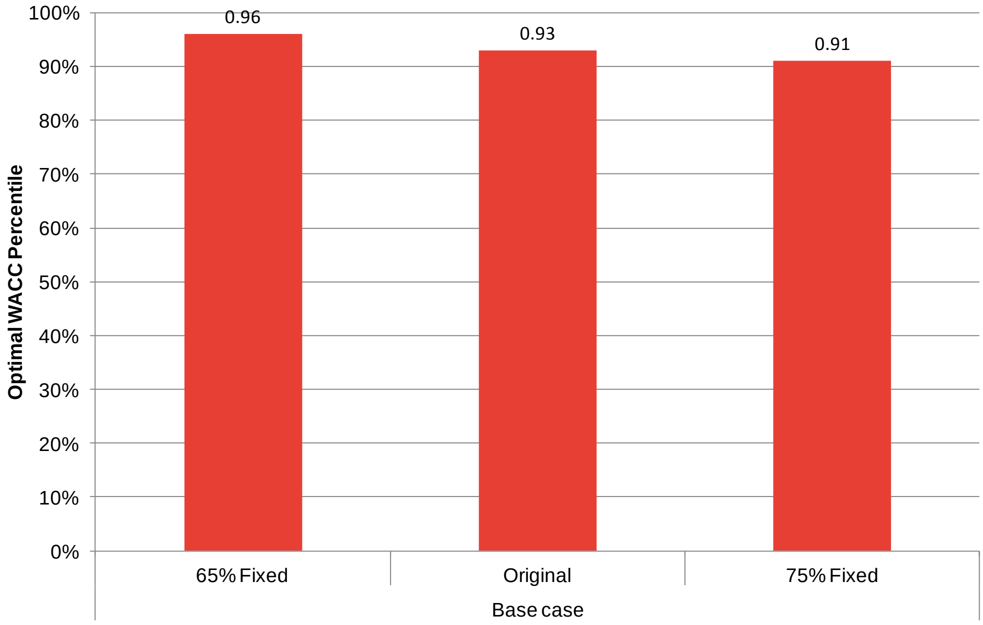
85 In Section 4.1 of his report, Professor Dobbs commented on the pass-through approach used in the model. He suggested that sensitivities around the proportion of fixed and variable costs in network businesses should be conducted.

86 We note that we had conducted these sensitivities in our August report, and we have also done so as part of the further modelling undertaken for this submission. Specifically, we varied the proportion of fixed cost in the network businesses in each scenario. The proportions assumed are 65%, 70% and 75% for scenario 1, the base case, and scenario 2 respectively.

87 Although the three main scenarios in our August report considered the effect of varying the pass-through assumption, those scenarios also reflected changes in other input parameters. In Figure 9 we demonstrate the effect of varying just the assumed fixed cost proportion under the *base case, with a linear demand specification*. In doing so, we assume all else remains equal. We find that the optimal WACC percentile corresponds to the:

- 96th percentile when the proportion of fixed cost is 65%; and
- 91st percentile when the proportion of fixed cost is 75%.

Figure 9: Base case varying fixed proportions



Source: Frontier Economics

88 This confirms the suggestion in our August report that, other things being equal, a higher fixed cost proportion is likely to lead to a lower optimal WACC percentile. This is because given the same increase in the allowed rate of return, a higher fixed cost implies a *larger* increase in network prices and final retail price, which in turn causes a larger marginal reduction in welfare.

89 The results reported above show that varying the fixed/variable proportions parameter does not cause the optimal WACC percentile to change materially.

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