Valuing investments in network reliability

An approach to estimating the value of reliability in electricity networks subject to WACC IM.

NZIER report to MEUG

9 September 2014

Final

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1. The Commission's 67th percentile proposal

The Commerce Commission (Commission) has released a paper[1] which proposes to change how they estimate the regulatory cost of capital (WACC) applied to energy businesses which are regulated under Part 4 of the Commerce Act. They propose that the 67th percentile of their estimated distribution of WACC be used for setting the price-quality path, replacing the 75th percentile that has been used from 2011 up until now. The change would take place immediately and apply to the price-quality resets that are due to be implemented in 2015.

Submissions on the 22 July paper closed on 29 August following which 35 documents from interested parties and their advisors were posted on the Commission's website. NZIER provided MEUG with advice regarding their submission including some brief local evidence that suggests network investments and performance in New Zealand is not as Oxera (one of the Commissions advisors) characterised. Amongst other matters we also advised MEUG that the persistent assumption of an asymmetric loss from mis-estimating the WACC was unreasonable and that the absence of evidence against uplift did not justify a presumption that uplift was consistent with the purposes of Part 4 of the Commerce Act.

1.1. Why this cross submission?

For cross submission purposes, NZIER has been asked by MEUG to consider whether the 29 August submissions contained locally relevant empirical data or local information that would better inform the assessment of over (or under) investment. We do not see anything of that nature in the material submitted on 29 August.

We have been asked to source evidence that adds to the work we started in our 29 August advice to MEUG, that can be assembled in a short time frame to further assist the Commission. The trigger has been the attempts in submissions by several expert advisors to adapt the Oxera "global" analysis more closely to New Zealand conditions while others have criticised the Oxera approach for being too abstract and assumption driven.

Submitters that offered analytical advice developed their thinking in various ways – Frontier Economics for instance extended the original Dobbs approach to New Zealand conditions using a range of assumptions and arrived at optimal uplift being the 99th percentile, a remarkable result on the face of it.

We will provide cross-submission advice on several other matters that we think deserve attention in another paper but here we want to describe and evidence an extension to our previous approach which we think the Commission could adopt to better understand the linkages between regulatory interventions, network investments (capex and opex), network performance (including reliability) and

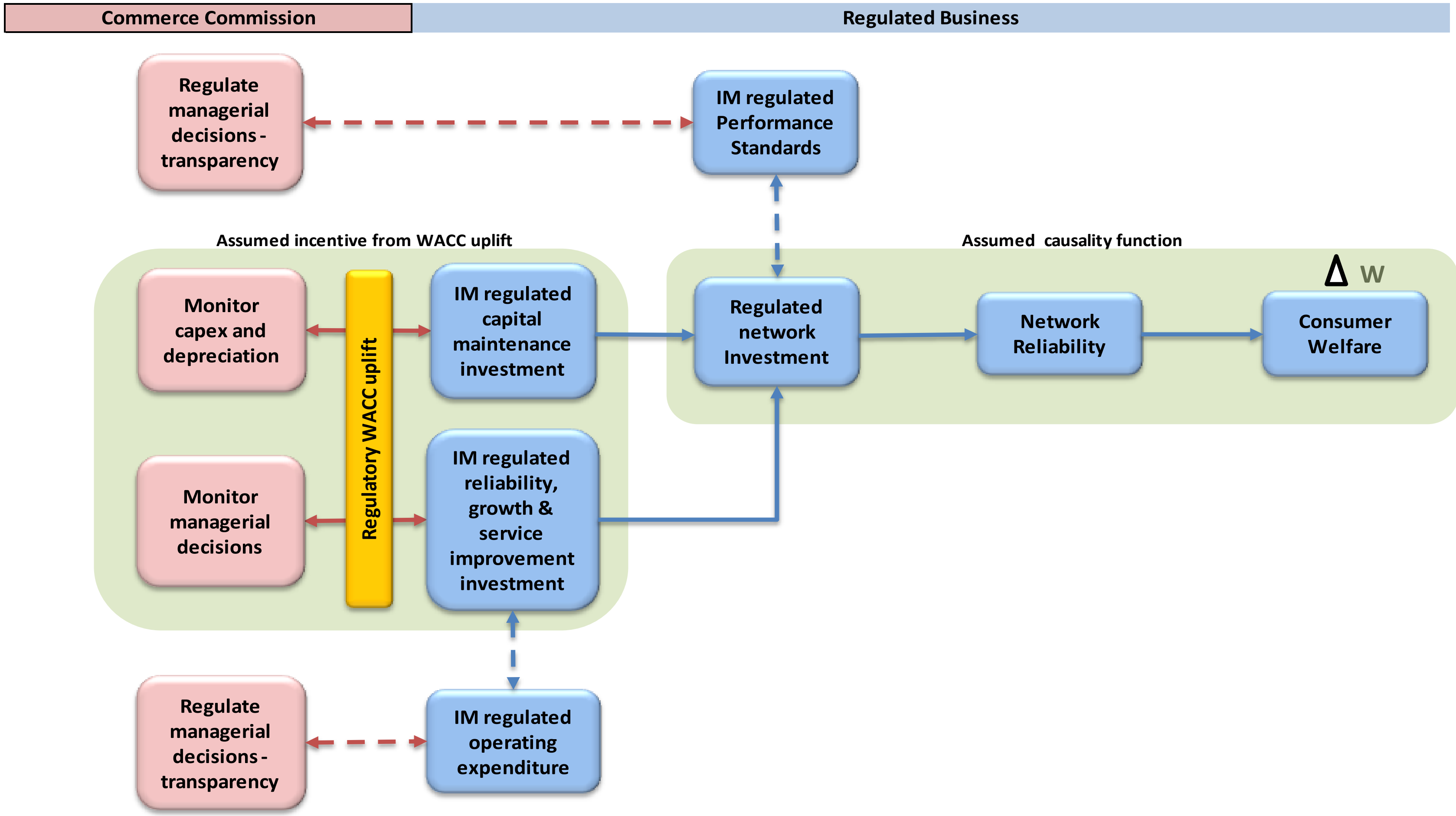
[1] "Proposed amendment to the WACC percentile for electricity line services and gas pipeline services" Commerce Commission 22 July 2014.

consumer welfare. Their improved understanding can then inform the nature of the intervention instruments they should use to manage regulatory risks or to incentivise the behaviour of the network businesses.

We provided preliminary suggestions to the Commission on this route in our 29 August advice to MEUG but in light of the importance of that material to assessing the reasonableness of assumptions in the other parties submissions, below we set out further empirical analysis and our assessments in more detail.

We found the Figure 1 over the page helpful for our understanding of the linkages between WACC, investments, network performance (outages) and their impact on changes to consumer welfare.

Figure 1 Where WACC uplift fits in the causal chain (Scope of the issue)



Source: NZIER

2. A structured way forward

2.1. Outage event causality

The first stage of our analysis is of the right hand shaded area in Figure 1 above to identify the scale of the outages and identify the prima-facie causal drivers.

2.1.1. Types of outage

To identify how additional investment could improve the reliability of the network, it is necessary to identify both the cause of the outage and the equipment affected. This information provides a starting point to consider whether additional EDB investment or other measures would be effective in improving network reliability.

The new format for the EDB Information Disclosure reports used by the Commerce Commission for the 2013 financial disclosures provides information on both the cause of disruption and the equipment involved. The disclosure reports the following data:

- Classes of outage; for the purpose of this analysis we focus on Class C (unplanned interruptions on the network)
- Measures of disruption
  - system average interruption duration index (SAIDI)
  - system average interruption frequency index (SAIFI)
- cause of class C outages measured by SAIDI and SAIFI
- equipment involved in each outage measured by SAIDI and SAIFI
- energy delivered (MWh) and the number of interconnection points (ICPs under each EDB pricing plan.

This data allows a more granular examination of how investment might improve network reliability and where this investment should occur.

The following comments apply to 16 of the 17 EDBs[2] 'price-path regulated' by the Commerce Commission. We have aggregated the SAIDI and SAIFI information reported for each EDB into a total by using the following formula:

- Sum of the SAIDI/SAIFI data for each EDB multiplied by number of ICPs to which the EDB supplied energy all divided by the total number of ICPs for the regulated EDBs.

The key insights from the data were:

- of the total number of interruptions, 1,444 for 2013, only 801 (55 percent) of the interruptions were unplanned EDB network outages. Energy delivery was restored for 69 percent of the Class C interruptions within 3 hours

[2] The information was downloaded from http://www.comcom.govt.nz/regulated-industries/electricity/electricity-information-disclosure/electricity-information-disclosure-summary-and-analysis/information-disclosed-in-august-2013/. The files did not include information for Otago Net.

- the duration of the average interruption for all customers in 2013 was 140 minutes of which 92 minutes (65 percent) was due to Class C interruptions
- most of the causes of unplanned interruption to the network are due to events that it would be arguably difficult to either efficiently avoid or mitigate through additional network investment
- distribution lines excluding low voltage lines are the equipment that is associated with the bulk of the Class C interruptions - 57 minutes (62 percent) of the average length of disruption as measured by SAIDI.

We have listed the information on the causes of failure and the equipment related to the failure in the network in the following table. We have also suggested a grouping of the causes and equipment according to whether it is likely to be easy or hard to avoid or mitigate these causes through investment. Our grouping is based on a qualitative judgement of whether the causes are predictable and concentrated on part of the network (easier to address efficiently with investment) or random and diffused across the network (harder to address efficiently with investment).

Table 1 Class C Cause of Outage

Duration of outage as measured by SAIDI

Harder to address through investment			
Cause of Outage	**Average duration (SAIDI)**	**Equipment Involved**	**Average duration (SAIDI)**
Lightning	1.5	Distribution lines	19.7
Vegetation	13.4	Distribution cables	2.3
Adverse weather	10.1	Distribution other	8.7
Adverse environment	0.5		
Third party interference	13.6		
Wildlife	3.6		
Human error	1.3		
Cause unknown	12.8		
Sub-total	**56.9**		**30.8**
Easier to address through investment			
Cause of Outage	**Average duration (SAIDI)**	**Equipment Involved**	**Average duration (SAIDI)**
Defective equipment	34.8	Sub-transmission lines	2.4
		Sub-transmission cables	0.0
		Sub-transmission other	0.2
Sub-total	**34.8**		**2.6**
Note: Distribution lines, cables and other all exclude "LV"			

Source: NZIER analysis of Commission data

Based on this grouping:

- about 60 percent of the causes of Class C interruptions are not directly attributable to defective equipment and are therefore likely to be difficult to address efficiently through investment
- distribution line failure is the main cause of the remaining 40 percent of Class C interruptions caused by defective equipment.

The data in Table 1 and our comments illustrate that the reliability problem that can be addressed efficiently by additional EDB investment (and therefore avoidance of consumer welfare loss from outages) is much more narrowly focused than the aggregate of all energy supply outages. Some of the data that is required to assess the difference that additional EDB investment could make to energy supply reliability is now publicly available and should be considered in the assessment of whether WACC uplift is the most efficient means of encouraging EDBs to improve reliability.

One of the weaknesses of this data is that it relies on SAIDI, a measure that averages outages over all customers and therefore is not adjusted for the different effects of outages on different groups of consumers. We discuss this point in more detail in section 2.3 and section 2.4

2.2. Investment in event recovery

The balance between EDB investment in network assets and operational spending on recovery from outages further illustrates the complexity of this issue and the opportunity for EDBs to substitute investment in reliability for operational expenditure on correcting outages. Bear in mind that the network had WACC + uplift to incentivise capital investment in reliability.

For the 2013 year the 'price-path regulated' EDBs spent:

- $456 million on network assets of which only $39 million was described as for 'reliability, safety and environment'
- $37 million on 'service interruptions and emergencies' plus a further $56 million on 'routine and corrective maintenance' and $14 million on 'vegetation management'.

The relatively high level of operational expenditure on fixing outages and outage prevention (total $107m) compared to both the total investment in network assets and the investment in network reliability, suggests that EDBs already have a strong incentive to identify investments that will efficiently improve network reliability and reduce operating expenses.

2.3. Consumers value reliability

There are accepted approaches to estimating the value to consumers of supply interruptions[3,4,5,6] and by implication the 'value of reliability' investment to consumers.

The 'Estimated Value of Service Reliability' paper prepared for the US Department of Energy:

- notes that value based reliability planning has been used for more than 20 years to estimate multiple elements of investment in generation and distribution assets including assessing the benefits of:
  - transmission system reliability reinforcements
  - distribution system reinforcements
- describes their work in combining the results of multiple cost of interruption surveys into a meta dataset on customer willingness to pay to avoid energy outages.
- estimate customer 'damage' functions[7] from these datasets, based on the following format :
  - interruption attributes such as duration, season, time of day and day of the week
  - customer characteristics such as type, size, business hours, sensitivity of business equipment to interruption and access to back-up equipment
  - environmental attributes such as temperature, humidity, frequency of adverse weather events etc.

The publicly available data for New Zealand EDBs aggregates data on the duration and customer group affected by outages into single measures such as SAIDI and SAIFI which are too general for us to adopt the approach used in the US DoE paper.

Given the short time available to develop and offer this analysis we have instead adopted a simpler approach of combining Value of Lost Load data (VoLL), originally prepared by the Electricity Authority, with EDB disclosure data on SAIDI and SAIFI, numbers of connections and total energy supplied. This analysis illustrates an approach to estimating the value of reliability investment by New Zealand EDBs that uses data from the New Zealand market rather than relying on the extrapolation of the ballpark estimates of the total economic cost of catastrophic failure in the USA.

[3] See 'Estimated Value of Service Reliability for Electric Utility Customers in the United States' prepared for the Office of Electricity Delivery and Energy Reliability U.S. Department of Energy by Principle Authors Michael J. Sullivan, Ph.D., Matthew Mercurio, Ph.D., Josh Schellenberg, M.A Freeman, Sullivan & Co, dated June 2009 for a detailed study of the data bases available and the approach used in the USA.

[4] See 'The Development of Renewable Energies and Supply Security: A Trade-Off Analysis', Röpke, Luise (2013) : Ifo Working Paper, No. 151 for a simplified approach to the estimation of the value of lost load that uses SAIDI data similar to the data that is publicly available for the New Zealand market.

[5] See 'Cost of power interruption to electricity consumers in the US', LaCommare, Eto (2006) : prepared for the Assistant Secretary of Energy Efficiency and Renewable Energy. U.S. Department of Energy and published in Energy: The International Journal, and

[6] Refer http://web.stanford.edu/~ayurukog/main_infrastructure.pdf.

[7] This is their version of a 'loss function'.

NZIER's recent update of this VoLL data for NZ[8], plus the Commission's own recent network data is used in this manner in section 2.4 below to estimate the value that an interruption would have across different classes of consumers in aggregate and for a per minute of outage.[9]

2.4. An approach to valuing reliability

Table 2 below describes this approach, class of customer is defined by the EDB disclosure data (connection point orientated rather than market defined) as is the number of customers while the remaining inputs are as described by the output data from the NZIER 2012 VoLL survey update;

- Load weighted $ value of outage (we tested the max and min range as well)
- SAIFI and SAIDI data from the survey that is best aligned to the network actuals (survey SAIDI of 180 mins vs 140 mins actual for 2013)
- Customer load at the time of the outage (MWh for larger businesses and average load per event for medium and small customers)

The remaining columns in table 2 are the calculated values of an outage by customer class and overall ($279m), plus the value per minute of outage for individual customers.

Table 2 Valuing network outages

Class of customer	# of customers	Load weighted value of outage (mean)	Average outage, SAIDI & SAIFI	Total Value of outage	Value per minute per ICP
Largest 5 ICP's	5	$203,754 /MWh	180 mins/1.4	$19,866,015	$16,979
Large ICP's	28	$11,740 /MWh	180 mins/1.5	$7,396,200	$978
Medium conn' points	137,182	$98 /outage	60 mins/3.0	$215,100,889	$26.13
Small conn' points	1,506,974	$6.08 /outage	60 mins/3.0	$36,649,615	$0.41
Total	1,644,246			$279,012,720	$2.60

Source: Commission reliability data, NZIER Voll update.

As a reality check we compared these results with two of the studies that we referenced earlier and we are satisfied that this is a sensible approach. One of the

[8] Client report to Electricity Authority 2012 VoLL survey update. The EA have not published NZIER's report though they have published a detailed report, Investigation into the Value of Lost Load in New Zealand, Report on methodology and key findings, 23rd July 2013, refer http://www.ea.govt.nz/development/work-programme/transmission-distribution/investigation-of-the-value-of-lost-load/

[9] The survey traversed a wide content, including the extent to which the consumers relied on energy, their usage and the outage mitigation steps that they had in place. We think that, if there is a bias of error in the results of the survey, it would probably be toward overstatement of losses because some of the large users surveyed have in place mitigation measures which reduce the likelihood of loss to a level they probably already consider optimal.

US studies estimated a mean per-minute loss at USD$2.48 for a 30 minute outage in 2013 which compares well with our $2.60.[10]

This result is not to be directly compared to the Oxera 'damage to the economy' estimate because each is prepared from a different perspective and with a different purpose in mind.[11] We are at a more granular level using in-network New Zealand data and, as discussed, we are more interested in identifying the scale and scope of linkages in the causal chain to shed some light on whether WACC + uplift is an appropriate intervention to incentivise network reliability. We think not.

2.5. Analysis and sensitivity

Putting aside outliers for a moment this analysis is important because it illustrates the diversity in the value that is placed on lost load. For instance small connection points (pretty much residential) place a very low value on outages – 41 cents per minute of outage. There is of course a range around this mean that depends on the length of outage and obviously there is a range across all residential customers.

The small value for the largest group of customers makes for a challenging cost-benefit justification for network investment in reliability. However, we observe that given most outages occur in the distribution network that connects residences to the high voltage sub-transmission network, it may be most efficient for networks business to continue to commit opex to outage recovery on an as-required basis in the low voltage network. Applying a general WACC uplift to all new capex and existing assets in the RAB, justified on the basis of reliability improvements leaves residential consumers paying twice – once for the operational cost of outage recovery and a second time for a WACC uplift to all new and old capex that is of only a very small value to them.

At the other end of the scale large commercial and industrial consumers place a high value on outages and (generally but not always) have standby generation capability to cover the outage event. It may well also be that a portion of their high valuation is being subsidised by other consumer classes, however to avoid problems of free-riding and/or others paying too much, there is a need to extend this work to get a better understanding of the effects by consumer type, their geographic location and their siting in the distribution network.

The data on the EDB network reliability published by the Commerce Commission and the value of lost studies completed by the Electricity Authority suggest that the two key building blocks for an assessment of the 'business case' for additional reliability investment by way of an uplift in WACC in the New Zealand EDB networks are available to the Commission. The discussion in the papers we have cited 'Estimated Value of Service Reliability for Electric Utility Customers in the United States' and 'Cost of power interruption to electricity consumers in the US' outline a proven approach to assessing the case for reliability investment.

[10] There are well known difficulties with using VoLL data to derive point estimates as the range of responses to these surveys can be influenced by the questions posed. The spread of responses illustrates this point. Also these surveys nearly always deliver outliers which do not fit with models developed from weight-averaged point estimates and have to be handled in a manner that is appropriate to the purpose of the research.

[11] Despite saying this we are satisfied that the orders of magnitude of the welfare loss from outages is no where near the $1b+ estimate that Oxera extrapolated from major US network failure events.

3. Submissions on the 67% proposal

We commented earlier on our high level views of submissions and here we provide additional commentary that we think would be useful.

3.1. A big judgement call

Our analysis of the advice that the Commission took and the investigatory work from our 29 August report highlighted for us that the Commission is making a bigger judgement call than might first appear on the surface. The Oxera benchmarking/loss function analysis is not helpful because it is conducted at an abstract or theoretical level based on some vital assumptions that are not tested by reference to real-world New Zealand conditions.

Oxera's, big assumption (shared by some others) is that the outcome from WACC mis-estimation is an asymmetric loss. There is no evidential basis for that assumption. It is simply not reasonable. Without evidence it leaves the Commission making an unanchored guess when selecting a WACC percentile. Apart from this assumption we still see little by way of concrete evidence to guide the Commission.

The Commission is left to guess on

- The net value of network reliability to the consumer and
- The costs in dynamic efficiency terms of the loss to consumers from excess prices
- whether WACC uplift is an efficient mechanism to encourage EDB investment in reliability that would make consumers 'better-off'.[12]

Based on our brief examination of empirical data of network investment and performance here in NZ we suggested that considerable recent investments in reliability and upgrade, on the back of flat to declining demand, had contributed to NZ networks performing well with a growing headroom of capacity; that despite the incentive of the 75th percentile, regulated networks appear to under-invest anyway (in the same way as they do in the US); and that the use of WACC + uplift is an incomplete and uncertain model of incentive regulation when other mechanisms exist to better manage potential welfare losses.

[12] In many submissions Oxera has been roundly criticised as providing only weak evidence of both the existence of asymmetric impacts from errors in regulatory WACC estimation and of the potential for losses from under-investment to be greater than the cost to consumers from prices being too high. Their quantification of the cost to the NZ economy has also been subject to critique in submissions.

3.2. How to make progress

So far it appears that $650million has been invested in network growth and reliability during Regulatory Control Period 1 (RCP1) and has, on the face of it, delivered performance improvements. Decision making on investments to improve network performance is allocated by the Commission to the networks who manage the risks of the 'lights going out'. Consumers are paying for these improvements at an inflated rate of return to the network owner.

This process leaves the Commission and the networks facing a series of complex trade-offs that change over time – regardless of the use of WACC at 50% or higher, they still face time-consistency problems.[13] As a first step to identifying appropriate mechanisms to manage potential welfare loss, the scale and scope of the Commission's trade-off can be informed by the value that consumers place on avoiding outages. This value also gives an indication of the damage that will be done in consumer-land if the lights do in fact go out. This is a vital ingredient to the cost – benefit analysis of reliability and capital replacement investment decisions.

That is – is it worth continuing to invest (either adding capital to the Regulatory Asset Base (RAB) and/or increasing regulated returns)? To consider this question the Commission needs to form a view on the following:

- the value that different consumer segments place on marginal improvements in reliability including:
  - what alternatives they have to increased network reliability to mitigate the risk of outages
  - how the allocation of the cost of improved network reliability across consumer segments compares to the value faced by each of those segments on improved reliability
- the nature of the capex/opex trade-off faced by the EDB including:
  - what level of investment is required to deliver the desired increment in reliability and what risk this investment addresses
  - how a WACC uplift encourages EDBs to make this investment as opposed to continuing to cover the operational cost of repairing outage causing faults when they occur.

3.3. Scope and scale of the WACC uplift

The Commission is intervening in a cause and effect chain with WACC uplift on the basis that it will incentivise network owners to improve reliability when the causal link through to consumer welfare changes is simply unclear.[14] It seems to us that the linkages between network investments and a consumer perspective of reliability are largely unknown – the right hand shaded area in figure 1 at that start of this

[13] From bullet point 3, p2 of NZIER advice 29th August 2014, "The Commission have set a process in motion that threatens the durability of the Part 4 regulatory approach. Their WACC percentile choice here is to be again reviewed with the other IM's in 2017. In some ways this is a good thing because if they do not get it right now, they have another chance in 2017. However this review of the WACC in isolation makes it harder to introduce other mechanisms that may be feasible under the IMs and more efficient and effective than a WACC uplift in securing an appropriate level of investment in network reliability"

[14] Ingo Vogelsang noted this very point in paragraph (1) of his advice of 12 June 2014.

report, making the WACC + uplift something of a blunt instrument to achieve this goal. Our suggested approach can helpfully inform the WACC uplift debate but it also has implications for both the Commission and the regulated networks when they assess network capital investment proposals.

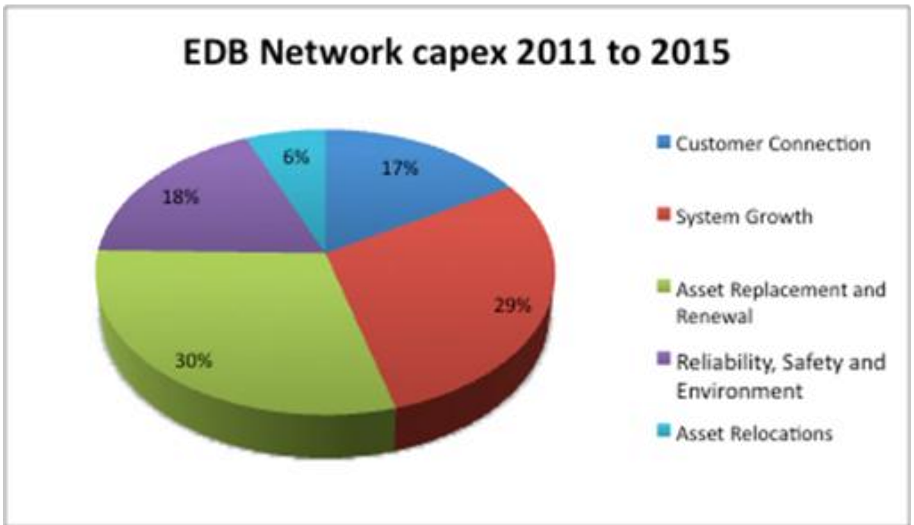
We caution here that this analysis is not targeted at advising the Commission what percentile they should choose (in the absence of evidence to the contrary the 50th percentile remains our preferred point). Rather it is an attempt, in the short time available, to illustrate that there are other approaches to quantifying the potential welfare loss from outage and that the linkages between the causes of outages, network investment in reliability and the incentives on the network owners are complex, involving many trade-offs. This situation suggests to us that WACC + uplift is likely less useful than other incentive systems that could be tailored towards particular linkages and trade-offs, some of which we suggested in our 29 August advice to MEUG.

The Commission has time to prepare for those improvements in the 2017 IM reset.

Figure 1 earlier illustrates this perspective. The shaded rectangle on the right hand side 'Assumed causality function' is the focus of prior sections 2.1 to 2.3 and this report demonstrates that a better approach to determining whether the bright yellow intervention 'Regulatory WACC uplift' in the left hand shaded side 'Assumed incentive from WACC uplift' is the best method of connecting the left and right hand sides together.

Now – to put the left-hand shaded part of figure 1 into perspective, recall this chart from our 29 August report (actual to date and EDB forecast for 2015). When we are talking reliability, we are referring to the purple piece of the pie (reliability) and maybe some of the red and green pieces as well, but not all of them because these two are targeted at a range of investment outcomes, not just reliability. Total allowed capex for this period is in excess of $2billion so the reliability investment capital that directly affects network performance is about $400m for the period.

Figure 2 Scale of the potential underinvestment



Source: NZIER from Commission disclosure models

4. Summary

The conclusions from our report to 29 August MEUG suggested that the point of that advice was two-fold;

- *WACC uplift is not necessarily the right instrument for dealing with concerns about the welfare costs of reduced investment. If any additional incentive is required to safeguard consumer welfare that incentive is most likely to be found elsewhere.*
- *the more fundamental point is that the Commission needs to adopt a more structured and disciplined way for thinking about its own rule-making under uncertainty. The current approach – to estimate WACC and add an adjuster motivated largely by intuition – is too ad hoc to promote certainty.*

We suggested that the interim decision is left at the mid-point and that time needs to be taken to consider the longer term issues between now and 2017 when the IM review is due.

This brief cross-submission provides a way forward for the Commission to adopt a more structured approach to identifying consumer welfare considerations. It could enable quantification of the potential for welfare loss using New Zealand value of lost load data and the EDB reliability data when applying accepted approaches to analysing the business case for reliability investment. These building blocks can be used immediately to inform the 67% decision and should the analysis suggest that no uplift is warranted then the Commission should feel encouraged to make that decision knowing that reliability is on a path of improvement and that demand growth is flat on the back of on-going capital investment in network capacity.

We suggest here that the loss value of outages to the largest group of customers is very small and that WACC uplift is ineffective and a very costly incentive solution for this group because networks seem to mostly spend opex on an 'as required' basis when they respond to class C outages in the distribution network. Because most outages occur in the low voltage network, network performance standards may be the best incentives here, rather than a general uplift.

For other groups who place a higher value on network outages, targeted capital investment using a differentiated network pricing may be a more efficient mechanism to deliver the level of reliability. We remain unconvinced that a WACC at anything other than the mid-point is the way to go at this stage.