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09/09/16

Ms Fiona Towers
Executive Director, Energy and Transport
Independent Pricing and Regulatory Tribunal
PO Box K35, Haymarket Post Shop
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Submitted by email

Dear Ms Towers

CBD and Inner Metro VCR estimates – A final report for TransGrid on research, methodology and results to assist in the recommendation of unserved energy allowances for Inner Sydney

TransGrid welcomes the opportunity to assist the Independent Pricing and Regulatory Tribunal (IPART) as part of its review of electricity transmission reliability standards in New South Wales (NSW); in particular the review of unserved energy allowances for Inner Sydney.

The attached HoustonKemp report is titled, CBD and Inner Metro VCR estimates – A final report for TransGrid on research, methodology and results.

This report was produced on behalf of TransGrid to determine the best Value of Customer Reliability (VCR) that can be applied to unserved energy estimates in both Sydney's CBD and Sydney's inner metropolitan areas (defined as Inner Sydney by the IPART), drawing on existing publically available VCR estimates.

TransGrid recommends that the IPART use these results, and not the Australian Energy Market Operator (AEMO), Final Report – Value of Customer Reliability, September 2014, to recommend unserved energy allowances for Inner Sydney. The HoustonKemp report shows that the AEMO VCR values are understated as they:

1. Provide state level VCR estimates and do not differentiate between sub regions, such as Inner Sydney where it is reasonable to expect higher VCR values for customers as compared to the state averages.
2. Do not consider prolonged outages (the longest outage considered was 12 hours), which may be significantly lower than for failure of supply cables to Inner Sydney.

If you would like to discuss any matter raised, please contact me on (02) 9284 3088 or Nalin Pahalawaththa on (02) 9284 3032.

Yours faithfully,

Gerard Reiter
Executive General Manager/Asset Management

HOUSTONKEMP
Economists

CBD and Inner Metro VCR estimates

A final report for TransGrid on research, methodology and results

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Disclaimer

Contents

Tables

Executive Summary

HoustonKemp has been engaged by TransGrid to determine defensible values of the Value of Customer Reliability (VCR) that can be applied to unserved energy estimates in both Sydney's CBD and Sydney's Inner Metropolitan (Inner Metro) areas, drawing on existing, publicly available VCR estimates. The resultant VCR estimates are to be suitable for use in the 'Powering Sydney's Future' (PSF) study of electricity supply to the CBD and Inner Metro sub-regions of Sydney, being jointly undertaken by TransGrid and Ausgrid.

TransGrid requested that the starting point for developing our VCR estimates be AEMO's 2014 VCR study.[1]

A key component of the PSF study is focused on options that would address low probability, but high impact supply outages in the CBD and Inner Metro sub-regions. AEMO's 2014 VCR study did not stratify VCR results into the CBD and Inner Metro sub-regions of NSW of interest in the PSF study. Nor did it include an assessment of the VCR associated with long duration outages. We therefore consider that AEMO's 2014 VCR estimates will *understate* the VCR values associated with the locations and types of outages that are the focus of the PSF study, particularly for commercial customers. In addition, AEMO's 2014 VCR study does not specifically consider significant customers in the Sydney CBD and Inner Metro area that can be expected to place a high value on having a continuous and reliable electricity supply, such as the Australian Securities Exchange (ASX), large financial institutions, the NSW Parliament and Sydney Airport.

Ausgrid has calculated separate VCR values for Sydney's CBD and Inner Metro sub-regions for the purposes of the PSF study by:

- **CBD:** Applying various uplift factors to a demand weighted average of AEMO's customer VCR estimates for NSW, to reflect expected drivers of key differences between the CBD area and NSW as a whole;
- **Inner Metro:** Weighting AEMO's customer VCR estimates for NSW together on the basis of the contribution to demand from each customer group to total urban load in the Inner Metro area.

We have reviewed Ausgrid's VCR estimates and the methodology underpinning them. Our conclusions are:

- **CBD:** We consider that Ausgrid's VCR estimate for the CBD of $191/kWh derived on the basis of adjusting the weighted average of AEMO's NSW customer VCR estimates to account for the higher economic contribution of Sydney's CBD is valid methodologically.
  - However, we note that the lack of consideration of the impact of long-duration outages in the AEMO study means that the value derived by Ausgrid using this approach can be expected to *under-estimate* the actual VCR associated with the types of outages being considered in the PSF study.
  - We do not consider that there is a robust justification for the other two uplift factors used by Ausgrid (ie, differences in floor space rental and differences in relative reliability performance targets). Neither of these factors appear to clearly drive differences in VCR between the Sydney CBD area and NSW as a whole, or are necessarily correlated with factors that may be expected to drive these differences. We therefore do not consider that the $245/kWh and $363/kWh VCR estimates derived by Ausgrid have a robust methodological basis.
- **Inner Metro:** Ausgrid's demand-weighting of AEMO's VCR estimates across different customer groups is methodologically sound, and reflects the approach suggested by AEMO to deriving VCR estimates for specific network studies. However, due to the shortcomings of the AEMO VCR estimates in terms of both lack of stratification of customers in urban areas and no consideration of long duration outages, we consider that the $40/kWh value derived by Ausgrid on this basis will *under-estimate* the VCR of customers in the Inner Metro region.

We considered several options in order to calculate specific VCR values for both Sydney CBD and Inner Metro customers, suitable for use in the PSF. Conducting a new, targeted survey of VCR was not possible in

[1] AEMO, *Final Report – Value of Customer Reliability*, September 2014

the time available, and we were unable to gain access to AEMO's raw data or sampling plan from its 2014 study.

A further option we considered was scaling up AEMO's average NSW VCR estimates by factors that capture differences in the expected VCR for CBD and Inner Metro customers compared to that for average NSW customers. However, given that this is that approach taken by Ausgrid in deriving its VCR estimate for Sydney CBD customers, we instead concentrated on an approach that augments the results of AEMO's 2014 VCR study with information derived from other published VCR studies. In particular, we have drawn from the more stratified results available from a 2012 VCR study by Oakley Greenwood (OGW).[2]

The VCR estimates for Sydney CBD and the Inner Metro area resulting from our analysis, and a comparison of those derived by Ausgrid, are set out in Table E-1, which also shows the different methodologies used.

Table E-1: Summary VCR estimates and methodology for Sydney's CBD and Inner Metro regions ($2015/16)

Sydney Sub-region	Ausgrid methodology for customer sector VCRs	VCR range Ausgrid ($/kWh)	HoustonKemp methodology for customer sector VCRs	VCR range HoustonKemp ($/kWh)
CBD	Obtain preliminary CBD VCR by demand weighting AEMO customer VCRs by customer demand breakdown in the CBD. Apply various uplift multipliers to preliminary VCR to account for differences in (i) economic contribution, (ii) STPIS targets and (iii) value of floor rental	$191- $363 (mid-point $250) (Results from uplift multipliers: (i)STPIS:$363 (ii) Economic contribution: $191 (iii) Floor space rental:$245)	**Residential** – use AEMO VCR **Commercial small & medium** – lower bound calculated by using OGW NSW state-wide VCR , upper bound calculated by escalating OGW NSW state-wide VCR by 50% to reflect a consistent ratio between CBD feeder results and all NSW feeder results **Commercial large** – use OGW CBD VCR	$150 - $192
Inner Metro	Obtain Inner Metro VCR by demand weighting AEMO VCRs by customer sector.	$15-$65 (average $40)	**Residential** – use AEMO VCR **Commercial small & medium –** use OGW Urban VCR **Commercial large** – use OGW Urban VCR	$90

The key results of our analysis are:

1. Our CBD VCR estimate is $150-$192/kWh.
   - > This shows good alignment with Ausgrid's CBD VCR estimate of $191/kWh that was based on an economic contribution multiplier. Ausgrid's higher VCR estimates are based on multipliers we consider to be less appropriate; and
2. Our Inner Metro VCR estimate is $90/kWh.
   - > This is approximately double Ausgrid's Inner Metro VCR estimate. Our higher value arises from our adoption of OGW's VCR estimate for small & medium commercial customers in an urban area. OGW's VCR estimate for these customers is significantly higher than AEMO's state-wide VCR estimates for the same customer groups. However, we consider that the OGW estimates are likely to

[2] Oakley Greenwood, *Final Report - NSW Value of Customer Reliability,* May 2012

be more robust, as they are specifically focused on commercial customers in urban areas, whose VCR value can be expected to differ materially from commercial customers in non-urban areas.

In both cases the VCR studies we have drawn on to derive our estimates do not consider long duration outages. We therefore consider that in the case of the PSF study, where the reduction in long duration outages is a key focus, our VCR estimates above will *under-estimate* the true VCR value, for both the CBD and Inner Metro sub-regions.

The Independent Pricing and Regulatory Tribunal (IPART) has recently commented on the shortcomings of the AEMO 2014 VCR study as the basis for determining reliability standards in particular areas of NSW. We agree with IPART that the only robust way to derive appropriate VCR estimates would be to conduct a new VCR study, focused on highlighting differences in VCR between different geographic areas in NSW and different customer groups. The study would also need to explicitly consider the VCR associated with low probability but high impact, long duration outages, such as those being addressed by the PSF study.

1. Background

1.1 HoustonKemp's task

We have been engaged by TransGrid to determine a defensible value of the Value of Customer Reliability (VCR) that can be applied to unserved energy estimates in both Sydney's CBD and Sydney's Inner Metropolitan (Inner Metro) areas. The resultant VCR estimates are to be suitable for use in the 'Powering Sydney's Future' (PSF) study of supply to the CBD and Inner Metro sub-regions of Sydney, which is being jointly undertaken by TransGrid and Ausgrid. In addition, we understand that both TransGrid and Ausgrid are seeking VCR estimates that would be suitable for use in other network planning assessments (including the RIT-T and RIT-D) relating to augmentation of supply to the Sydney CBD.

TransGrid requested that we use AEMO's 2014 VCR estimates as the starting point in developing our estimates.[3]

We understand that the PSF study is considering a number of different outage scenarios. Some outage scenarios, although low probability, would have a high impact and are of particular relevance for the PSF study. Such outage scenarios are characterised by:

- prolonged supply disruptions over a period of weeks, with repeated rolling outages for customers over this time; and
- widespread supply disruption within an area, restricting the ability of customers to mitigate the impact of a disruption (eg, by eating out in their neighbourhood rather than cooking at home).

The VCR approach seeks to determine the costs that electricity supply interruptions impose on end-use customers. It is assumed that a customer would be willing to pay a price for increased reliability that is no more (and presumable somewhat less than) the cost they would incur in the event of an interruption to their electricity supply.

As part of our task, we were also asked to review VCR estimates developed by Ausgrid for Sydney's CBD and Inner Metro sub-regions.

1.2 AEMO's 2014 VCR study is the most recent.

The AEMO 2014 VCR study estimated the VCR for each jurisdiction in the National Electricity Market (NEM), across four (4) customer classifications, as well as a state-wide average. The customer classifications include residential and different sizes of commercial customer.

Table 1-1 below presents AEMO's VCR 2014 summary results for NSW for each customer sector and across the state as a whole.

[3] AEMO, *Final Report – Value of Customer Reliability*, September 2014

Table 1-1 : Summary of AEMO NSW VCR estimates from 2014 study[4] ($2014)

Customer Sector	AEMO VCR NSW ($/kWh)
Residential	$26.53
Small commercial (<40 MWh pa)	$57.13
Medium commercial (40-100 MWH pa)	$57.28
Large commercial (>100 MWh pa)	$42.13
NSW average	**$34.15***

** Includes direct connect customers*
Note: AEMO provides a margin of error for its VCR estimates as +- 30%

Because the transmission and distribution networks supply many different classes of customer from the same connection point, AEMO's VCR Application Guide points out that it is necessary to weight VCRs so as to arrive at a single usable value for modelling purposes for specific network planning studies.[5] AEMO's VCR Application Guide suggests weighting VCRs by the sectoral split in energy consumption for a particular location in applying its VCR estimates to specific investment decisions.[6]

1.3 Shortcomings with adopting the AEMO VCR estimates for the PSF study

Before applying existing published VCR values from AEMO (or any other sources), we need to ensure that the VCR values are 'fit for purpose' for the current PSF study. This involves critical examination of whether or not the sample from the AEMO study (and other studies) is representative of the types of customers being considered in the PSF study, and whether the outage scenarios considered are also representative of the outage scenarios under consideration in the PSF study.

We see two major shortcomings in using AEMO's 2014 VCR values for the PSF study:

1. AEMO's VCR estimates are not stratified into different geographic areas beyond state-level values and therefore do not provide any insight into differences in VCR between customers in CBD and Inner Metro sub-regions, and the rest of the state. Section 2 discusses the unique features of CBD and Inner Metro customers and reasons for which it is reasonable to expect that VCR values for customers in these sub-regions to be significantly higher than state averages; and
2. The methodology used to calculate AEMO's VCR estimates did not consider prolonged outages (the longest outage considered was 12 hours).[7] Therefore the low probability but high impact supply interruptions of interest in the PSF study are not captured in AEMO's study and resulting VCR estimates. It is reasonable to expect that the impact on customers of a prolonged and widespread outage will be greater than the impact of shorter duration outages, leading to a higher VCR in relation to avoiding these outages. Again, Section 2 provides some insight into why we would expect this to be the case.

[4] AEMO, *Final Report – Value of Customer Reliability*, September 2014, pp.23-24.
[5] AEMO, *Value of Customer Reliability - Application Guide*, December 2014, pp. 6-9.
[6] AEMO, *Value of Customer Reliability - Application Guide*, December 2014, p. 7.
[7] AEMO, *Final Report – Value of Customer Reliability*, September 2014, p. 11.

In addition to the above shortcomings, we also note that:

- AEMO's study does not include important customers in the Sydney CBD and Inner Metro area, such as the Australian Securities Exchange (ASX), NSW Parliament, large financial institutions, public transport agencies and Sydney airport;
- AEMO's study does not provide any information or data on CBD-specific sampling;
- AEMO's VCR estimates rely on a very specific methodology (choice modelling) which is different to that adopted in previous studies (where the estimates were derived from surveys). Whilst the different methods used to estimate VCR are both valid, the difference in methodology limits the ability to perform detailed statistical analysis and comparisons between VCR values derived from the different studies. This is because they rely on different assumptions in relation to the underlying data as well as differences in the structure of the model used; and
- AEMO's VCR methodology does not make the distinction that the losses incurred by residential customers as the result of a supply disruption will be significantly different in nature to those incurred by commercial businesses who rely on electricity to generate and collect revenue.

The Independent Pricing and Regulatory Tribunal (IPART) recently released a Draft Report prepared in the context of setting NSW Electricity Transmission Reliability Standards, which discusses the appropriateness of using AEMO's VCR estimates in the context of setting reliability standards in NSW.[8] Concerns raised about use of AEMO's VCR estimates include the small sample size,[9] the strong dependence on the specific methodology used,[10], and customers such as the Australian Stock Exchange, NSW Parliament and large financial institutions not being included in the sample.[11]. In addition, concerns are raised that AMEO's VCR study does not adequately capture low probability but high impact supply interruptions.[12] Submissions to IPART generally acknowledged that these issues will take time to address.[13]

A separate report by Parsons Brinckerhoff (PB)[14] commissioned by IPART also considered and rejected alternatives to using AEMO's average VCR estimate in the aggregated weighted VCR values being derived by IPART in the context of the reliability review. It did not recommend using upper quartile or maximum values derived from AEMO's study as it considered that these approaches will overstate the VCR[15]. In addition, the PB report tested the sensitivity of the VCR values calculated for each connection point and found them insensitive to changes in assumed customer splits.[16]

The above issues raise questions about the representativeness of the customer sample used in the AEMO study, and its consequent ability to produce robust VCR estimates for sub-regions, let alone for particular customer segments within sub-regions.

Based on the above observations regarding AEMO's 2014 VCR study, it is our opinion that AEMO's VCR estimates will be *under-estimating* VCR values for commercial customers in the CBD and Inner Metro sub-regions. We also consider that the AEMO VCR estimates are not suitable for valuing customer reliability for prolonged outages in the CBD, or in the Inner Metro area.

[8] IPART, *Electricity Transmission Reliability Standards, An economic assessment – Energy - Draft Report*, May 2016, p. 28. This draft report discusses responses to issues raised in IPART's earlier Issues Paper: IPART, *Electricity Transmission Reliability Standards, An economic assessment – Energy - Issues Paper*, December 2016

[9] Essential Energy submission to IPART Issues Paper, 28 January 2016, p 5.

[10] ETSE Consulting submission to Issues Paper, 27 January 2016, p 7.

[11] Ausgrid submission to IPART Issues Paper, 22 January 2016, pp 7-8.

[12] Ausgrid submission to IPART Issues Paper, 22 January 2016, p 9.

[13] IPART, *Electricity Transmission Reliability Standards, An economic assessment – Energy - Draft Report*, May 2016, p. 28

[14] Parsons Brinckerhoff, *NSW Transmission Reliability Standards Review, Value of Customer Reliability*, May 2016

[15] Parsons Brinckerhoff, *NSW Transmission Reliability Standards Review, Value of Customer Reliability*, May 2016, p. 3.

[16] In our opinion this outcome is more a reflection of the sample limitations in the AEMO study, rather than a true artefact of VCR insensitivity to customer splits.

1.4 Structure of this report

The remainder of this report is structured as follows:

- Section 2 discusses differences between CBD and Inner Metro electricity customers, and those across NSW as a whole, that can reasonably be expected to lead to different VCR values, as well as the higher VCR that is likely to be associated with prolonged disruptions;
- Section 3 provides commentary on Ausgrid's estimates of the VCR for CBD and Inner Metro customers;
- Section 4 outlines the options considered by HoustonKemp for developing VCR estimates for the Sydney CBD and Inner Metro sub-regions, suitable for adoption in the PSF study;
- Section 5 introduces Oakley Greenwood's (OGW) 2012 VCR study and provides our observations on this study and its applicability to the VCR estimation task at hand;
- Section 6 provides the detail and results of our calculations of a Sydney CBD VCR estimate;
- Section 7 provides the equivalent detail and results of our calculations of a Sydney Inner Metro VCR estimate; and
- Section 8 summarises our conclusions.

2. What differentiates the VCR for CBD and Inner Metro customers versus average NSW customers?

Customers' expectations for reliable electricity supply are significantly different in the Sydney CBD and Inner Metro sub-regions compared with other areas of NSW. This is evidenced by higher reliability standards applied in the CBD and to feeders in urban areas compared to rural feeders. It is also reasonable to expect that the value that customers place on having a reliable electricity supply is different in both the CBD and Inner Metro sub-regions than in more rural areas of NSW, due to differences in both:

- the nature of commercial businesses in the CBD and Inner Metro sub-regions, and therefore the impact on them of a disruption in their electricity supply; and
- the higher residential incomes in these areas, which can be expected to lead to a greater ability and therefore willingness to pay for a more reliable electricity supply.

These drivers for a higher VCR value for customers in the areas affected by the PSF study are discussed further below.

We also discuss the reasons why prolonged and widespread supply disruptions, which are a particular focus of the PSF study, may be expected to lead to a greater impact on customers, and therefore why it is reasonable to expect that a higher VCR estimate would be appropriate for these types of outages.

2.1 Commercial customers

Sydney's CBD is characterised by a high density of high value businesses that generate a substantial proportion of the state of NSW's GDP. Such businesses include banks and financial institutions, head offices of large corporations, and local offices of large multinationals. It is reasonable to expect that these businesses would place a substantially different value on the reliability of their electricity supply than businesses located elsewhere in the state, as a result of the impact on them of a supply disruption.

Sydney's CBD accounts for 5% of NSW's electricity consumption yet contributes 21.4% of the state's GDP/Gross State Product.[17] Based on this, we can conclude that higher 'worth' or value is created from each kWh consumed in the CBD, and that interruptions to electricity supply in the CBD would have a higher impact on the revenue generated by CBD businesses than would an interruption to commercial businesses located in rural NSW.

Many large commercial customers in the Sydney CBD have made significant investment in order to manage outages, in the form of back-up generators, or through choosing to locate in buildings that provide back-up power supply. This indicates that such customers place a different value on the reliability of electricity than say smaller commercial operations or residential customers.

Vital public services such as NSW Parliament and several State Government departments have their primary operations in Sydney's CBD. Such organisations have not been surveyed as part of the VCR estimation studies to date and no doubt a prolonged electricity outage would have wide-spread, significant impact on the services they provide. In addition, Sydney's heavy and light rail networks require electricity to operate - an electricity outage would require passengers to move to buses or private vehicles or at worst, not travel to and within the CBD and around Sydney at all, resulting in wide-spread economic impacts. Sydney Airport is

[17] Data provided by Ausgrid , sourced from: http://economy.id.com.au/ and http://www.economicprofile.com.au/

also located in the Inner Metro region of Sydney and it appears reasonable to expect that it too would place a high value on electricity reliability.[18]

2.2 Residential

Residents living in Sydney's CBD are likely to have greater ability and more willingness to pay for reliability in their electricity supply, resulting in a higher CBD residential VCR.

We obtained ABS data on the average incomes of residents across statistical divisions within NSW and Sydney. After analysing the data, we observed that the average total income for residents in Sydney's CBD was about 10-20% higher than those of residents in the remainder of NSW.[19] This supports the above view.

In Section 5, we introduce and discuss a 2012 VCR study undertaken by Oakley Greenwood (OGW)[20] OGW's VCR estimates for residential CBD customers are higher than its average state-wide VCR for residential customers, which also aligns with our observations above.

Similarly, OGW's VCR estimate for residential customers on Urban feeders is above its estimate of residential VCR across NSW as a whole, although the difference is less pronounced than for the CBD.

We also analysed the ABS income data for Inner Metro residents and observed that the average total income for residents in Sydney's Inner Metro sub-regions was about 5% higher than those of residents in the remainder of NSW.[21]

2.3 Impact of prolonged outages

It is generally understood that the impact of an electricity outage depends on its duration. However, the cost and effects of prolonged outages (ie of more than 24 hours) have not been widely published or analysed in the literature on VCRs.

In Appendix A.2 we summarise the effects and impacts of a prominent prolonged outage; that experienced by Auckland in 1998. Not all impacts and costs can be quantified, but the summary describes the wide-ranging impacts on citizens, businesses and public services. It is clear from the descriptions available of the Auckland experience that a prolonged outage in a CBD area would have a major impact on both commercial and residential customers.

We discussed above that many businesses in the CBD choose to adopt back-up generation, or to locate in buildings that provide a back-up electricity supply service. However, these strategies would not be sufficient to address prolonged outages, such as those being considered as part of the PSF study. It is not typical practice to run back-up generators for extended periods of time, and we understand that back-up generators are typically sourced to run emergency lighting and elevators for a short period of time, rather than to replicate full operations.[22] This is discussed further in Appendix A.1.

Given the above, it is therefore reasonable to consider that the VCR associated with a prolonged outage in the Sydney CBD and Inner Metro area would be substantially higher than that associated with short duration outages. None of the existing VCR studies to date have considered long duration outages, and so information is not currently available to underpin an estimate of the VCR for longer outages. As a consequence, both the existing AEMO VCR estimates, and our estimates derived in this report can be expected to under-estimate the VCR associated with the types of outages being considered in the PSF study.

[18] We understand from discussions with TransGrid and Ausgrid that Sydney Airport does not have a separate back-up generation and relies primarily on grid-connected electricity supply.

[19] The figures we obtained were averages across suburbs and do not reflect variation in incomes. We were also unable to draw out differences in wages versus investment and other income.

[20] Oakley Greenwood, *Final Report - NSW Value of Customer Reliability,* May 2012

[21] The figures we obtained were averages across suburbs and do not reflect variation in incomes. We were also unable to draw out differences in wages versus investment and other income.

[22] SKM Consulting, *Standby generation for demand management,* April 2008.

3. Ausgrid's VCR calculations

Ausgrid has estimated separate VCR values for Sydney's CBD and Inner Metro sub-regions, drawing on AEMO's 2014 VCR estimates. [23] We have reviewed Ausgrid's VCR estimates, and this section summarises our conclusions.

3.1 Ausgrid's CBD VCR

Table 3.1 summarises Ausgrid's VCR estimates for customers in the Sydney CBD.

Table 3-1: Ausgrid's VCR estimates and methodology ($2015/16)

Base CBD VCR ($/kWh) ($2014)	Uplift metric	Adjustment factor	Resulting proxy VCR ($/kWh)
$44	Relative targets under Service Target Performance Incentive Scheme	8.1	$363
	Contribution to NSW Economic GDP	4.3	$191
	Relative floor space rentals	5.5	$245
Final adjusted CBD VCR (midpoint of above proxies)			**$250**

*Note : base CBD VCR value of $44 ($2014) is first escalated to $2015/16, adjusted for losses and then the multiplier applied

Ausgrid has used a preliminary aggregate VCR for the CBD across all customer groups of $44/kWh ($2014), based on demand weightings for the different customer groups in the CBD,[24] indexation of the AEMO 2014 VCR estimates to 2015/16 dollars and adjusting by 3.9% to account for network losses.[25]

Three different methods have then been applied to calculate an 'uplift factor' which is then applied to this preliminary CBD aggregate VCR, to reflect the unique factors that mean that customers in the CBD can reasonably be expected to have a higher VCR value than those across the state as a whole.

3.1.1 Difference in targets under the Service Target Performance Incentive Scheme (STPIS)

Ausgrid's CBD reliability targets are 3.8 and 12.5 times more stringent than for urban areas for SAIDI and SAIFI[26] respectively. Ausgrid argues that it is unreasonable to expect that such different levels of service reliability do not reflect similarly different values for customer reliability. Since SAIDI and SAIFI performance are equally weighted in calculating STPIS outcomes, Ausgrid has used an implied multiple of 8.1.

Applying an adjustment/uplift factor of 8.1 to the $44/kWh ($2014) aggregated CBD value results in an adjusted VCR of $363/kWh ($2015/16).

[23] TransGrid / Ausgrid : *Powering Sydney's Future Value of Customer Reliability in the Inner Metropolitan Area Selection Methodology Report, 26 May 2016,* pp. 10-11.

[24] See Table 6-1 in this report for the demand weightings used.

[25] TransGrid / Ausgrid : *Powering Sydney's Future Joint Planning Report V1.2*, p. 10.

[26] TransGrid / Ausgrid : *Powering Sydney's Future Joint Planning Report V1.2*, p. 10.

In our opinion, the differences in the STPIS targets between CBD and urban areas are not necessarily indicative of differences in the value of electricity reliability; as the targets are set on the basis of actual performance, rather than by reference to VCR. We therefore don't think that this particular uplift factor is appropriate.

We also note that the uplift factor is calculated on the basis of differences between CBD STPIS targets and urban targets, rather than by reference to the difference with average NSW-wide STPIS targets.

3.1.2 Contribution to economic productivity

As discussed in Section 2.1, businesses in the CBD contribute a higher proportion of NSW's GDP per kWh of electricity used than do businesses across the state as a whole. The Sydney CBD accounts for 5% of energy consumption in NSW, but 21.4% of Gross State Product.[27] The value generated by each kWh of electricity consumed in the CBD is therefore a little over four times higher than the state average.

Ausgrid has applied an uplift factor of 4.3 to the $44/kWh ($2014) aggregate CBD value, to result in an adjusted VCR of $191/kWh ($2015/16).

We support the general methodological approach taken by Ausgrid in applying a GDP-related uplift factor to the aggregate VCR value for the CBD. As discussed earlier, data shows that the types of businesses in the CBD contribute more to the state's GDP (or Gross State Product) per kWh of electricity consumed than do businesses across the state as a whole. The value of a kWh of electricity to these businesses can therefore be expected to be higher, as the output that it leads to is 'worth' more than for businesses in other areas. There is therefore a link between the uplift factor applied by Ausgrid and factors that can be expected to drive a higher VCR value in the CBD area.

In terms of the specific approach adopted by Ausgrid, we recommend that the adjustment factor be applied to the VCR associated with commercial customers only and not to the 3% of demand that is consumed by residential customers. However we recognise that the very low contribution that residential customers make to the aggregate CBD VCR estimated by Ausgrid makes this change immaterial.

3.1.3 Difference in floor space rentals

Ausgrid makes the assertion that real estate costs represent another relatively elastic cost input to businesses that choose to locate in the Sydney CBD, with higher rents reflecting the value they are able to generate from being located in this area compared to other urban or state-wide locations. Ausgrid quotes retail rents in the Sydney CBD as averaging from $6,000-$7,000 per square metre. For urban and neighbourhood shops this drops to $300 per square metre – a ratio of twenty to one. Office space shows a little less divergence. Ausgrid compares the costs of Sydney CBD office space to office space in North Ryde and states that the CBD cost is 2-3.5 times higher. Ausgrid also notes that office space rental cost in North Ryde would itself be higher than the NSW state average.

Ausgrid averages the retail and office space rent multipliers to give an average multiplier of 5.5.

Applying an uplift factor of 5.5 to the $44/kWh ($2014) aggregated CBD value results in an adjusted VCR value of $245/kWh ($2015/16).

In assessing this uplift factor, we note that a business locates itself in the CBD for many reasons; including access to skilled labour, being in the proximity of clients and peers and, in some cases, for the prestige. Reliability of electricity supply will not necessarily be valued in the same way a business values and decides on which floor space they will rent. Nor will it necessarily be correlated with factors that do drive differences in VCR value. We therefore don't consider that this adjustment factor represents a good proxy for elevating the VCR estimate for the CBD.

[27] Data provided by Ausgrid , sourced from: http://economy.id.com.au/ and http://www.economicprofile.com.au/

3.1.4 Ausgrid's adjusted CBD VCR

Ausgrid calculates a final adjusted CBD VCR by taking the midpoint of its three proxy VCRs, calculated in accordance with the three uplift factors discussed above. This gives a final adjusted CBD VCR of $250/kWh ($2015/16).

Given that we consider only one of the above uplift factors to reflect drivers of differences in the VCR value for the Sydney CBD, we don't consider this adjusted VCR value to be applicable.

3.1.5 Summary

We consider that Ausgrid's methodology in adjusting its aggregate VCR value for the CBD for differences in the economic contribution of the CBD relative to NSW as a whole to be sound, and therefore support the value of $191/kWh ($2015/16) obtained by Ausgrid as a more appropriate estimate of the CBD VCR than use of the unadjusted AEMO VCR estimates alone.

We do not believe the two higher adjustment factors using floor space rental and STPIS reliability standards to be well-justified.

In addition, we consider that the $191/kWh ($2015/16) value is likely to be an *under-estimate* for the purposes of the PSF study, as it is based on the AEMO VCR estimates which do not include prolonged outages, which can be expected to lead to higher VCR values.

3.2 Ausgrid's Inner Metro VCR

Ausgrid's VCR estimation methodology for Inner Metro load is based on AEMO's VCR Application Guide[28] [29].

Ausgrid's Inner Metro VCR value reflects the composition of customers within the Inner Metro sub-region of Sydney.

The distribution of demand across customer groups was determined and then applied to AEMO's 2014 VCR values, indexation of the AEMO 2014 VCR estimates to 2015/16 dollars and adjusting by 3.9% to account for network losses.[30]

We agree with the methodology that Ausgrid has adopted of demand-weighting the AEMO VCR estimates, and note that it is consistent with AEMO's recommended methodology.

However we believe that AEMO's VCR estimates are *too low* for customers in the Inner Metro area, particularly commercial customers, as they reflect the average VCR for customers across NSW as a whole. We also consider that the AEMO VCR values will *under-estimate* the VCR associated with long duration outages, which are important in the context of the PSF study.

[28] TransGrid / Ausgrid : *Powering Sydney's Future Value of Customer Reliability in the Inner Metropolitan Area Selection Methodology Report, 26 May 2016,* p. 9.

[29] AEMO, *Value of Customer Reliability - Application Guide*, December 2014, p. 7.

[30] TransGrid / Ausgrid : *Powering Sydney's Future Joint Planning Report V1.2*, p. 10.

4. Options considered by HoustonKemp for developing CBD and Inner Metro specific VCR estimates

We considered several options for calculating specific VCR values for both Sydney CBD and Inner Metro customers, suitable for use in the PSF study. Table 4-1 below describes the four key options considered and the reasons for their feasibility or otherwise.

Table 4-1 : Summary of options considered by HoustonKemp

Option	Notes	Feasible?
Conduct a new, targeted VCR survey	Not feasible on the time available	☒
Form aggregated VCR by stratifying AEMO's VCR estimates	No access to AEMO raw data or sampling plan	☒
Scale up AEMO NSW average VCRs by factors relevant to CBD/Inner Metro (such as GDP & income)	Need to ensure scaling factors are unique to CBD/Inner Metro	☑
Augment AEMO VCR estimates with other VCR studies	Apply observed trends in Oakley Greenwood 2012 study to AEMO VCR	☑

AEMO's 2014 VCR study does not consider prolonged outages, nor provide stratified VCR results across specific Sydney sub-regions.[31]

In order to develop suitable VCR estimates that reflect the particular characteristics of different types of CBD and Inner Metro customers, and to adequately assess the impact of long duration outages, it would be necessary to undertake a new VCR study specifically focused on deriving these values.

Other recent commentary has also highlighted the need for more focused studies in order to derive VCR estimates suitable for application in targeted areas. IPART in its recent draft report on NSW electricity transmission standards states that accurate VCRs will need to be based on high quality survey work and recommend a new, comprehensive VCR study.[32] A report by Parsons Brinckerhoff (PB)[33] commissioned as part of IPART's review, recommends that a framework be put in place to outline future reliance on VCR and to develop a roadmap to overcome current uncertainties[34]. We agree with both IPART's and PB's recommendations.

A bespoke VCR study could target:

- specific customer types in Sydney's CBD and Inner Metro sub-regions;

[31] AEMO, *Final Report – Value of Customer Reliability*, September 2014, p.11.

[32] IPART, *Electricity Transmission Reliability Standards, An economic assessment – Energy - Draft Report*, May 2016, p. 28.

[33] Parsons Brinckerhoff, *Final Report - NSW Transmission Reliability Standards Review, Value of Customer Reliability*, May 2016

[34] Parsons Brinckerhoff, *Final Report - NSW Transmission Reliability Standards Review, Value of Customer Reliability*, May 2016, p. iii.

- specific losses that would be incurred by CBD and Inner Metro businesses; and
- the impact on VCR of widespread, long duration outages.

However, the short length of time available for the current study makes the option of conducting a new, bespoke VCR study infeasible.

A second option we considered was to build up alternative VCR estimates by stratifying AEMO's 2014 VCR estimates according to the sampling plan[35] that was used to derive those estimates. However, TransGrid has been unable to gain access to AEMO's raw data, nor its sampling plan and therefore this is also an unfeasible option in practice.

This leaves us with two further, but less data intensive, options:

- Scale up AEMO's average NSW VCR estimates by factors that capture differences in the likely VCR between CBD and Inner Metro customers compared to average NSW customers:
  - We need to ensure scaling factors are unique to the CBD and Inner Metro sub-regions and reflect (or are correlated with) drivers of differences in VCR values; and
- Augment results of AEMO's 2014 VCR study with information derived from other published VCR studies:
  - In particular, by drawing on the more stratified results available from OGW's 2012 VCR study[36].

The first of these two approaches is the one taken by Ausgrid and summarised in Section 3.1. We have provided comments on Ausgrid's methodology and results in Section 3.1.

To provide an alternative estimation approach, we have therefore concentrated on the second of the above approaches, augmenting the AEMO VCR study with information derived from other public studies. We discuss our approach in the remaining sections of this report.

[35] A sampling plan is a detailed outline of which surveys will be undertaken across which customers. The sampling plan should ensure appropriate coverage of all variables of interest; in this case customer type, location and size as measured by annual electricity consumption.

[36] Oakley Greenwood, *Final Report - NSW Value of Customer Reliability,* May 2012

5. Oakley Greenwood's (OGW) 2012 study of VCR Values

The OGW 2012 study of VCR values in NSW[37] was commissioned by the AEMC and was widely applied prior to AEMO's 2014 VCR study.

One purpose of OGW's study was to assess the value of electricity supply reliability to customers, and in particular to provide specific values of customer reliability for:

- Three (3) customer sectors (residential, small business and medium to large businesses, as defined by their annual electricity consumption);
- Each of the three feeder types maintained by the state's electricity distribution companies (ie, CBD, urban and rural;
- The three DNSPs – Ausgrid, Endeavour Energy and Essential Energy; and
- NSW as a whole.

As with AEMO's 2014 VCR study, prolonged outage durations were not put to survey participants - the maximum outage considered was 24 hours.[38] Therefore, the OGW VCR estimates still have material shortcomings in being applied to long duration outages such as those being considered in the PSF study.

However, an advantage of the OGW VCR study compared to AEMO's 2014 VCR study is that it provides results for different customer types in sub-regions such as Sydney's CBD and on Urban feeders, rather than only the state average.

The approach to OGW's VCR study differs from AEMO's 2014 VCR study and follows the methodology used by Monash University in 1997, 2002 and 2007[39] in applying interview techniques rather than choice modelling. OGW undertook different surveys for residential and business customers and differentiates between the types of costs incurred by these distinct customer types following an electricity supply disruption. Electricity supply disruptions are more likely to see residential customers' costs dominated by inconvenience rather than direct costs (eg a longer interruption will result in spoiled food but a short outage can cause material inconvenience such as preventing food preparation or using appliances). On the other hand, businesses incur direct costs through the impact of the disruption on their ability to operate and earn revenue, and intangible costs via damage to reputation or inability to deliver products in line with customer's expectations. Such intangible costs are certainly more difficult to estimate but should be included to the extent possible in the estimation of damages resulting from electricity outages.[40]

The OGW study sampled 41 customers in the CBD, which we understand is significantly more than those sampled in AEMO's 2014 study. However, only 11 commercial customers were sampled in the CBD, which raises concern as to the robustness of the OGW VCR estimates for this particular sector.

Table 5-1 below shows the NSW VCR values calculated by OGW, split by customer and feeder type. As can be seen, the VCR values for small to medium businesses are significantly higher than the corresponding values for residential and larger business customers.

[37] Oakley Greenwood, *Final Report - NSW Value of Customer Reliability,* May 2012

[38] Oakley Greenwood, *Final Report - NSW Value of Customer Reliability,* May 2012, p. 17.

[39] www.aemo.com.au/~/media/Files/Other/planning/0409-0002%20pdf.pdf

[40] Oakley Greenwood, *Final Report - NSW Value of Customer Reliability,* May 2012, p. 12.

Table 5-1 : OGWs state-wide VCRs by sector and feeder type ($/kWh) ($2012)[41]

Customer Sector	All feeders ($/kWh)	CBD feeders ($/kWh)	Urban feeders ($/kWh)	Rural feeders ($/kWh)
Residential	$20.71	$32.27	$23.05	$15.11
Business <160 MWh pa	$413.12	$295.87*	$452.12	$302.49
Business >160 MWh pa	$53.30	$80.54*	$29.96	$128.50*
Total	**$94.99**	**$120.52**	**$93.88**	**$93.86**

*Values marked with a * refer to low sample size*

OGW list the following caveats for wider application of their VCR estimates:

- The VCR estimates likely overstate the damages of inconvenience associated with most power failures because respondents were asked to consider an outage at a time that is the worst for them.
  - > Given that the current PSF exercise seeks to estimate VCR values for prolonged and multi-day outages with wide-spread inconvenience and impact, we consider this issue to have no material implications for the adoption of the OGW VCR estimates for the PSF study;
- It is likely that the customer is going to be using a higher than average amount of electricity at the time he or she defines as being the 'worst' time for a power failure. OGW did not inflate electricity use in its report because it was unknown how much electricity was being used at the 'worst' time.
  - > Again, given that the current PSF exercise seeks to estimate VCR values for prolonged and multi-day outages with wide-spread inconvenience and impact, we consider this issue to have no material implications for the adoption of the OGW VCR estimates for the PSF study;
- The VCR values based on CBD feeders for commercial customers are based on a small sample size.
  - > We agree with concerns relating to the small sample size used to calculate OGW's commercial VCR values for CBD customers. However, in the absence of access to AEMO's raw data or the sampling plan from its 2014 VCR study, and given the lack of other published studies, we consider that the OGW CBD VCR estimates do provide relevant information; and
- The VCR values presented in the OGW study are not point estimates. There is a material error band around several of the VCR estimates that needs to be kept in mind when reporting VCR estimates across sectors and feeders.
  - > We report on sensitivity of our VCR estimates in Sections 6.3 and 7.3.

5.1 HoustonKemp's observations from OGW's 2012 VCR study

OGW's commercial VCR estimates are higher than those estimated by AEMO, and this trend also holds for OGW's CBD commercial VCR values, despite the small sample size.

Table 5-2 below provides a summary comparison between AEMO's VCR estimates and OGW's VCR estimates by sub-region and customer type. We note that:

- AEMO does not split its VCR estimates into sub-regions, so all AEMO VCR values given are NSW state-wide values.

[41] Oakley Greenwood, *Final Report - NSW Value of Customer Reliability,* May 2012, p.42.

- AEMO and OGW define the threshold of energy consumption for medium and large businesses differently, with AEMO having a 100 MW pa threshold and OGW having 160 MWh pa threshold. We have elected to show the OGW threshold value of 160 MWh in Table 5-2 as this matches the customer demand profile provided in the PSF Joint Planning Report[42].
- The OGW 2012 VCR estimates in Table 5-1 have been escalated to 2014 dollars for comparison with the AEMO 2014 VCR estimates.
- OGW's standard error of the mean (SEM) for CBD medium commercial customers is high for CBD feeders but lower for Urban feeders. We believe OGW's high SEMs are due to low sample size and high variation within the small sample.

Table 5-2 : Summary comparison between AEMO and OGW VCR estimates ($2014)

Region	Customer segment	AEMO vs OGW VCR ($/kWh) (all figures in $2014)	Comments
NSW state-wide	Residential	OGW $21.75 AEMO $26.53	OGW 18% lower than AEMO but still within +/- 30% margin of error given by AEMO. Not statistically significant
NSW state-wide	Small & Medium Commercial (<160 MWh pa)	OGW = $433.78 AEMO = $57.13-$57.28	OGW significantly higher than AEMO
NSW state-wide	Large Commercial (>160 MWh pa)	OGW = $55.97 AEMO = $42.13	OGW 32% higher than AEMO which is very close to the +/- 30% margin of error given by AEMO.
Inner Metro	Residential	OGW = $24.20 AEMO state-wide $26.53 No Inner Metro VCR values available from AEMO study	OGW 9% lower than AEMO state-wide but still within +/- 30% margin of error given by AEMO. Not statistically significant
Inner Metro	Small & Medium Commercial (<160 MWh pa)	OGW = $474.73 AEMO state-wide $57.13-$57.28 No Inner Metro VCR values available from AEMO study	OGW significantly higher than AEMO state-wide
Inner Metro	Large Commercial (>160 MWh pa)	OGW = $31.46 AEMO state-wide = $42.13 No Inner Metro VCR values available from AEMO study	OGW 25% lower than AEMO state-wide but still within +/- 30% margin of error given by AEMO. Not statistically significant
CBD	Residential	OGW = $33.88 AEMO state-wide = $26.53 No CBD VCR values available from AEMO study	OGW 28% higher than AEMO state-wide but still within +/- 30% margin of error given by AEMO. Not statistically significant
CBD	Small & Medium Commercial (<160 MWh pa)	OGW = $310.66* AEMO state-wide = $57.13-	OGW significantly higher than AEMO state-wide, caution must be observed with low sample size

[42] TransGrid / Ausgrid : *Powering Sydney's Future Value of Customer Reliability in the Inner Metropolitan Area Selection Methodology Report, 26 May 2016,* p. 3.

		$57.28. No CBD VCR values available from AEMO study	
CBD	Large Commercial (>160 MWh pa)	OGW = $84.57* AEMO state-wide = $42.13 No CBD VCR values available from AEMO study	OGW significantly higher than AEMO state-wide, caution must be observed with low sample size

** small sample sizes and therefore results should be treated with caution*

The values given in Table 5-2 have been adjusted to 2014 dollars and therefore the OGW figures provided in Table 5-2 do not exactly match those given in the table on page 42 of OGW's report[43] because they have been inflated to adjust from 2012 dollars to 2014 dollars.

The key observations from Table 5-2 are:

- All OGW residential VCR values are within the +/- 30% margin of error given for AEMO VCR estimates;
- For large commercial state-wide and Inner Metro customers, OGW VCR values are within the +/- 30% margin of error given for AEMO VCR estimates;
- OGW's VCR estimates for large commercial customers in the CBD are significantly higher than AEMO's state-wide value for large commercial customers. (However we note that OGW CBD VCRs are based on a small sample);
- For all small & medium commercial (<160 MWh pa) customers, OGW VCR values are significantly higher than AEMO VCR values (However we note that OGW CBD VCRs are based on a small sample);
- There is trend of large commercial businesses having lower VCR values than small & medium businesses across both studies, and in all sub-regions. We note that this is a common finding across a number of VCR studies.
  - Potential reasons for this trend are discussed in Appendix A.1, but are likely to in part reflect greater incidence of back-up generation, which can address short duration interruptions in power supply; and
- A ratio of 50% is observed between OGW's VCR estimates for residential and large commercial customers in the CBD and OGW's state-wide VCRs for those same customer groups. However we note that OGW highlights its CBD commercial values as being less robust.

We expand on this last point in the following section.

5.2 Observed ratio of VCR for CBD customers versus NSW state average

Table 5-3 below shows the ratios observed between OGW's VCR estimates for each customer group for CBD feeders compared with its All Feeder estimates.

Table 5-3 : Ratio of OGW CBD VCR to State-wide OGW VCR by customer type

Customer type	CBD feeders : All feeders
Residential	1.56
Business <160 MWh pa	0.72*
Business >160 MWh pa	1.51*

**blue highlighted cells refer to VCR estimates with low sample size*

[43] Oakley Greenwood, *Final Report - NSW Value of Customer Reliability,* May 2012, p.42.

The same ratio of 50% is observed for CBD residential customers to state-wide residential customers and for CBD large commercial customers and all large commercial customers.

We believe that this 50% ratio of the VCR for residential and large commercial CBD customers to state-wide VCRs for these customer groups provides a helpful proxy for considering the relative differences between VCRs for customers in the CBD compared with customers across the state as a whole.

In the absence of other more robust information, it appears appropriate to assume that the same ratio may apply for small commercial customers, albeit that the OGW estimates show a lower ratio for this customer group (based on a low sample size). The ratio between CBD VCR and state VCR may not necessarily be the same for all customer groups, but adopting this same ratio for small commercial customers likely reflects a conservative lower bound in estimating the higher VCR that may be expected for small commercial customers in the CBD. Moreover we would not expect this ratio to change substantially over time because the underlying drivers of VCR are unlikely to have changed since the OGW work.

We acknowledge that the ratio of 1.51 calculated for large commercial customers (>160MWh pa) is based on a small sample. To test our belief that this higher ratio is appropriate, we have reviewed global studies that estimate the costs of electricity outages, and customers' willingness to pay for a more reliable electricity supply. Whilst the results of these studies are not directly comparable to the NSW VCR estimates, they do show a trend of the costs of outages and customers' willingness to pay being significantly higher in cities as opposed to regional and rural areas.[44] [45] [46]

In Section 6.2 and 7.2, we discuss how we incorporate the observed ratio between CBD customer VCR values and NSW state-wide values arising from the OGW VCR study into the calculation of VCR estimates for CBD and Inner Metro commercial customers.

[44] Larwence Berkeley Laboratory : *Estimated value of Service Reliability for Electric Utility Customers in the United States, June 2009,* pp. xxi-xxvi.

[45] London Economics, 2013 : *The Value of Lost Load (VoLL) for Electricity in Great Britain*, July 2013, pp.108-111.

[46] Göteborg University :*The effect of power outages and cheap talk on willingness to pay to reduce outages (Sweden), 2009*, p.10.

6. Our approach: CBD VCR value

Based on our analysis to this point, and the information available to us, we have adopted different methodologies for estimating VCRs for residential and commercial customers.

We have estimated a CBD VCR of $150-192/kWh (in 2015/16$), with a relative standard error (RSE) of 32%.

6.1 CBD Residential VCR

We have used the AEMO 2014 state-wide residential VCR of $26.53/kWh ($2014) as an appropriate basis for deriving the VCR value for residential customers in the Sydney CBD.

Our rationale for using this value is:

- OGW provides a stratified VCR value for CBD residential customers of $33.88/kWh (in 2014 dollars), which is well within the +/- 30% margin of error given in AEMO's 2014 VCR study. Therefore, no additional information would be gained by using OGW's residential CBD VCR value over AEMO's state-wide residential VCR;
- OGW calculates the relative standard error (RSE, as a percentage of VCR) of its CBD residential VCR value as 18.2%, which is lower than AEMO's margin of error, and also leads us to conclude that the AEMO and OGW residential VCR values are within each other's margin of error;
- The demand weighting applied to residential customers in the CBD is only 3% (refer to Table 6-1), and interchanging the AEMO state-wide residential VCR and the OGW CBD residential VCR values makes no material difference to the aggregated CBD VCR value.

As a sensitivity, we applied CBD income uplift factors of between 10% and 50% to account for CBD residents' higher incomes and greater ability and willingness to pay to avoid electricity outages. The reasonableness of applying an income uplift factor is reinforced by the fact that OGW's CBD residential VCR values are higher than its state-wide VCR values by approximately 50%. However, a sensitivity analysis showed that applying this income uplift factor is immaterial to the aggregated CBD VCR value. Given that residential customers' electricity demand in the CBD accounts for only 3% of total CBD demand (see Table 6-1), it is not surprising that inclusion of these income uplift factors made no material difference to the aggregated CBD VCR estimate.

Given the immateriality of applying an income uplift factor, we have elected to use AEMO's 2014 state-wide residential VCR of $26.53/kWh ($2014) with no uplift applied.

6.2 CBD Commercial VCR

6.2.1 Small & Medium commercial customers (<160 MWh pa electricity consumption)

We have calculated lower and upper bounds for the CBD small & medium commercial VCR as follows:

- **Lower bound:** we used OGW's state-wide VCR value for small & medium commercial customers of $413.12/kWh ($2012);
- **Upper bound:** we escalated OGW's state-wide VCR for small & medium commercial customers of $413.12/kWh ($2012) by 50% to reflect a consistent ratio between OGW's VCR estimates for different customer groups between CBD feeders and across all feeders, as discussed in Section 5.2 and shown in Table 5-3.

We believe this approach is preferable to using AEMO's state-wide commercial VCR estimate because:

- The lower bound is based on surveys that targeted the specific losses suffered by commercial businesses; and
- The upper bound is based on a consistent ratio observed from the OGW study between the VCR estimated across feeders state-wide, and that estimated across CBD feeders only.
  - The point estimate of $295.87/kWh[47] ($2012) for small and medium commercial customers estimated in the OGW study is based on a small sample size and OGW notes that caution must be taken not to apply this value directly. We therefore consider that this value can be ignored, in favour of instead adopting a value for these customers based on the above adjustment to the state-wide VCR estimate.

6.2.2 Large commercial customers (>160 MWh pa electricity consumption)

We calculate a point estimate of the VCR for large commercial customers in the CBD based on OGW's estimate of VCR for large commercial customers in the CBD of $80.54/kWh ($2012). Despite this value being based on a small sample size, we have chosen to adopt OGW's VCR estimate rather than AEMO's in this case for consistency with the adoption of the OGW estimate for small & medium commercial customers, since the cut-off thresholds between medium and large commercial businesses differ between the AEMO and OGW studies. However, the AEMO and OGW VCR estimates for large commercial businesses are within the +/- 30% error bounds for AEMO's estimate.

6.3 Results

We have weighted the customer specific VCR derived above for the CBD according to the energy consumption demand profile of each customer type within Sydney's CBD, which is given in Table 6-1. For example, residential customers make up 3% of the electricity consumption within Sydney's CBD and in an aggregated total their VCR value is given a 3% weighting.

Table 6-1 : CBD electricity consumption – demand weighting by customer type

Customer category	Energy consumption (GWh)	Demand weighting
Residential	287	3%
Small commercial(< 40 MWh pa)	1,033	10%
Medium commercial (40-160 MWh pa)	980	10%
Large commercial (>100 MWh pa)	7,798	77%

Source: TransGrid / Ausgrid : Powering Sydney's Future Value of Customer Reliability in the Inner Metropolitan Area Selection Methodology Report, 26 May 2016, *p. 9.*

The final step in calculating a final aggregate VCR estimate for the CBD is to index the base VCRs to 2015/16 dollars and then apply a loss factor of 3.9% as per Ausgrid's calculation.[48] An aggregate VCR is then formed by applying the demand weighting profile given in Table 6-1.

Applying the approaches described in Sections 6.1 and 6.2 and calculating an aggregated CBD VCR as described above results in a range for the **CBD VCR of $150-192/kWh (in 2015/16$),** with a relative standard error (RSE) of 32%.

We note this range of values shows good alignment with Ausgrid's CBD VCR estimate of $191/kWh, which has been derived on the basis of an Economic Contribution multiplier (see discussion in Section 3.1).

[47] Oakley Greenwood, *Final Report - NSW Value of Customer Reliability,* May 2012, p.4.

[48] TransGrid / Ausgrid : *Powering Sydney's Future Value of Customer Reliability in the Inner Metropolitan Area Selection Methodology Report, 26 May 2016,* p. 10.

Although we consider our estimated range for the VCR value for the CBD to be reasonable, based on the available information, we also note that it is likely to *under-estimate* the true VCR of CBD customers, particularly for the types of long-duration outages that are being considered in the PSF study.

7. Our approach: Inner Metro VCR value

As with our estimates of the VCR for CBD customers, we have adopted different methodologies for estimating VCRs for residential and commercial customers in the Inner Metro area.

We have estimated an Inner Metro VCR of $90/kWh (in 2015/16$), with a relative standard error (RSE) of 7.5%.

7.1 Inner Metro Residential VCR

We have adopted the AEMO 2014 state-wide residential VCR estimate of $26.53/kWh ($2014) as the basis for our estimate of the VCR for residential customers in the Inner Metro area.

Our rationale for using the AEMO VCR value for residential customers is:

- OGW provides a stratified VCR value for residential customers on Urban feeders of $24.20/kWh ($2014), which is well within the +/- 30% margin of error given in AEMO's 2014 VCR study. Therefore, no additional information would be gained by using OGW's residential Inner Metro VCR value over AEMO's state-wide residential VCR;
- OGW calculates the relative standard error (RSE as a percentage of VCR) of its Urban residential VCR value as 6.4%, which is lower than AEMO's margin of error of +/- 30%, and also leads us to conclude that the AEMO and OGW residential VCR values are within each other's margin of error;

As a sensitivity we applied CBD income uplift factors of between 10% and 30% to account for Inner Metro residents' higher incomes and greater ability and willingness to pay to avoid electricity outages. The reasonableness of adopting an income uplift factor is reinforced by the fact that OGW's Urban residential VCR value is higher than its state-wide VCR estimate by approximately 10%. However, a sensitivity analysis showed applying this income uplift factor to be immaterial to the aggregated Inner Metro VCR value.

As a consequence, we have elected to use AEMO's state-wide residential VCR of $26.53/kWh ($2014) with no uplift applied.

7.2 Inner Metro Commercial VCR

7.2.1 Small & Medium commercial (<160 MWh pa electricity consumption)

We have elected to use OGW's small and medium commercial VCR estimate for customers connected to an Urban feeder ($452.12/kWh - $2012, Table 5-1) as the basis of our VCR estimate for small and medium commercial customers in the Inner Metro area.

Our rationale for using the OGW value is:

- The sample size is sufficiently large and no caution is given by OGW as to the robustness of this VCR estimate;
- The RSE for OGW's Urban feeders small & medium commercial VCR is 7.7%, which is significantly lower than AEMO's +/- 30% margin of error for all of its commercial VCR estimates;
- OGW's study stratifies its VCR values into Urban areas, which can be taken as representative of the Inner Metro area and provide more granularity in the small & medium commercial VCR estimate than does the AEMO study; and
- OGW's study uses a more targeted survey for commercial customers than AEMO's study does. This recognises that commercial customers incur substantially different types of loss than residential customers - in particular they suffer loss in their ability to generate and collect revenue if there were to be an electricity outage.

7.2.2 Large commercial (>160 MWh pa electricity consumption)

We have elected to use OGW's VCR estimate for large commercial customers on Urban feeders ($29.96/kWh - $2012 Table 5-1) as the basis of our VCR estimate for large commercial customers in the Inner Metro area, for the following reasons;

- OGW's study stratifies its VCR estimate into results for large customers on urban feeders, which corresponds to the Inner Metro area and provides more granularity than AEMO's VCR estimates;
- The sample size used by OGW is sufficiently large and no caution is given by OGW as to the robustness of the VCR estimate;
- The RSE for OGW's VCR estimate for large commercial customers on urban feeders is 24.6%, which has OGW's value falling within AEMO's +/- 30% margin of error for all its large commercial VCR estimates;
- OGW's study uses a more targeted survey for commercial customers than does AEMO's study. As noted earlier, this recognises that commercial customers incur different types of loss than residential customers.

The observed trend in both the AEMO VCR study and the OGW VCR study of large commercial businesses (ie those consuming over 160MWh per annum) having lower VCR values than small and medium sized commercial businesses is not surprising. Appendix A.1 discusses the findings of our research into this trend.

7.3 Results

We have weighted the customer specific VCR derived above for the Inner Metro area according to the energy consumption demand profile of each customer type within the Inner Metro area, which is given in Table 7-1 below. For example, residential customers make up 37% of the electricity consumption within Sydney's Inner Metro and the Inner Metro residential VCR estimate is given a 37% weighting in the aggregate Inner Metro VCR estimate).

Table 7-1 : Inner Metro electricity consumption – demand weighting by customer type

Customer category	Energy consumption (GWh)	Demand weighting
Residential	29,611	37%
Small commercial(< 40 MWh pa)	5,694	7%
Medium commercial (40-160 MWh pa)	5,194	7%
Large commercial (>160 MWh pa)*	38,514	49%

The final step in calculating a final aggregate VCR estimate for the CBD is to index the base VCRs to 2015/16 dollars and then apply a loss factor of 3.9% as per Ausgrid's calculation.[49] An aggregate VCR is then formed by applying the demand weighting profile given inTable 7-1.

Applying the approach described in Sections 7.1 and 7.2 to derive the residential and commercial VCR estimates, and then bringing them together into an aggregate VCR number as described above results in an **Inner Metro VCR of $90/kWh (in 2015/16$),** with an RSE of 7.5%.

We note this value is approximately double Ausgrid's estimate of $40 for the average VCR for the Inner Metro area. Our higher estimate arises from our adoption of OGW's VCR estimate for small & medium commercial customers in urban areas; which is significantly higher than AEMO's commercial VCR estimate

[49] TransGrid / Ausgrid : *Powering Sydney's Future Value of Customer Reliability in the Inner Metropolitan Area Selection Methodology Report, 26 May 2016,* p. 10.

for NSW as a whole. We believe the value of $90/kWh to be more representative of the likely commercial VCR in the Inner Metro area, because of the stratification made by OGW into the specific Urban sub-region.

As with our estimate of the VCR for the CBD areas, we consider that our estimate is likely to *under-estimate* the true VCR of Inner Metro customers for the types of long-duration outages that are being considered for the PSF study, as neither the AEMO nor the OGW VCR studies considered long duration outages.

8. Conclusion

We have thoroughly reviewed both AEMO's 2014 VCR study and OGW's 2012 VCR study, as well as relevant industry reports on calculating aggregate VCRs for Australian jurisdictions.

Our conclusions from this review are:

- A key component of the PSF study is focused on options that would address low probability, but high impact supply outages in the CBD and Inner Metro sub-regions. AEMO's VCR values are not stratified beyond a NSW state-wide level and do not differentiate between the expected higher value of electricity reliability in Sydney's CBD & Inner Metro sub-regions, as opposed to the rest of the state;
- AEMO's 2014 VCR study also did not include an assessment of the VCR associated with long duration outages. We therefore consider that AEMO's 2014 VCR estimates will *understate* the VCR values associated with the locations and types of outages that are the focus of the PSF study, particularly for commercial customers; and
- Whilst OGW's study stratifies its VCR values into CBD and Inner Metro sub-regions, the sample size for commercial customers in the CBD is small (11 in total) and these VCR values should be used with caution. In contrast, OGW's VCR estimates for both large and small & medium commercial customers on Urban feeders have a sufficiently large sample size and are considered robust.

As a consequence of these observations, we have applied different methods to estimating VCR in each sub-region (ie, CBD vs Inner Metro).

For the Sydney CBD we have estimated a range for the VCR of $150-$192/kWh ($2015/16). This range shows good alignment with Ausgrid's CBD VCR estimate based on its economic contribution uplift factor, which resulted in an estimate for the CBD VCR of $191/kWh ($2015/16).

For the Inner Metro VCR, we have used OGW's estimates of the VCR for commercial customers attached to Urban feeders, as representative of the VCR for customers in the Inner Metro area. These VCR estimates are more stratified than AEMO's NSW-wide estimates of commercial VCR. They also have low relative standard errors and are based on targeted surveys for commercial customers.

Our approach results in an estimate of the Inner Metro VCR of $90/kWh ($2015/16) with a relative standard error of 7.5%. This value is significantly higher than that obtained by Ausgrid by averaging AEMO's commercial VCR estimates. However, we believe the higher Inner Metro VCR of $90/kWh to be more representative of the particular customer composition that makes up the Inner Metro sub-region of Sydney.

In both cases the VCR studies we have drawn on to derive our estimates do not consider long duration outages. We therefore consider that in the case of the PSF study, where the reduction in long duration outages is a key focus, our VCR estimates above will *under-estimate* the true VCR value, for both the CBD and Inner Metro sub-regions.

We agree with recent observations by IPART that the only robust way to derive appropriate VCR estimates would be to conduct a new VCR study, focused on highlighting differences in VCR between different geographic areas in NSW and different customer groups. The study would also need to explicitly consider the VCR associated with low probability but high impact, long duration outages, such as those being addressed by the PSF study.

A1. Research into the observation that large commercial customers have a lower VCR than small and medium commercial customers

Studies consistently estimate smaller VCRs for large commercial businesses, compared to small and medium commercial businesses. For example, as discussed in the body of this report:

- Oakley Greenwood's 2012 VCR estimates (in $2012) are for:[50]
  - Businesses <160 MWh pa: $413.12/kWh
  - Businesses ≥ 160 MWh pa: $53.30/kWh
- AEMO's 2014 VCR estimates for commercial businesses (in $2014) are:[51]
  - Small size (generally <40 MWh pa): $57.13/kWh
  - Medium size (generally 40-100 MWh pa): $57.28/kWh
  - Large size (generally >100 MWh pa): $42.13/kWh

AEMO noted that its estimation of a lower VCR for larger businesses is consistent with previous studies conducted domestically and internationally, and suggested this may be due to larger businesses establishing back-up systems to mitigate the effect of outages.[52]

There is evidence for this in Sydney. A study conducted by SKM in 2008 identified 194 standby generators (predominantly diesel) in the Sydney CBD intended to supply electricity to a building in the event of an outage.[53] It is probable that the number of emergency generators in the CBD has increased since SKM's study was undertaken – newly constructed buildings commonly feature emergency generators, for example:

- Commonwealth Bank Place at Darling Quarter was built with two 1650kVA back-up emergency generators[54];
- Liberty Place was constructed with stand-by power generators that power base essential services[55];
- 420 George St was built with two 2200 kVA emergency diesel generators[56]; and
- 200 George St has a standby generator to accommodate 'realistic load backup'.[57]

However, we note that these back-up generation arrangements would likely have limited effectiveness for prolonged outages, such as are being considered as part of the PSF study. The majority of diesel generators are rated for standby or emergency use, which applies to generators that will be used to short periods of time when the main supply fails and are typically used for less than 16 hours a year.[58] Generally, emergency generators are used to ensure that essential services in a facility (ie, lifts, fire services, medical and electronic equipment) receive a continuous supply of electricity. Emergency generators have been designed with this type of usage in mind. Diesel generators typically draw fuel from a day tank, which has capacity to

[50] Oakley Greenwood, *Final Report - NSW Value of Customer Reliability,* May 2012, p.42.

[51] AEMO, *Final Report – Value of Customer Reliability*, September 2014, pp.23-24.

[52] AEMO, *Final Report – Value of Customer Reliability*, September 2014, p. 1.

[53] SKM Consulting, *Standby generation for demand management,* April 2008.

[54] Mpower website: https://www.mpower.com.au/solutions/cogeneration/commonwealth-bank-place-case-study/

[55] Liberty Place website: http://libertyplace.com.au/wp-content/uploads/2014/01/LP1735-Liberty-Place-Tech-Specs-ANZ-Tower_V4.pdf

[56] 420 George St website: http://www.420georgestreet.com.au/Core/Pages/GetFile.aspx?id=1b052892efb747f48eb4

[57] Mirvac website: http://www.mirvac.com/uploadedFiles/Main/Content/200%20George%20leasing%20brochure%20226%20x%20320_v18_flipbook%20version.pdf

[58] Econnect, *Demand management and planning project – preliminary feasibility study, December 2006,* p. 24.

operate the generator for a few hours, after which fuel is drawn in from a main store tank (which typically has a capacity 10 times that of the day tank). [59] For example:

- 20 Bond St: maximum duration of day tank is 4 hours;[60]
- 55 Market St: maximum duration of day tank is 4 hours;[61]
- 153 Clarence St: maximum duration for day tank is 6.5 hours; [62] and
- 453-461 Kent St: maximum duration for day tank is 11 hours.[63]

Furthermore, running emergency generators for extended periods can be unsafe. During the 1998 Auckland power outage, emergency generators led to fires due to running beyond their intended utilisation time and the refilling of generators while they were running.[64] Therefore, the ability of emergency generators to mitigate the effects of a prolonged outage appears likely to be limited.

The studies that find VCR estimates for large businesses are lower than those of small and medium sized businesses due to investments in standby generators have relatively short durations:

- the Oakley Greenwood 2012 study uses outage durations of 20 minutes; 1 hour; 2 hours; 4 hours; 8 hours; or 24 hours; [65] and
- the AEMO 2014 study has scenarios with outage durations of 1 hour, 3 hours, 6 hours or 12 hours[66].

Therefore, the VCR estimates for large businesses faced with an outage of prolonged duration is likely to be under estimated by both the Oakley Greenwood and AEMO VCR studies.

[59] Econnect, *Demand management and planning project – preliminary feasibility study, December 2006,* p. 23.

[60] Econnect, *Demand management and planning project – preliminary feasibility study, December 2006,* p. 35.

[61] Econnect, *Demand management and planning project – preliminary feasibility study, December 2006,* p. 40.

[62] Econnect, *Demand management and planning project – preliminary feasibility study, December 2006,* p. 45.

[63] Econnect, *Demand management and planning project – preliminary feasibility study, December 2006,* p. 49.

[64] Davis, G., 1999, *The Auckland electricity supply disruption 1998: emergency management aspects*, Australian Journal of Emergency Management, p. 45.

[65] Oakley Greenwood, *Final Report - NSW Value of Customer Reliability*, May 2012, p.14.

[66] AEMO, *Final Report – Value of Customer Reliability*, September 2014, p.11.

A2. Research into the impact on customers of prolonged outages

It is widely understood that the impact of an electricity outage depends on its duration. However, the cost and effects of prolonged outages (ie of more than 24 hours) have not been widely published or analysed in the literature on VCRs.

Below we summarise the effects and impacts of a prominent prolonged outage; that experienced by Auckland in 1998. Not all impacts and costs can be quantified, but the following summary describes the wide-ranging impacts on citizens, businesses and public services.

Auckland 1998 outage

On 20 February 1998, downtown Auckland lost power when the four cables that supplied the area's electricity all failed. The outage lasted for five weeks.[67] At the time 8,000 businesses, employing 70,000 people were located in Auckland's central business district and 6,000 people resided there, largely in high-rise apartments. [68]

In response to the outage, Mercury Energy – the power company responsible – brought in generators from other areas of New Zealand and Australia. The largest generators were used to reinforce Mercury's substations, while smaller generators were given to Mercury's major customers.[69] A large proportion of generators in New Zealand were moved to Auckland.[70]

There was a significant impact on corporate businesses located in the CBD. The emergency power supplies of office buildings were insufficient to power air-conditioning, lifts and computers, which meant employees could not work in their offices. [71] Many large organisations mitigated the effects by moving operations outside the CBD, and in some cases, outside New Zealand. Many companies distributed staff between regional offices, or asked employees to work from home. [72] For example;

- The Bank of New Zealand closed its nine CBD branches, and its transferred employees to other branches;[73]
- A leading law firm (Buddle Findlay) moved the location of its computer network and installed ISDN in four partner's homes and a motel; and
- Qantas moved its entire Auckland office to Sydney.[74]

Despite these workarounds, overall productivity was reduced as access to information and communication were impeded. For example, retrieval of paper documents required a trip to the CBD and many companies had inflexible computer systems that needed the network wiring in their particular building.[75] Re-establishing communication with employees and clients required changes to computer systems, and telephone and fax lines.

[67] Wired Magazine's website: http://www.wired.com/1999/04/life/

[68] Wired Magazine's website: http://www.wired.com/1999/04/life/

[69] Wired Magazine's website: http://www.wired.com/1999/04/life/

[70] Ackermann, T. and Muller, Dorte, 1998, *Auckland unplugged*, Electric Light and Power, vol. 76, no. 11, pp. 20-22.

[71] Ackermann, T. and Muller, Dorte, 1998, *Auckland unplugged*, Electric Light and Power, vol. 76, no. 11, pp. 20-22.

[72] Ackermann, T. and Muller, Dorte, 1998, *Auckland unplugged*, Electric Light and Power, vol. 76, no. 11, pp. 20-22.

[73] Wired Magazine's website: http://www.wired.com/1999/04/life/

[74] Ackermann, T. and Muller, Dorte, 1998, *Auckland unplugged*, Electric Light and Power, vol. 76, no. 11, pp. 20-22.

[75] Davis, G., 1999, *The Auckland electricity supply disruption 1998: emergency management aspects*, Australian Journal of Emergency Management, p. 45; Wired Magazine's website: http://www.wired.com/1999/04/life/

An additional cost to businesses was security, with some companies engaging security staff to protect their premises.[76]

Businesses located in the CBD that relied on commuters as their customer base were also impacted, as foot traffic in the city fell. Of the approximately 1,000 retailers operating in Auckland's CBD, about 200 remained open through the outage. [77] Businesses operating in hospitality and entertainment industries saw similar reductions in customer numbers.[78] There is evidence that the power outage led to small businesses going out of business, due to lack of patronage.[79] The outage also led to losses, for example, restaurants without access to generators had to dispose of the contents of their freezer. [80]

The tourism industry in Auckland was significantly affected, as the city's tourist facilities lost power. [81] Reports of the outage had a negative effect on tourism, 30 to 40 percent of hotel reservations were cancelled, although 25 hotels in the CBD continued to run on generators.[82] A large tourist vessel cancelled a three day visit and moved on to the next port.[83]

Many governmental organisations operating in Auckland were also disrupted during the power outage. For example:

- the Fire Department received an unusually high number of emergency calls, mostly related to generators – fumes from operating generators without sufficient ventilation, fires due to refuelling generators while they were running and fires due to generators running for extended periods;[84]
- traffic control was also made difficult, as traffic lights were only intermittently supplied with electricity; [85]
- government departments based in Auckland's CBD were unable to carry out regular businesses, for example, the Land Title Office could not process thousands of transactions; and [86]
- the Health Department was concerned that food outlets were retaining food that had insufficient refrigeration. [87]

[76] Ackermann, T. and Muller, Dorte, 1998, *Auckland unplugged*, Electric Light and Power, vol. 76, no. 11, pp. 20-22.

[77] Wired Magazine's website: http://www.wired.com/1999/04/life/

[78] Davis, G., 1999, *The Auckland electricity supply disruption 1998: emergency management aspects*, Australian Journal of Emergency Management, p. 45.

[79] Wired Magazine's website: http://www.wired.com/1999/04/life/

[80] Ackermann, T. and Muller, Dorte, 1998, *Auckland unplugged*, Electric Light and Power, vol. 76, no. 11, pp. 20-22.

[81] Davis, G., 1999, *The Auckland electricity supply disruption 1998: emergency management aspects*, Australian Journal of Emergency Management, p. 45.

[82] Wired Magazine's website: http://www.wired.com/1999/04/life/

[83] Davis, G., 1999, *The Auckland electricity supply disruption 1998: emergency management aspects*, Australian Journal of Emergency Management, p. 45.

[84] Davis, G., 1999, *The Auckland electricity supply disruption 1998: emergency management aspects*, Australian Journal of Emergency Management, p. 45.

[85] Davis, G., 1999, *The Auckland electricity supply disruption 1998: emergency management aspects*, Australian Journal of Emergency Management, p. 45.

[86] Davis, G., 1999, *The Auckland electricity supply disruption 1998: emergency management aspects*, Australian Journal of Emergency Management, p. 45.

[87] Davis, G., 1999, *The Auckland electricity supply disruption 1998: emergency management aspects*, Australian Journal of Emergency Management, p. 45.

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