Values of Customer Reliability

Final report on VCR values

December 2019

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REGULATOR

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Contents

Shortened forms

Shortened form	Extended form
AAM	annual adjustment mechanism
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
CBD	central business district
COAG	Council of Australian Governments
the Committee	the VCR Consultative Committee
CPI	Consumer Price Index
DER	distributed energy resources
ECA	Energy Consumers Australia
ESB	Energy Security Board
HILP	high impact low probability
GWh	gigawatt hour
kVA	kilovolt ampere
kWh	kilowatt hour
MEI	Melbourne Energy Institute
MVA	megavolt ampere
NEL	National Electricity Law
NEM	National Electricity Market
NEO	National Electricity Objective
NER	National Electricity Rules
NSP	network service provider
PPI	Producer Price Index
RERT	reliability and emergency reserve trader
RIT	regulatory investment test
Solar PV	solar photovoltaic
STPIS	service target performance incentive scheme

the Subcommittee	the HILP Subcommittee
USE	unserved energy
UPS	uninterruptable power supply
VCR	values of customer reliability
WTA	willingness to accept
WTP	willingness to pay
$/kWh	dollars per kilowatt hour

1 Overview and executive summary

The Australian Energy Regulator (AER) is the independent regulator for Australia's national energy markets. We are guided in our role by the national electricity, gas, and energy retail objectives set out in in the National Electricity Law (NEL), the National Gas Law (NGL) and the National Energy Retail Law (NERL). These objectives focus on promoting the efficient investment, operation and use of energy services for the long-term interests of consumers.

This report sets out the values of customer reliability (VCR) we have derived for unplanned electricity outages of up to 12 hours in duration (i.e. standard outages) for the National Electricity Market (NEM) and the Northern Territory (NT). These values have been calculated in accordance with our final methodology on determining VCR, which builds upon the Australian Energy Market Operator's (AEMO's) 2014 review of VCR.

VCRs are an important input to help ensure customers pay no more than necessary for safe and reliable energy. VCRs seek to reflect the value different types of customers place on a reliable electricity supply under different conditions and are usually expressed in dollars per kilowatt hour ($/kWh). Thus, they highlight the competing tensions between reliability and affordability which customers face. VCRs are an important input in identifying efficient levels of network expenditure and in determining the National Electricity Market (NEM) reliability standard and market settings.

Our review found that while there are some differences[1] between 2014 and 2019 in VCR values for residential and business customers, in general VCR values are similar between the two years. The other key findings of our review are:

- consistent with previous VCR studies, we observe that business customer VCRs are higher than residential customer VCRs
- residential customers continue to value reliability and have a preference to avoid longer outages, and outages which occur at peak times (defined as 7-10 am and 5-8 pm). However, residential values are lower in 2019 than in 2014 with the exception of customers in suburban Adelaide
- the 2019 VCR values are lower than the 2014 values for agricultural and commercial customers, and higher for industrial customers.

Recognising how different types of customers' value reliability is important to properly consider the competing tensions of reliability and affordability. Any investment decisions where VCR is applied should use a VCR value reflective of the affected customer composition on the network. For example, an investment decision in a substation should reflect the composition of residential and business customer types at that substation. Our values suggest network investments in residential areas will face a higher cost benefit hurdle than an area dominated by industrial customers because of the lower value of residential customer VCRs.

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[1] We note that due to the differences in some aspects of the VCR methodology between us and AEMO the results are not directly comparable.

1.1 What is VCR?

VCRs seek to reflect the value different types of customers place on reliable electricity under different conditions. As such, VCRs are useful inputs in regulatory and network investment decision-making to factor in competing tensions of reliability and affordability. Importantly, VCR is not a single number but a collection of values across residential and business customer types, which need to be selectively applied depending on the context in which they are being used.

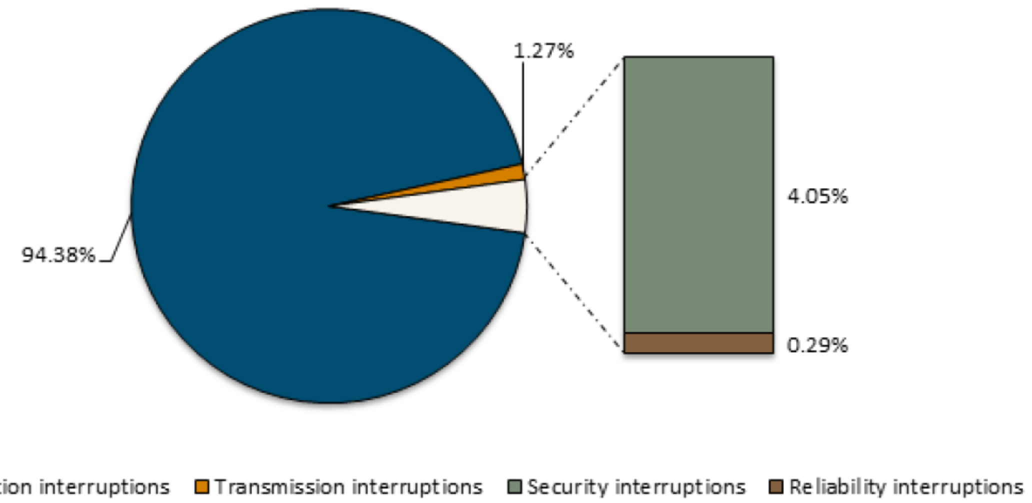
Electricity outages incur costs for customers, both directly through financial losses resulting from lost productivity and business revenues, and in the form of intangible or indirect costs such as a reduction in the convenience, comfort, safety and amenity provided by electricity.

How different customers value electricity supply depends on what they use their energy for, from running air conditioners in residential homes to helping to manage a small business to powering large scale manufacturing processes. The value customers place on electricity reliability therefore depends on the value they place on these services and because these services differ, so too does the value of reliability across these different customer segments.

Outages which cause an interruption to a customer's electricity supply can be caused by a lack of generation supply, transmission network outages or distribution network outages. The main cause of customer supply interruptions in the NEM is outages on the distribution network. As shown in figure 1 below, analysis by the Reliability Panel[2] shows that 94 per cent of interruptions to customer supply (both planned and unplanned) in the past decade were caused by distribution network outages. Less than five per cent of customer outages were caused by system security issues and generation supply reliability interruptions.

[2] A NEM body specified in Chapter 8 of the National Electricity Law.

Figure 1. Sources of supply interruptions in the NEM from 2007/08 to 2017/18



Source: AEMC analysis and estimates based on publicly available information from AEMO's incident reports and the AER's RIN economic benchmarking spreadsheets.

Note: With regard to outages on the distribution network in 2017/18, a number of distribution network service providers (DNSPs) have reported unsupplied energy data on a calendar year rather than financial year basis via the RINs. For these DNSPs, the data for the 2017 calendar year was treated as 2017/18 financial year data. The DNSPs reporting unsupplied energy data on a calendar year basis are: ActewAGL, Endeavour Energy, Energex, Ergon, SA Power Networks and TasNetworks.

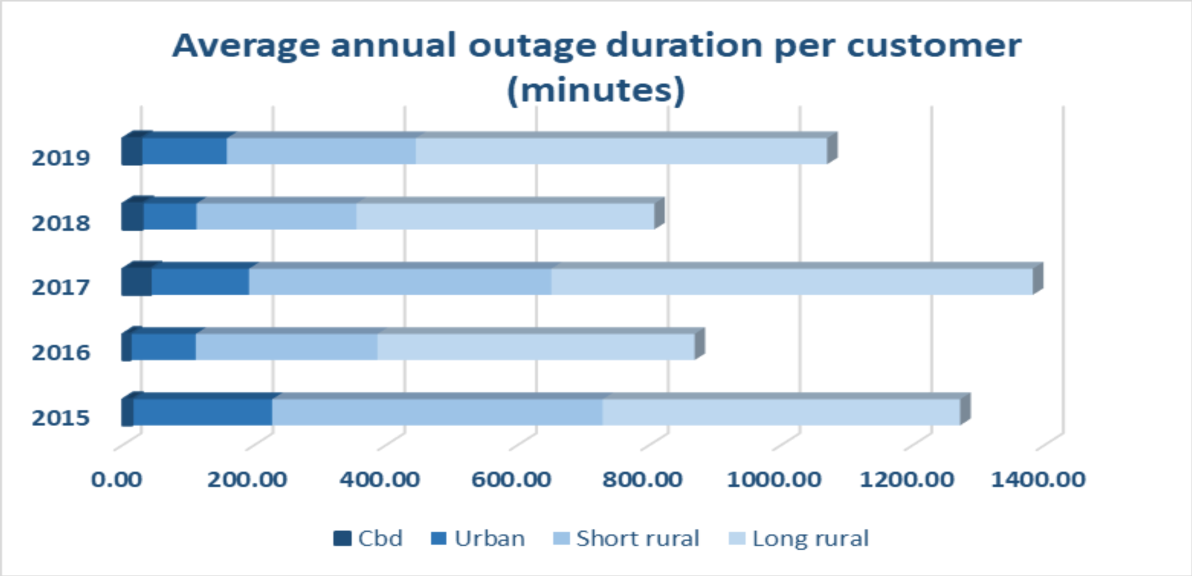
Source: Reliability Panel, Annual Market Performance Review 2018, page 81. Reliability interruptions in the above figure refer to interruptions caused by generation supply reliability issues.

Network reliability in Australia is generally of a high standard. Analysis of customer outage data collected in annual regulatory information notices (RINs) from distribution network businesses in the NEM and Northern Territory show that during the 2019 regulatory year the average minutes without power experienced by customers due to unplanned outages were:

- 28 minutes without power on average for customers connected to CBD feeders
- 130 minutes (2.17 hours) without power on average for customers connected to urban feeders
- 287 minutes (4.78 hours) without power on average for customers connected to short rural feeders
- 625 minutes (10.42 hours) without power on average for customers connected to long rural feeders.

This is broadly consistent with average outage minutes experienced by customers in the past five years, outlined in figure 2 below.

Figure 2 - average annual outage duration per customer due to unplanned outages in the 2015 to 2019 regulatory years



Source: AER analysis of customer outage information provided through Distribution Network Business Annual RINs[3]

A reliable electricity supply requires investment in transmission and distribution network assets, which is paid for by electricity customers. There is, therefore, a trade-off to be made between electricity reliability and affordability. Understanding this is important because, in order to achieve a higher level of reliability, a higher amount of investment is required. In turn, this imposes costs on consumers through higher electricity bills. It is therefore important that the right balance be struck between the level of electricity supply reliability and consequent investment costs to customers, as these costs form a significant portion of customers' bills. The value which different types of customers place on having a reliable electricity supply in different parts of the network assists electricity planners, asset owners, and regulators in striking this balance, providing customers with a more reliable electricity supply where desired and avoiding an overbuild of network assets in places where further network investment is not valued by customers.

1.2 Why did the AER review VCR?

On 5 July 2018 the Australian Energy Market Commission (AEMC) made a Rule Change determination, which gave effect to a rule change proposed by the Council of Australian Governments (COAG) Energy Council to give the AER the responsibility of determining the values different customers place on having a reliable electricity supply.

The AEMC considered that assigning a single body responsibility for developing a nationally consistent VCR methodology and for calculating VCR estimates would remove unnecessary duplication and decrease the overall administrative burden associated with the use of VCR

[3] Notes:

- as they report on a calendar year basis, this excludes 2019 data for the Victorian distribution network businesses
- Power and Water (NT) only has outage data for the 2019 regulatory year
- data includes TasNetworks, which has different feeder categories to other network businesses

by a wide range of stakeholders. The AER was considered the most appropriate body for developing the VCR methodology and VCR estimates on an on-going basis because the responsibility most aligns with our statutory functions.[4]

The AEMC's Rule Change became effective on 13 July 2018. It requires us to develop a VCR methodology and publish the VCRs calculated in accordance with the methodology by 31 December 2019.

1.3 AER review - development of VCR methodology

We developed our VCR methodology through an extensive consultation process that commenced in October 2018. We have engaged widely with governments, energy regulators, customer and industry representatives and the public through a series of issues papers, requests for submissions and public fora.

As part of our consultation process we published a Consultation paper (October 2018) and a Consultation update paper (April 2019), which set out our progress on developing the VCR methodology. Our draft decision on the methodology was published in September 2019 and our final decision on the methodology in November 2019. We received 38 submissions from a wide range of stakeholders from industry, Government and customer representatives in response to our consultation papers and draft decision.

We also established as a key advisory body the VCR Consultative Committee (the Committee), which we have regularly consulted on key issues throughout the VCR review. The Committee consists of representatives from organisations with a particular interest in VCRs, and who have relevant expertise in how VCRs should be used and/or determined. We met with the Committee seven times throughout the course of the VCR review. We also formed a subcommittee to assist us with developing a methodology to derive VCRs for widespread and long duration outages which will be published next year. We met twice with the subcommittee.

1.4 AER VCR methodology

The VCR values published in this report have been calculated in accordance with our VCR methodology as set out in our final decision on the VCR methodology.

Our methodology for standard outages (i.e. outages up to twelve hours in duration) is to use a combination of survey techniques. For widespread and long duration outages which are more severe than standard outages, with a total impact ranging from 1-2 GWh to 15 GWh of unserved energy, our methodology is model based and VCRs derived using this approach will be published next year.

To derive standard outage VCR values for residential and business customers we used a combination of contingent valuation and choice modelling survey techniques:

4 AEMC, Establishing VCRs, Rule Determination, 5 July 2018, page 7. Available at https://www.aemc.gov.au/rulechanges/establishing-values-of-customer-reliability.

- contingent valuation was used to determine the willingness to pay (WTP) to avoid a baseline outage scenario (defined as two localised one hour outages in a year, occurring in winter in off-peak times)
- choice modelling was used to determine the increment (or decrement) in value respondents' placed on specific outage attributes in addition to the baseline outage scenario. Attributes tested in the choice model were peak (7-10 am and 5-8 pm) and off-peak time of day, season (winter / summer), day of week (weekday / weekend), severity (localised / widespread) and duration (1 hour, 3 hours, 6 hours, 12 hours).

The contingent valuation and choice modelling results were then combined to calculate the dollar value which a customer cohort places on specific outage scenarios. The dollar values for the outage scenarios are then used to derive the standard outage VCR for the customer segment.

This combination of survey techniques is the same as AEMO used in 2014, but with some changes. Key changes include:

- including an open-ended question in our contingent valuation questions so as to obtain more accurate WTP responses from residential and business customers
- capping residential WTP responses at $22 per month by reference to the cost of back up generation
- updating the definition of peak and off peak times to account for changes in consumption patterns since 2014

The VCR values set out in this report apply to standard outages only. Our VCR values for widespread and long duration outages will be published in early 2020.

Our published VCR values will be updated annually using a CPI-X approach. CPI is used to ensure the real value of the VCRs is maintained. X represents the annual change in customer reliability preferences, which may be influenced by factors such as technological changes (for example home battery installation), but is set at zero due to the lack of available information. We consider these difficulties are likely to remain an impediment to calculating a non-zero X in the near future. We would welcome further discussions with stakeholders on how changes in customer reliability preferences could be monitored annually.

For business sites consuming more than 10MVA peak demand per annum (very large business customers) we used a direct cost survey approach similar to that used by AEMO in 2014. There are around 300 business sites in the NEM which meet this criteria. Key changes we made to the survey were expanding it to include distribution connected customers with a peak demand of more than 10 MVA per annum (AEMO only surveyed transmission-connected customers) and making some minor amendments to the survey design.

While we have used the same survey techniques as AEMO, the changes we have made means that our results will not be directly comparable to AEMO's 2014 results. That is, differences in the VCR values derived by this review and those by AEMO in 2014 can be attributable to changes in the methodology, changes in customer preferences or a combination of both. The direct cost survey results are also reflective of a change in the range of customers sampled.

1.5 VCR survey implementation

Our final survey methodology was implemented between 5 September and 23 October 2019, during which time we collected over 9,000 survey responses.[5] This includes:

1. 7,426 residential customer responses
2. 1,821 business customer responses

Survey recruitment was undertaken primarily using online panels supplemented by responses using 'open link' surveys and computer assisted telephone interview (CATI) to online recruitment.

For very large business customers we received 67 responses to our direct cost survey. The direct survey was hosted online with links to access the survey distributed directly to eligible business sites.

This makes this the largest survey review of VCR undertaken to date in Australia. In 2014 AEMO collected around 3,000 residential and business customer survey responses and 13 direct cost survey responses.

1.6 Application of VCRs

Identified applications of VCR

In the course of our VCR review we identified the following current and potential applications of VCRs in the NEM and NT:

- as an input in the cost benefit analysis for network planning (such as regulatory investment test (RIT) assessments and integrated system plan (ISP)
- in the assessment of network business revenue proposals
- in informing reviews of the market reliability standard, which relates principally to generation investment in the NEM, and other market settings
- in the setting of transmission and distribution reliability standards and targets
- to inform reliability and emergency reserve trader (RERT) procurement
- in the distribution service target performance incentive schemes (STPIS) as the key measure for linking outcome performance with the STPIS incentive
- to inform reviews of the system restart standard
- to inform the assessment of requests to declare certain risks as protected events
- determining load shedding priorities and jurisdictional compensation mechanisms
- as an input in recommendations arising from the AEMC's Black System Event Review.

5 In total we surveyed over 10,000 customers but approximately 1,300 responses were involved in a pilot study. As we refined the methodology following the pilot study, we have not included those responses in the final analysis.

Application of VCRs in this report

The VCRs published in this final report represent the aggregate value which residential and business customers place on standard outages. This encompasses outages which are relatively localised and last up to twelve hours in duration. They factor in the additional value (if any) a residential or business customer may place on an outage occurring in peak times (defined in our surveys as occurring between 7-10 am and 5-8 pm) or during a particular season (summer or winter). Standard outages are the outages customers are most likely to experience and can be caused by issues relating to distribution, transmission and/or generation.

When applying the VCR, the value used should be reflective of the customer composition on the network. For example, network investment decisions should use a VCR reflective of the composition of customer types located on the feeder or substation, rather than the VCR for the region, to properly consider the competing tensions of reliability and affordability. Our values suggest network investments in residential areas will face a higher cost–benefit hurdle than an area dominated by industrial customers because of the lower value of residential VCRs.

Importantly, the surveys used to derive the VCRs published in this report did not ask customers the value they place on high impact outages such as those occurring on high temperature days or widespread outages which affect a substantial proportion of customers in a region. Thus, these VCRs would not be appropriate to consider high impact, low probability events such as the 'tail risks' outlined by AEMO in the recent 2019 Electricity Statement of Opportunities (ESOO).

The Energy Security Board (ESB) has been tasked by the COAG Energy Council to provide advice on the implementation of interim measures to preserve reliability and system security in the National Electricity Market, including reviewing the reliability standard, during the transition to the 2025 market design. This is to be achieved by using existing mechanisms where possible, and the ESB advice is to be provided for Council consideration and decision by March 2020. The ESB review of the reliability standard should, among other things, include a cost/benefit analysis and impacts on prices for consumers by jurisdiction.[6] The VCR may form an input into the ESB review of the reliability standard.

Under the NER, the Reliability Panel is tasked with the standing review of the NEM reliability standard. The basis of this review is set out in the NER and the Reliability Standard and Settings Review Guidelines. In the context of the NEM, VCR is to be used by the Reliability Panel:

- as one of the two key factors to consider in determining whether there would be a material benefit in reassessing the reliability standard. The other consideration is any changes made to the way in which consumers use electricity that suggests a large number of customers may place a lower or higher value on the reliable supply of

6 The ESB scope of work can be found at: http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Reliability%20and%20Security%20Measures%20-%20Scope%20of%20work.pdf.

electricity in the NEM (for instance, due to the technology change such as the take up of rooftop solar and residential batteries)

- to help calibrate the level of the standard by understanding the value which customers place on reliability so this can be considered against the cost of providing that reliability. The Panel is: "to have regard to estimates of the value placed on reliability by customers when exercising its judgement as to the level of the standard. The reliability settings (including the market price, cumulative price threshold and administered price cap) should be sufficient to support the level of investment necessary to deliver the standard, over the long run."

Further information on how the VCR is used in the Reliability Panel's assessment of the NEM reliability standard and market settings can be found in the Guidelines published by the Reliability Panel.[7]

The VCR values published in this report could assist reviews of the NEM reliability standard and settings by helping to understand the value customers place on certain interruptions to supply which they would likely experience as a result of the reliability standard not being achieved. The relevant interruptions to supply would be those that fall within the definition of standard outages for which the published VCR values in this report are applicable. More severe interruptions to supply may be valued using widespread and long duration VCRs, provided they fall within the definition of widespread and long duration outages which we have used.[8] Our VCR values for widespread and long duration outages will be published in early 2020.

1.7 Quality assurance processes

Our review was assisted by two consultancy groups: the University of Melbourne's Melbourne Energy Institute (MEI); and a consortium consisting of KPMG and Insync (KPMG/Insync). The MEI is an inter-disciplinary academic research group that assisted us in developing the VCR methodology and provided expert advice and quality assurance over the course of our review. KPMG/Insync also assisted us to develop the VCR methodology and survey design, and undertook the delivery of surveys which were conducted as part of the review.

To ensure the robustness of the VCR values published in this report, we undertook an extensive internal and external review process. This included:

- having our survey results reviewed by the University of Melbourne's Melbourne Energy Institute (MEI) and cross-checked against calculations performed independently by KPMG
- an internal review of all calculations and input data used to derive the published VCR values, including by experts from the ACCC's Legal and Economic Division. Additionally,

7 Available at https://www.aemc.gov.au/sites/default/files/content/4d5fb7a2-5143-4976-a745-217618b49e73/REL0059-Final-guidelines.PDF.

8 The VCRs on widespread and long duration outages cover outages with a total unserved energy ranging from 1 to 15 GWh. These VCRs quantify the socio-economic costs associated with the loss of supply caused by the outage. Importantly, we do not explore what the probability of widespread and long duration outages occurring is.

an external review of calculations and input data used to derive the published values was undertaken by MEI.

1.8 Key Findings

The key findings from our survey results are:

- VCR values are similar to those AEMO found in 2014. However there are some differences in VCR values for residential and business between the two reviews
- consistent with previous VCR studies, we observe that business customer VCRs continue to be higher than residential customer VCRs
- residential customers continue to value reliability and have a preference to avoid longer outages, and outages which occur at peak times (defined as 7am-10am and 5pm-8pm). However, residential values are lower in 2019 than in 2014 with the exception of customers in suburban Adelaide
- the increase in the industrial VCR value has driven a small increase in the NEM and State VCR values compared to 2014. This is because proportionally industrial customers use the most energy relative to other customer segments and so have a greater influence on load weighted VCR numbers
- the direct cost survey results show that VCR values amongst the approximately 300 business sites that consume the highest amount of energy in the NEM can vary greatly depending on sector. Due to the different range and sample of businesses surveyed these results are not directly comparable to AEMO's direct cost survey results, which only surveyed transmission connected customers.

1.9 Detailed findings

Residential customers and business customers were surveyed using a combination of choice modelling and contingent valuation techniques. The contingent valuation question was used to determine the willingness to pay (WTP) of a baseline outage scenario (defined as two localised one hour outages in a year, occurring in winter in off-peak weekday times). The choice modelling question was then used to determine how much respondents' preferences for reliability vary from the baseline outage scenario with respect to different outage attributes such as peak (7-10 am and 5-8 pm) and off-peak time of day, season (winter / summer) and duration (3 hours, 6 hours, 12 hours).

The $/kWh VCR values presented in the tables below set out the value which customers place on reliability that have been derived from the survey responses we received.

Residential customers

We sampled a total of 7,426 residential customers between 5 September 2019 and 23 October 2019. Our VCR values for residential customers are segmented by climate zone and remoteness rather than by jurisdiction as per AEMO's 2014 VCR review. We found that when grouped together by climate zones, residential customers had very similar reliability preferences. In particular, customer preferences as to whether to avoid outages in summer or winter were broadly consistent with climate zone characteristics.

Similar to AEMO's 2014 study we found that for residential customers duration and peak attributes were all statistically significant. The results indicate that people had a preference for localised outages over widespread outages, shorter duration outages over longer duration outages and off-peak timing of outages over peak timing of outages.

Table 1.1 sets out our final VCR values for residential customers by climate zone and remoteness groupings and are also graphically represented in Figure 3. For comparative purposes to AEMO's 2014 review we have also derived residential VCRs by state[9]. These are set out in Table 1.2. While our results are not directly comparable given the changes in some aspects of the methodology, in general our VCR values for residential customers are lower than those calculated by AEMO in 2014.

9 See section [insert] of this Report for how these State VCRs were derived.

Table 1.1 Residential VCR values ($2019)

Residential customer segment	Applicable State and Territory	Aggregate residential VCR ($/kWh)
Northern Territory	Northern Territory	18.31
Climate Zone 1 Regional	Queensland	23.95
Climate Zone 2 CBD & Suburban	Queensland, New South Wales	22.95
Climate Zone 2 Regional	Queensland, New South Wales	25.56
Climate Zone 3&4 Regional	Queensland, New South Wales, Victoria, South Australia	26.47
Climate Zone 5 CBD & Suburban NSW	New South Wales	29.27
Climate Zone 5 CBD & Suburban SA	South Australia	33.23
Climate Zone 5 Regional	New South Wales, South Australia, Queensland	24.57
Climate Zone 6 CBD & Suburban	Victoria, New South Wales, South Australia, Australian Capital Territory	21.25
Climate Zone 6 Regional	Victoria, New South Wales, South Australia	21.77
Climate Zone 7 CBD & Suburban	Australian Capital Territory, Victoria	21.39
Climate Zone 7 Regional	Tasmania, Victoria, New South Wales	16.96

Figure 3: Residential VCR values by residential segment

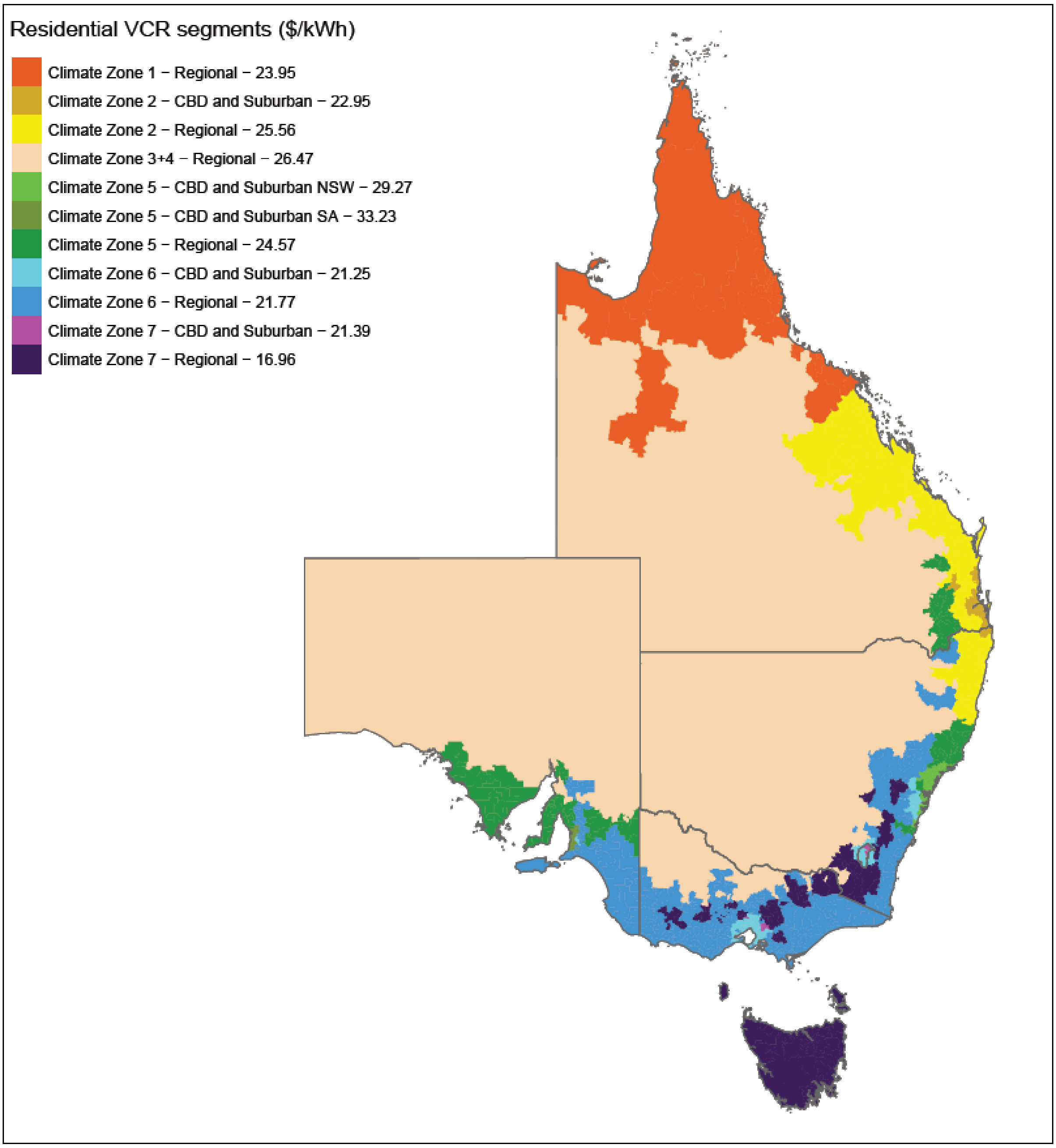


Table 1.2 Residential NEM and State VCR comparison to AEMO 2014 Review (real $2019)

Region	AER 2019 residential VCR ($/kWh) $2019	AEMO 2014 residential VCR ($/kWh) real $2019
Northern Territory	18.31	N/A
National Electricity Market	24.08	27.95
Queensland	23.76	27.38
New South Wales	25.85	28.57
Australian Capital Territory	21.38	N/A - included as part of NSW
Victoria	21.43	26.66
South Australia	30.31	28.95
Tasmania	16.96	30.78

Business customers

Using the contingent valuation and choice modelling survey techniques, we sampled a total of 1,821 business customers between 5 September 2019 and 23 October 2019 across the NEM and NT. Business responses were collected across all 19 ABS ANZSIC sectors. From these we produced VCR values for agriculture, commercial and industrial business sectors. These are broadly the same business sectors as AEMO developed VCR values for in 2014. We explored the development of more granular business sectors than AEMO, however we did not find sufficient statistical differences to warrant additional segmentation.

Our key findings from the business survey were:

- broadly consistent with previous VCR studies: business VCRs are higher than the residential values
- the 2019 VCR values are lower than the 2014 results for agricultural and commercial customers, and higher for industrial customers.

Table 1.3 below sets out our final VCR values for business customers and how they compare to AEMO's 2014 VCR Review.

Table 1.3 Business < 10MVA peak demand per annum, VCR values (real $2019)

Business customer segment	AER 2019 business VCR ($/kWh)	AEMO 2014 business VCR ($/kWh) real $2019
Agriculture	37.87	51.34
Commercial	44.52	48.16
Industrial	63.79	47.45

Business customers with a peak demand of 10 MVA or more (very large business customers)

For very large business customers in the NEM a direct cost survey approach was used as these customers are better able to quantify the costs incurred as a result of an outage. To be eligible for this survey, a business site's peak demand had to have reached 10 MVA at some time in the past twelve months. Around 300 business sites across the NEM met this criteria and are either connected to the transmission network or to a high voltage distribution network.

We received 67 completed surveys from a range of large businesses including metals processing, mines, manufacturing (various industries) and service sector businesses. 40 of the 67 completed surveys included outage cost data from which we could calculate VCR values.

Responses were segmented into services, industrial, metals and mines sectors. In general our VCR values for large customers are higher than those calculated by AEMO in 2014. However our values are not directly comparable to AEMO's due to differences in the sample composition and characteristics of the business sites that responded.[10] Importantly, AEMO only surveyed transmission-connected customers in 2014 while we extended the survey to distribution-connected customers who met the 10 MVA peak demand threshold.

Table 1.4 sets our final VCR values for very large business customers by sector and Table 1.5 sets out the aggregate load weighted VCR values by transmission and distribution groupings.

10 AEMO provided a confidential copy of their direct cost survey results enabling us to compare the sample composition and cost characteristics of survey respondents.

Table 1.4: Very large business customer VCR values, ($/kWh) by sector

Segment	$/kWh VCR values
Services	10.54
Industrial	117.99
Metals	19.86
Mines	35.16

Table 1.5: Very large business customers VCR values ($/kWh) by network connection

Segment	$/kWh VCR values
Transmission	26.44
Distribution	56.69

Given the differences in the VCR values in the different sectors we consider these values are more useful for granular planning applications that directly impact on such large business customers. However, for the purposes of deriving NEM, state or regional VCR values it is preferable to use the indicative transmission and distribution values in the absence of detailed information to load weight the sector VCR values.

1.10 Next steps

We will publish VCR values for widespread and long duration outages in early 2020.

Both the VCR values published in this report and the VCRs for widespread and long duration outages will be updated annually using the CPI-X approach outlined in the VCR methodology.

2 AER role in determining Values of Customer Reliability (VCR)

The Australian Energy Regulator (AER) is the independent regulator for Australia's national energy markets. We are guided in our role by the national electricity, gas, and energy retail objectives set out in the NEL, NGL and NERL. These objectives focus on promoting the efficient investment, operation and use of energy services for the long-term interests of consumers.

2.1 Why is the AER responsible for setting VCR?

In response to a rule change proposal from the COAG Energy Council, the AEMC amended the Rules to give the AER responsibility for determining the values different customers place on having a reliable electricity supply.[11] This is referred to as the VCR. VCR links efficiency and reliability, playing a pivotal role in network planning and investment and informs the design of wholesale market standards and settings and network reliability incentives.

The AEMC considered that assigning a single body responsibility for developing a nationally consistent VCR methodology and for calculating VCR estimates would remove unnecessary duplication and decrease the overall administrative burden associated with the use of VCR by a wide range of stakeholders. The AER was considered the most appropriate body for developing the VCR methodology and VCR estimates on an on-going basis because the responsibility strongly aligns with its statutory functions.[12]

The AEMC's rule change came into effect on 13 July 2018.[13]

2.2 VCR Rule

Part I, Rule 8.12 of the Rules requires that the AER must, in accordance with the Rules consultation procedures:

- develop, publicly consult on, and publish a national methodology for estimating VCRs across the National Electricity Market (NEM) and the Northern Territory;
- include a mechanism for directly engaging with customers and include a mechanism for adjusting VCRs on an annual basis;
- publish the first VCRs calculated in accordance with the VCR methodology on or before 31 December 2019;
- adjust the VCRs using the adjustment mechanism specified in the VCR methodology each year between updates;

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11 AEMC, Establishing VCRs, Rule Determination, 5 July 2018. Available at https://www.aemc.gov.au/rule-changes/establishing-values-of-customer-reliability.

12 AEMC, Establishing VCRs, Rule Determination, 5 July 2018, page 7. Available at https://www.aemc.gov.au/rule-changes/establishing-values-of-customer-reliability.

13 AEMC, National Electricity Amendment (Establishing values of customer reliability) Rule 2018 No. 8, page 2. Available at https://www.aemc.gov.au/rule-changes/establishing-values-of-customer-reliability.

- review the VCR methodology and update the VCRs at least once every five years, and publish updated numbers.

The Rules establish a VCR objective, which requires the AER's VCR methodology and any VCR values calculated in accordance with the VCR methodology to be fit for purpose for any current or potential uses of values of customer reliability that the AER considers to be relevant.

2.3 AER development of the VCR methodology

The VCR methodology was developed following an extensive consultation process that commenced in October 2018. We have engaged widely with governments, energy regulators, customer and industry representatives and the public. This included the establishment of the VCR Consultative Committee (Committee), an advisory body consisting of representatives with a particular interest or expertise in VCRs, who met regularly throughout the course of the review and provide advice on key issues.

Our consultation has included two public forums in December 2018 at the commencement of our review and seven meetings of the Committee throughout the course of the VCR review. We also published two consultation papers, one in October 2018 and another in April 2019, before publishing the *Draft decision* on the VCR methodology in September 2019.

The development of the VCR methodology was also informed by:

- expert advice and quality assurance provided by the University of Melbourne's Melbourne Energy Institute (MEI) and KPMG working in consortium with Insync (KPMG/Insync)
- focus groups and one-on-one interviews conducted by Insync across Australia in March 2019
- findings from a pilot residential and business survey conducted in April and May 2019

More information about our consultation process for the VCR review, including consultation documents and Committee meeting minutes, can be found on the AER's website.[14]

2.4 VCR methodology

We published our *Final decision*[15] for the VCR methodology on 26 November 2019. Our VCR methodology builds on the techniques used in AEMO's 2014 NEM-wide VCR study[16] and consists of the following key components:

- the use of contingent valuation and choice experiment techniques to derive standard outage (up to 12 hours in duration) VCRs for residential and business customers with a peak demand of less than 10 megavolt-amperes (MVA)

14 Available at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability-vcr.

15 Available at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability-vcr/final-decision.

16 Available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Value-of-Customer-Reliability-review.

- the use of a direct cost survey approach to derive standard outage VCRs for business customers with a peak demand of more than 10 MVA (very large business customers)
- the approach to converting residential, business and direct cost survey value of reliability results into dollar per kilowatt hour ($/kWh) values and how they will be combined to produce aggregate VCRs
- the use of a macroeconomic modelling approach supplemented by other techniques to derive VCRs for widespread and long duration outages with a total impact ranging from 1-2 gigawatt hours (GWh) to 15 GWh of unserved energy
- the use of a CPI-X formula for the annual adjustment mechanism. In this formula, X represents the key drivers of annual change in customer reliability preferences but, for this 5 year period, X is set at zero due to a lack of available information.

A copy of the VCR methodology is attached to this report (Attachment 1)

3 Implementation of Methodology - Residential and business customers

This chapter sets out how the residential and business customer surveys using the techniques set out in the VCR methodology were designed and implemented. KPMG/Insync assisted us in the design and implementation of the residential and business surveys.

3.1 Survey methodology

Our VCR methodology outlines the use of combined contingent valuation and choice modelling survey techniques to estimate standard outage (up to 12 hours duration) VCRs for residential and business customers. The two techniques are used together in the following way:

- contingent valuation is used to determine the value of a baseline outage scenario[17] (defined as two localised one hour outages in a year, occurring in winter in off-peak times)
- choice modelling is used to determine the increment (or decrement) in value respondents placed on specific outage attributes in addition to the baseline outage scenario. Attributes tested in the choice model were peak (7-10 am and 5-8 pm) and off-peak time of day, season (winter / summer), day of week (weekday / weekend), severity (localised / widespread) and duration (1 hour, 3 hours, 6 hours, 12 hours).

The contingent valuation and choice modelling results can be combined to derive the dollar value which customers placed on specific outage scenarios.

Combined contingent valuation and choice modelling survey techniques were also used by AEMO in their 2014 NEM-wide VCR study for residential and business customers. We considered it was appropriate to continue the use of these techniques as they best satisfied the VCR assessment criteria[18] compared to other alternative techniques.[19] We improved on these techniques used by AEMO in our VCR methodology by:

- including the use of open-ended contingent valuation questions to better allow respondents to more accurately indicate their willingness to pay (WTP) to avoid the baseline outage
- capping residential WTP responses at the cost of back up generation, estimated to be $22 per month. This limits the influence of unusually high WTP responses on the

17 This baseline scenario was chosen for two reasons. Firstly it maintained consistency with AEMO 2014, which used the same baseline scenario. Secondly it was expected to be a relatively benign scenario for most consumers, based on the AEMO 2014 results. For example, it is of short duration and occurs in off-peak times rather than peak times. Choosing a relatively benign baseline outage simplified the design of the choice modelling, by allowing us to assume only discounts needed to be offered for outages that differed from the baseline scenario.

18 See page 11 of the *Final decision* for more information. Available on the AER website at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability-vcr.

19 See chapter 6 of the *Draft Decision* and chapter 3 of the *Final decision* for more information. Available on AER website at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability-vcr.

average WTP, particularly as improved reliability is available to these customers at a lower price[20]

- modifying the definition of the frequency and time of day attributes in the choice model.

3.2 Survey design

This section provides an overview of the design of the residential and business surveys. A copy of the surveys can be found in Appendix D of the KPMG report on the main survey.[21]

3.2.1 Background and screening questions

A number of screening questions were employed at the start of the surveys to ensure only eligible residential and business customers were identified and allowed to continue onto the choice modelling and contingent valuation questions.

For the residential survey, the main screening question asked was for participants to identify the postcode of their residential premises. This was important for the purposes of segmentation (discussed later) and to screen out participants not residing in the NEM or the Northern Territory. Residential survey participants were also asked to identify which of the following statements best described the local area they lived in:[22]

- most people live in units, townhouses or high level apartments
- most people live in standalone houses in a capital city suburb
- most people live in a suburb in a regional town
- most people live on acreage or a farm.

For the business survey, it was important that respondents identified what type of business they were involved in, that the business site location was in the NEM or NT, and whether they were qualified to answer questions about the business's use of electricity. This was done through a series of screening questions. Respondents who did not have a business site in the NEM or NT, or were not involved in decisions regarding the business's use of electricity were screened out.

Additionally business survey respondents were also asked background questions to:

- identify the business site they would be answering the survey in relation to and what type of area it was located in[23]
- indicate what frequency their business was billed and provide an estimate of their last electricity bill

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20 See page 29-30 of the *Draft decision* for more information. Available on the AER website at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability-vcr.

21 Available on the AER website at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability-vcr,

22 This was to determine what qualitative description the respondent was provided for localised and widespread in the choice model question later on in the survey.

23 This was to determine what qualitative description the respondent was provided for localised and widespread in the choice model question later on in the survey.

- indicate how many unplanned outages their business site experienced in the last twelve months and how disruptive they have been
- identify the type of losses they would incur during a power outage and indicate if there is a worse time of day and period over the course of the year to experience an outage.

3.2.2 Contingent valuation technique

The contingent valuation survey technique was used in combination with the choice modelling survey technique. Our contingent valuation question was used to determine the willingness to pay (WTP) of a baseline outage scenario (defined as two localised one hour outages in a year, occurring in winter in off-peak weekday times[24]).

For both residential and business customers our contingent valuation question asked two cost prompt WTP questions followed by an open-ended WTP question. The response to our follow-up open-ended WTP question was the value we used as the respondent's WTP. The use of an open-ended question removes the necessity to make assumptions about a respondent's WTP as AEMO did.[25]

An example of our contingent valuation WTP question is set out in the box and diagram below.

Residential contingent valuation question

Imagine you experience two unexpected power outages a year. It turns out that each unexpected outage occurs on a different random weekday in winter (Jun, Jul, Aug) and lasts for one hour in off-peak times (outside 7-10am, 5-8pm). Each one only affects your local area.

Would you be willing to pay an increase of $8 in your monthly electricity bills (over 6 months

24 This baseline scenario was chosen for two reasons. Firstly it maintained consistency with AEMO 2014, which used the same baseline scenario. Secondly it was expected to be a relatively benign scenario for most consumers, based on the AEMO 2014 results. For example, it is of short duration and occurs in off-peak times rather than peak times. Choosing a relatively benign baseline outage simplified the design of the choice modelling, by allowing us to assume only discounts needed to be offered for outages that differed from the baseline scenario.

25 Under AEMO's 2014 approach the following assumptions regarding a residential respondent's WTP were made by AEMO:

- No/No implied a zero WTP
- No/Yes implied WTP = half of the first cost prompt
- Yes/No implied WTP = the first cost prompt
- Yes/Yes implied WTP= twice the value of the first cost prompt

For business customers AEMO made the following assumptions :

- No/No was followed by an open-ended WTP question – implied WTP was the response to the open-ended question
- No/Yes implied WTP = half of the first cost prompt
- Yes/No implied WTP = first cost prompt
- Yes/Yes was followed by and open-ended WTP question – implied WTP was the response to the open-ended question

this is a total of $48) to avoid both the power outages described in the above scenario

Yes

No

If YES to first prompt - Continue to imagine the same scenario - there are two unexpected power outages a year. Each unexpected outage occurs on a different random weekday in winter (Jun, Jul, Aug) and lasts for one hour in off-peak times (outside 7-10am, 5-8pm). Each one only affects your local area.

Would you be willing to pay an increase of $16 in your monthly electricity bills (over 6 months this is a total of $96) to avoid both the power outages described in the above scenario.

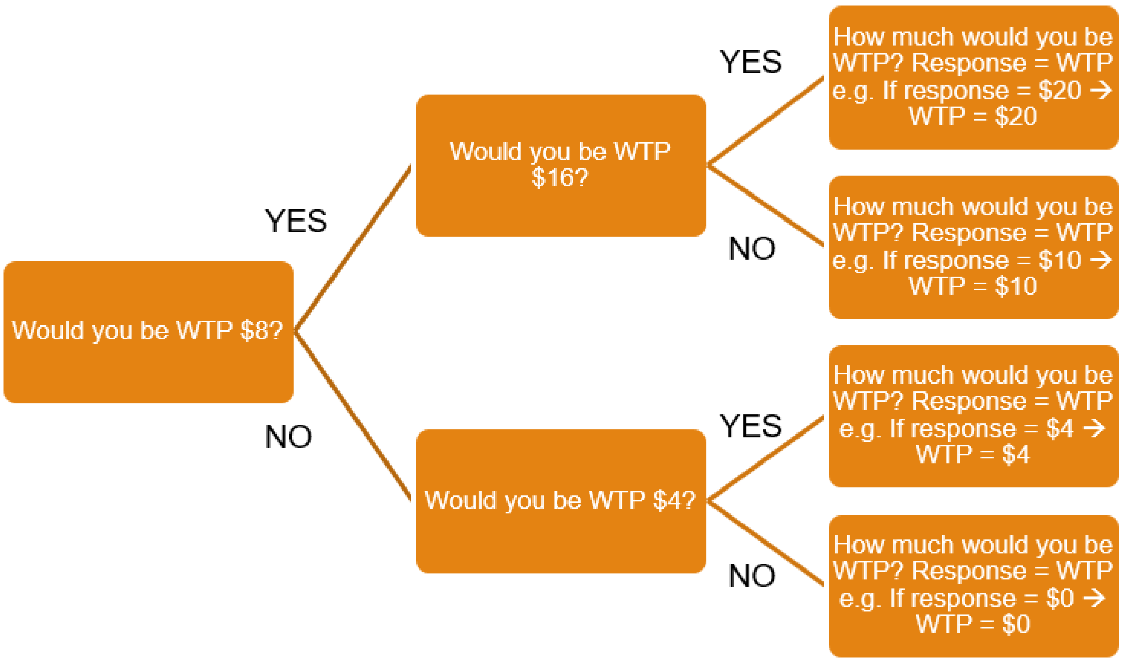
If NO to first prompt - Continue to imagine the same scenario - there are two unexpected power outages a year. Each unexpected outage occurs on a different random weekday in winter (Jun, Jul, Aug) and lasts for one hour in off-peak times (outside 7-10am, 5-8pm). Each one only affects your local area.

Would you be willing to pay an increase of $4 in your monthly electricity bills (over 6 months this is a total of $24) to avoid both the power outages described in the above scenario.

Asked to all respondents

What is the maximum increase in $ you would be willing to pay in your monthly electricity bill to avoid both the power outages described in the above scenario?

Diagram 1: Tree diagram of residential contingent valuation question



Contingent valuation question - residential customers

For residential customers the cost prompts were expressed in dollars. The first cost prompt ranged from $2 to $9 in one dollar increments and was randomly assigned. The second cost prompt used was either double or half the first cost prompt depending on whether the respondent answered YES or NO to the first cost prompt. Following the cost prompt questions all respondents were asked and open-ended WTP question of the form,

What is the maximum increase in $ you would be willing to pay in your monthly electricity bill to avoid both the power outages described in the above scenario?

Those residential respondents who answered with a WTP of more than $22 to our follow up open-ended question were asked an additional question towards the end of our survey as to whether they would be WTP for ‘back-up’ if it is available at a lower price.

"*Imagine a company could install a backup power system at your premises. The system would readily provide electricity at your premises for one hour if an outage occurs. The total cost of the system, including installation, would be $22 per month. Would you get the company to install the backup system at your premises at a cost of $22 per month?*"

If the response to the back-up question was YES we assumed the WTP is $22. However, if the response is NO, a follow up open-ended question asking how much they would be WTP for the backup system was presented. The response to the follow up open ended question was treated as the WTP value for that respondent.[26]

Contingent valuation question - business customers

For business customers the cost prompts were expressed in dollars. However, the dollar value was based on a percentage of the respondent's bill. We used percentages ranging from one per cent to ten per cent, in one per cent increments, to determine the dollar value of the initial cost prompt. The initial cost prompts were randomly distributed and the second cost prompt was either doubled or halved depending on the respondents answer to the first cost prompt. Following the cost prompt questions all respondents were asked an open-ended WTP question of the form,

What is the maximum increase in $ you would be willing to pay in your electricity bill to avoid both the power outages described in the above scenario?

The response in $ was then converted to the equivalent per cent of the respondent's electricity bill.

For business customers we applied the same cap as AEMO applied in its 2014 study. This cap is set at the amount equal to the last bill indicated by the business survey respondent.[27]

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26 If the respondent answered more than $22 then their response would be capped at $22.

27 We considered whether we could similarly apply a cap based on back-up generation for business customers. However, due to the heterogeneity of businesses we found it difficult to identify appropriate back-up generation on which to base the cap. This is because within an industry the business could vary significantly in size. Calculating a cap by industry type would require us to make a large number of assumptions about average energy use and average peak demand for each industry. This is particularly problematic for industries where businesses vary significantly in size, such as mining and manufacturing.

We also considered a cap based on the energy use of the business itself may be more appropriate. This approach would better allow us to determine the appropriate back-up generator size for each business and hence an appropriate cap. However, our survey asks only about how much the last energy bill was. The survey does not ask about energy use. For a

3.2.3 Choice modelling

3.2.3.1 Overview

Choice modelling, also known as choice experiments, seeks to measure the preferences of a group of respondents by asking them to choose between different scenarios and, by doing so, to make trade-offs between different attributes. The results of this can be used to estimate the monetary value or cost placed by the group on each attribute. This technique was used in our VCR review to estimate the incremental value residential and business customer segments placed on particular outage attributes changing[28] from the baseline scenario presented in the contingent valuation question.

The choice model we used is largely based on the one AEMO used in 2014 with some amendments. This included changes in the language and presentation based on focus group feedback and expert advice from KPMG/Insync and MEI to help increase respondent comprehension and engagement.

In the residential and business surveys, respondents were asked a series of eight questions. Each question presented respondents with a 'choice set' of three hypothetical outage scenarios each with a compensation amount they would receive for experiencing the outage. Outage scenarios were defined using seven attributes with the attribute 'levels' varying between the scenarios. Respondents were asked to select their preferred outage scenario. For each choice set, one of the three outage scenarios was the baseline outage scenario used in the contingent valuation question, with no change to the bill.

The outage attributes and levels included in the choice model were:

- change in your bill - for residential the levels were: no change, $3 per month, $7 per month and $15 per month. For business the levels were: no change, one per cent of bill, two per cent of bill and three per cent of bill. For residential, the 'change in your bill' attributes and levels were presented to match the billing frequency indicated by respondents.[29] For business, the 'change in your bill' attribute was also presented to match the frequency in which respondents indicated they were billed. Additionally, the levels were presented to show both the percentages and corresponding estimated dollar per bill values based on the bill information provided by the respondent[30]
- severity - localised or widespread. The levels were defined qualitatively with the definition defined in relation to the area in which the business site or residential premises was located
- duration - 1 hour, 3 hours, 6 hours, 12 hours

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cap based on energy use we would need to incorporate a question about energy use and peak demand in our survey for the business. We considered this additional complexity for respondents could decrease our response rate.

28 For example, the outage duration could be extended from 1 to 3 hours.

29 For example, if a residential respondent indicated they were billed quarterly then the attribute would have been shown as 'change in your quarterly (every three months) electricity bills' and they would have seen changes in bill of no change, $9 lower per bill, $21 lower per bill and $45 lower per bill in the choice set outage scenarios.

30 For example, if a business respondent indicated they had a quarterly bill of $300 then the attribute would have been shown as 'change in your quarterly (every three months) electricity bills' and they would have seen changes in bill of no change, 1% lower ($3 lower per bill), 2% lower ($6 lower per bill) and 3% ($9 lower per bill) in the choice set outage scenarios.

- season - summer (December, January and February) or winter (June, July, August)
- day of week - weekday or weekend
- time of day - peak (occurring between 7-10 am and 5-8 pm) and off peak (occurring outside 7-10 am and 5-8 pm).

The changes made to the attributes and levels from the AEMO 2014 review were:

- outage frequency - the frequency of outages was included in the scenarios presented and held constant at two outages per year. AEMO in 2014 varied the frequency attribute (with levels of two times per year and three times per year) in the survey scenarios they presented. They were unable to include the results in calculating the $/kWh VCR values due to a lack of supporting outage data. We face the same issue and so reduced the complexity of the scenarios presented by holding the outage frequency constant
- the definition of peak and off peak in the time of day attribute were also updated to reflect changes in energy consumption since the 2014 AEMO review.

3.2.3.2 Choice set design

To maximise the information that can be obtained about reliability preferences in a choice model it is important to optimise the design of the choice sets used.

For the pilot survey, the design of the choice sets was undertaken by KPMG with review by MEI and the AER.[31]

For the main survey, we undertook the design of the choice sets for the main survey with expert advice from MEI. Following analysis of the pilot survey results, MEI advised that the choice set design could be recalibrated using the pilot survey results to help improve the choice experiment estimates in the main survey by 20 to 30 percent. MEI recommended the use of NGENE[32], a software tool used and developed by leading experts in the field to optimise choice set design.

We accepted this advice and undertook a redesign of the choice sets using NGENE. Details about the key inputs, settings and parameters used in this process are set out in Attachment 2. The choice sets produced by NGENE were then reviewed to remove and replace any dominated options.[33] MEI provided expert advice and oversaw this process.

3.2.3.3 Presentation of choice sets

Figure 1 below shows how the choice model was presented to respondents in the main survey.

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31 KPMG & Insync, Value of Customer Reliability Pilot Survey Report, 5 September 2019, page 17. Available at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability-vcr/draft-decision.

32 Available for trial and purchase at http://www.choice-metrics.com/index.html.

33 This refers to choice sets created where one of the three outage scenarios presented is the clear best option for a respondent to pick.

Figure 1 - choice model survey question

51%

Australian Government | AUSTRALIAN ENERGY REGULATOR

Please indicate which of the three options you would prefer:

You can point your cursor on the bold text description below for further descriptions before you answer

Question 1 out of 8

	Option 1	Option 2	Option 3
Change in your bi-monthly (every two months) electricity bills	$30 less per bill	No change	$14 less per bill
Localised/widespread	Localised	Localised	Widespread
Duration	1 hour	1 hour	6 hours
Frequency	*Twice a year*	*Twice a year*	*Twice a year*
Summer/winter	*Winter*	*Winter*	*Winter*
Weekday/weekend	Weekends	Weekdays	Weekdays
Time of day	Peak	Off-peak	Off-peak

The presentation of the choice model in our main survey differed in two ways from the choice model in our pilot survey and the choice model used by AEMO in their 2014 review:

- the 'change in your bill' was moved from the bottom of the attribute list to the top to ensure respondents saw the compensation amounts first
- the location of baseline outage scenario was randomised. In the pilot and the AEMO 2014 review this option was always located on the left. This was done to increase respondent engagement with the choices and trade-offs.

3.2.4 Consumer demographics and behaviour questions

Following the choice model section of the survey, residential respondents were asked a range of demographic questions. This included questions on the respondent's gender, age and financial situation, and questions about the respondent's dwelling, including household size and characteristics (for example, whether the household has a pool). The residential survey also asked two questions relating to behaviour that would influence electricity consumption. Such behaviours included the ownership of electric vehicles and rooftop solar panels. Similarly, the business survey included questions relating to actual outages experienced by the business, and whether they had electricity monitoring devices and/or back-up options.

3.3 Implementation

3.3.1 Pilot survey

In May 2019, a pilot survey was conducted to test the survey design before the release of the main survey. In total, 1022 residential and 321 business responses were received. The pilot survey methodology was based on AEMO's 2014 survey, but included revised language and definitions, and tested a number of variants of the contingent valuation question.[34] The main objectives of the pilot survey were to:

- verify the ability of the combined contingent valuation and choice experiment techniques to deliver useful results
- test the improvements made to the wording and design of AEMO's survey based on feedback from focus groups
- establish and quantify differences changing the contingent valuation question made to the contingent valuation results
- re-test the AEMO survey and compare results against changes made to the AER pilot survey
- test technical solution and reporting requirements.

The key findings of the pilot survey were:

- regressions of the pooled residential and business choice model responses gave results largely qualitatively consistent with the AEMO 2014 survey results
- a high number of choice model responses selected the baseline option
- online panels were able to collect a large number of responses in a short timeframe
- the contingent valuation results that used open-ended responses produced significantly different results to the responses to the closed prompt questions asked by AEMO (both the 2014 results and re-run AEMO survey sample for the pilot)
- some respondents provided unusually high responses to the open-ended contingent valuation question which had a significant effect on the average WTP value.

Based on these findings and feedback from stakeholders, the key changes made for the main survey were:

- introducing an open-ended WTP question following the two cost prompt WTP questions for the contingent valuation component of the survey
- introducing a cap of $22 to residential responses to the open-ended WTP question based on the estimate of the cost of a back-up generator.
- lowering the levels of the cost prompts for residential customers

34 Specifically: an open-ended question, two cost prompts followed by an open-ended question, and two cost prompts only (as used by AEMO in its 2014 survey).

- changing the location of the bill discount in the choice model sets so it appeared first and was more prominent, and randomising the position of the baseline option in each choice model set.

More information about the pilot survey can be found in the *Consultation update paper* and *Draft decision,* including the attached KPMG report on the pilot survey, which we published earlier as part of this VCR Review.[35]

3.3.2 Main survey

The main survey was open from 5 September to 23 October 2019. During this time 7426 residential and 1821 business survey responses were collected. The majority of these respondents (8704) were recruited by online panels run by Dynata and coordinated by KPMG/Insync. 'Open link' surveys and recruitment using 'Computer assisted telephone interviewing (CATI) to online'[36] were also used.

The 'open link' surveys were versions of the residential and business survey which could be accessed via a survey link. We used the 'open link' surveys to target difficult to survey segments, such as the agricultural sector and the Northern Territory, and promote the survey more broadly. Noting the difficulties AEMO had in recruiting survey respondents from the agricultural sector, we contacted a range of agricultural organisations around the country to distribute the surveys via their communication networks. For the Northern Territory, we sought assistance from Jacana Energy, NT Government agencies and consumer representatives to distribute the surveys. The 'open link' surveys were also distributed via a range of channels, including through AER and ACCC stakeholders, and published on the AER website.

CATI to online recruitment was undertaken near the close of the survey to recruit agricultural sector responses. A cash prize draw[37] was used to incentivise customers to participate in the survey. This was carried out by Newgate Research and Thinkfield.

Further details about the main survey recruitment, including a full list of stakeholders provided the 'open link' survey, are provided in KPMG's main survey report.[38]

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35 Available on the AER website at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability-vcr.

36 CATI to online involves calling consumers and asking if they would like to participate in the study, then emailing them a link to the survey.

37 Respondents were agreed to answer the survey were also asked to answer an additional question. $100 cash was given to the five most creative answers.

38 See in particular Appendixes A and E. Available on the AER website at: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability-vcr/final-decision.

4 Implementation of methodology - very large business customers

This chapter provides a high level overview of the direct cost survey design for large customers and the main differences to AEMO's 2014 direct cost survey and a summary of the implementation of the survey.

4.1 Survey methodology and design

We adopted a direct cost survey to collect information from the largest grid connected customers in the NEM – those reaching peak demand levels of at least 10 MVA. The direct cost survey asks customers in particular, about the costs they incur for outages of different lengths (10 minutes, 1 hour, 3 hours, 6 hours, 12 hours, 24 hours and 48 hours) and occurring at different times. We chose these durations as they are broadly consistent with the range used by AEMO in 2014 for its direct cost survey. Our direct cost survey also sought additional information to help us contextualise these costs, including:

- about the types of costs experienced by the business as a result of an outage
- measures they may have taken to reduce the impact of outages, and whether they have installed backup supply
- how many times the business site experienced an outage in the past year
- whether the business received information about the outage and whether it helped reduce the costs of the outage.

We adopted this survey type for large scale businesses because they are likely to have detailed knowledge of the value of energy to their business and any costs they would incur as a result of an outage. We considered large businesses to be better able to answer questions of this nature compared to smaller businesses (for which we used contingent valuation and choice modelling survey techniques).

In its 2014 review, AEMO similarly adopted a direct cost survey for transmission-connected customers. For our review we decided to extend the direct cost survey approach to very large distribution-connected customers of a similar size, who meet or exceed a threshold requirement of 10 MVA peak demand. We consider very large distribution-connected customers who meet this threshold are likely to have similar characteristics and reliability needs to transmission-connected customers, making them well-suited to answering a direct cost survey. The benefit of extending the direct cost survey to these large distribution customers is that it allowed us to increase the size of the pool of eligible businesses[39] for the survey compared to AEMO's survey.

Corresponding to our approach to build on and improve AEMO's approach, our survey includes some revisions to AEMO’s 2014 direct cost survey. They are as follows:

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39 By increasing the scope of the survey to distribution connected sites this expanded the number of eligible sites from around 30 to 300.

- we included additional questions to capture differences in costs experienced for outages during peak and off-peak times. This was because we extended our survey to include large distribution-connected customers as well as transmission-connected customers and could not assume all business sites operate 24 hours a day, 7 days a week. Unlike transmission-connected customers some distribution-connected businesses may not operate all the time. As such we want to capture any differences in costs experienced for outages during peak and off-peak times, and included additional questions to capture any differences.
- whereas AEMO asked respondents to indicate incremental cost differences for outages of increasing durations, our survey asks respondents for the total cost experienced for outages of different durations. This was a minor change that simplified the calculations for converting these costs into $/kWh VCR values.
- AEMO asked respondents about whether they currently have or intend to install back up power options in the near future. Our survey additionally sought information on how any back-up is used (such as to continue operations or enable businesses to power down after an outage).

4.2 Implementation

Each survey response was intended to be completed for a single site. Owners with more than one eligible site were asked to complete one survey for each. To encourage eligible respondents to complete the surveys and give them the best chance of doing so, we sought assistance from our VCR Consultative Committee members and other stakeholders to distribute surveys to customers and members with eligible sites. The survey was hosted online, and survey links were distributed primarily by retailers[40], network businesses[41] and end user groups, the Energy Users Association of Australia and the Major Energy Users, who have established relationships with eligible respondents. Reminders to complete the survey were also sent towards the end of the survey period. A copy of the survey link was also provided to members of the ACCC/AER Infrastructure Consultative Committee.

In developing our survey we took account of feedback to AEMO that their direct cost survey constituted a significant resource commitment and required input from multiple staff.[42] We decided to host our survey online to limit handling of survey information. Using the online links provided to them, respondents generated one survey questionnaire for each eligible site. They accessed the survey using personally generated login details, and could complete it over multiple sessions or send it to colleagues or service providers to complete as well if necessary. The survey questions themselves were emailed to recipients to enable them to plan and draft responses before completing the survey online. In this way, we intended to facilitate easy, convenient and flexible access to the survey. We received several requests to extend the survey in order to provide respondents with extra time to complete it, which we agreed to. The survey was launched on 23 August 2019 and was open for 44 days.

40 Organised through the Australian Energy Council.

41 Organised through Energy Networks Australia

42 AEMO: *Value of customer reliability review*, September 2014, p.16.

5 VCR survey results - residential and business customers

This chapter sets out the residential and business $/kWh VCR values alongside the detailed residential and business contingent valuation and choice modelling survey results. It also explains the process of how the survey results were converted to $/kWh VCR values.

5.1 Residential survey results

Residential responses were collected across the NEM and Northern Territory. For the NEM, residential customers were segmented into different combinations of climate zone and remoteness groupings. For the Northern Territory, a single residential segment was used. Table 5.1 below sets out the VCR values for each of these residential segments. Table 5.2 sets out the NEM and state residential VCRs that we have derived using our residential VCRs, and indicates how they compare to AEMO's 2014 review results.

Table 5.1 - Residential VCR values

Residential customer segment	Applicable State and Territory	Aggregate residential VCR ($/kWh)
Northern Territory	Northern Territory	18.31
Climate Zone 1 Regional	Queensland	23.95
Climate Zone 2 CBD & Suburban	Queensland, New South Wales	22.95
Climate Zone 2 Regional	Queensland, New South Wales	25.56
Climate Zone 3&4 Regional	Queensland, New South Wales, Victoria, South Australia	26.47
Climate Zone 5 CBD & Suburban NSW	New South Wales	29.27
Climate Zone 5 CBD & Suburban SA	South Australia	33.23
Climate Zone 5 Regional	New South Wales, South Australia, Queensland	24.57
Climate Zone 6 CBD & Suburban	Victoria, New South Wales, South Australia, Australian Capital Territory	21.25
Climate Zone 6 Regional	Victoria, New South Wales, South Australia	21.77
Climate Zone 7 CBD & Suburban	Australian Capital Territory, Victoria	21.39
Climate Zone 7 Regional	Tasmania, Victoria, New South Wales	16.96

Table 5.2 Residential NEM and state VCR comparison to AEMO 2014 review (real $2019)

Region	AER 2019 residential VCR ($/kWh)	AEMO 2014 residential VCR ($/kWh) real $2019
Northern Territory	18.31	N/A
National Electricity Market	24.08	27.95
Queensland	23.76	27.38
New South Wales	25.85	28.57
Australian Capital Territory	21.38	N/A - included as part of NSW
Victoria	21.43	26.66
South Australia	30.31	28.95
Tasmania	16.96	30.78

5.1.1 Findings and observations

- Our review has found that while there are some differences between 2014 and 2019 in residential VCR values for residential, in general they are similar between the two years.
- The majority of the VCR values calculated for the residential segments are lower than the range of VCRs calculated by AEMO in 2014 with the exception of customers in suburban Adelaide. However there is a greater variation in residential VCR values between segments compared to 2014. For example, there is more than $10/kWh difference between the highest and lowest residential state VCRs in our results. This compares to a difference of less than $5/kWh between the highest and lowest state residential VCRs from the AEMO 2014 review.
- Among residential cohorts climate Zone 5 CBD & Suburban SA had the highest VCR, while Climate Zone 7 Regional, that includes areas in New South Wales, Victoria and Tasmania, had the lowest VCR.
- Climate zone 5 suburban was separated into NSW and SA segments. Choice modelling analysis showed that within the same segment, SA customers had a preference to avoid outages in summer while NSW customers had a weak preference to avoid outages in winter.
- Duration was the outage attribute that generally contributed the most to residential VCR values. The choice modelling results showed that residential customers placed the highest values on the duration attribute levels (3 hours, 6 hours, 12 hours). Thus, in most instances, when combining the contingent valuation and choice modelling results to derive dollar values for specific outage scenarios, the value added by the duration attribute was greater than other attributes and the baseline outage scenario.

- The WTP to avoid the baseline outage scenario was generally lower in Regional areas than in CBD and suburban areas within the same climate zone, but this did not mean VCR values were necessarily lower in Regional areas once other VCR calculation inputs, such as choice modelling results, unserved energy and outage probabilities were taken into account.

5.1.2 Sample characteristics

A total of 7,426 residential customers in the NEM and the Northern Territory (NT) were sampled in the main survey.

1,022 residential customers were also surveyed in the pilot survey. We have not used these responses in calculating residential VCRs due to the changes made to the main survey (in part informed by the results from the pilot).

During consultation stakeholders expressed a preference for more granular customer segments to be considered. We considered ways to group customers to identify distinct and important differences in VCR. We thought that climate zone, via its effect on heating and cooling, and remoteness were likely key drivers of residential customer reliability preferences and would provide a useful way to segment residential customers given how VCR is applied. Accordingly, the residential customers in the NEM were divided into different climate zone and remoteness combinations and sampled along those lines.

To build the different climate zone and remoteness combinations:

- climate zone mapping was sourced from the Australian Building Codes Board[43]
- remoteness classifications and mapping was done using a combination of Accessibility/Remoteness Index of Australia (ARIA)[44] and CBD postcode definitions which were refined with input from network businesses during the survey
- overlaying the climate zone and remoteness mappings, with manual adjustments where necessary, to ensure that every NEM postcode was assigned a unique climate zone and remoteness classification.

Further detail about this process is set out in Attachment 3. The VCR Final report appendix sets out the postcode mapping for climate zone and remoteness that we used.

A different sample plan was used for the Northern Territory. NT residential customers were divided into NT north, consisting of the Darwin-Katherine regulated electricity network and NT south, consisting of the Tennant Creek and Alice Springs regulated electricity networks. This was to accommodate the preference of Power and Water Corporation, and the Utilities Commission for any VCRs applicable to the NT to be developed using customers sampled only in the NT.

Table 5.3 below sets out the residential customer sample plan and the responses achieved in each sample plan grouping. The sample plan initially included a CBD cohort for each capital city but this was reduced to CBD cohorts for Brisbane, Sydney and Melbourne only.[45]

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43 https://www.abcb.gov.au/Resources/Tools-Calculators/Climate-Zone-Map-Australia-Wide.

44 See Attachment 3 for more information.

45 The following CBD definitions were used. For Sydney, CBD was defined as only postcode 2000. For Melbourne, CBD was

A CBD cohort was not included for the other capital cities as it was not possible to identify postcodes where the majority of residential customers were supplied through CBD feeders. Responses for these capital cities were captured within their ARIA remoteness classification and climate zone.

Table 5.3 - Main survey residential sample plan and responses

Climate Zone[46]	Remoteness	Responses
1 - Hot humid summer, warm winter	Outer regional Australia	195
1 - Hot humid summer, warm winter	Remote Australia	0
2 - Warm humid summer, mild winter	Brisbane CBD	22
2 - Warm humid summer, mild winter	Suburban Australia	1017
2 - Warm humid summer, mild winter	Inner regional Australia	382
2 - Warm humid summer, mild winter	Outer regional Australia	25
2 - Warm humid summer, mild winter	Remote Australia	3
3 - Hot dry summer, warm winter	Inner regional Australia	7
3 - Hot dry summer, warm winter	Outer regional Australia	23
3 - Hot dry summer, warm winter	Remote Australia	8
4 - Hot dry summer, cool winter	Inner regional Australia	188
4 - Hot dry summer, cool winter	Outer regional Australia	114
4 - Hot dry summer, cool winter	Remote Australia	12
5 - Warm temperate	Sydney CBD	44
5 - Warm temperate	Suburban Australia	1566
5 - Warm temperate	Inner regional Australia	215
5 - Warm temperate	Outer regional Australia	24
5 - Warm temperate	Remote Australia	6
6 - Mild temperate	Melbourne CBD	55

defined as the following postcodes: 3000, 3002, 3003, 3004 and 3006. For Brisbane, CBD was defined as postcode 4000 only.

46 While climate zone 1and 3 are in both the NEM and NT, the responses counts for climate zone 1 and climate zone 3 only include responses from NEM regions. All NT responses are included in the NT responses counts.

6 - Mild temperate	Suburban Australia	2076
6 - Mild temperate	Inner regional Australia	451
6 - Mild temperate	Outer regional Australia	57
6 - Mild temperate	Remote Australia	5
7 - Cool temperate	Suburban Australia	211
7 - Cool temperate	Inner regional Australia	389
7 - Cool temperate	Outer regional Australia	68
7 - Cool temperate	Remote Australia	6
Northern Territory North		212
Northern Territory South		45

5.1.3 Residential customer segmentation

5.1.3.1 Approach to segmentation

The use of the choice modelling survey technique provides for flexibility in grouping responses, as it is not restricted to any pre-determined segments or cohorts. This allows for customers with similar reliability preferences to be identified and grouped together as a segment. The main constraint of choice modelling is that it requires a minimum sample size of responses before statistically significant relationships can be reliably identified.

To determine the appropriate level of segmentation, we considered:

- whether there was sufficient sample size. Where particular climate zone and remoteness groupings did not achieve a minimum sample size we determined responses would have to be aggregated with other climate zone and remoteness groupings
- whether combinations would make sense within the energy context and the applications of VCR
- whether there were statistically significant differences in the choice modelling results between different climate zone and remoteness groupings. Where there are no significant differences between groupings they can be merged together unless there are strong reasons to keep them separate (for example, it would be easier for the purposes of application)
- the preference from Power and Water Corporation and the Utilities Commission for VCRs applicable to the NT to be developed using only NT responses.

5.1.3.2 Segmentation analysis

NEM residential segments

Our analysis of the residential responses found that climate zone was a strong driver of differences in reliability preferences. This supported our view that different home heating and cooling requirements between climate zones could be a driver of preferences. When residential responses were grouped by climate zone, choice modelling analysis found that:

- preferences for duration and peak attributes were all statistically significant at the 95 per cent or 99 per cent level in line with expectations. Respondents expressed a preference for localised over widespread outages, shorter duration outages over longer duration outages and off-peak timings of outages over peak timings.
- the season attribute results were in line with expectations based on climate. Warmer climate zones had a statistically significant preference to avoid outages in summer and this preference generally weakens as climate zones become cooler. Climate zone 7 which has the coldest climate, showed a preference to avoid winter outages over summer outages.

For this reason, residential responses were segmented by climate zones. The only exceptions were climate zones 3 and 4 that were combined because of the low number of responses received for climate zone 3 in the NEM.[47] We combined them with climate zone 4 responses due to the climatic similarities between climate zone 3 and 4, where residential households would have the most similar heating and cooling requirements.

By comparison, remoteness was a weaker driver of differences in reliability preferences. When analysis was undertaken to examine potential differences in remoteness within the residential climate zone groups:

- CBD and suburban residential choice model results were not significantly different. Combined with the small CBD samples collected for each climate zone, we decided to merge CBD and suburban cohorts within each residential climate zone groups.
- Inner and outer regional residential responses had few significant differences in all but one of the climate zone groups. Analysis found that climate zone 7 inner responses had statistically significant differences in preferences across all 3 duration attribute levels compared to climate zone 7 outer responses. The sample size for climate zone 7 outer regional is small and it is unclear whether this trend would continue with a larger sample size. Further, separate VCRs for inner and outer regional cohorts would likely be difficult to apply in practice. Thus, we decided to merge inner and outer regional responses together within each climate zone.

  The small number of remote residential responses in each of the climate zone groups were also combined with inner and outer regional responses.

We also analysed whether we could further subdivide the residential segments. For example, we considered state differences within the climate zone 5 suburban and CBD group. We found the South Australian subset had a 99 per cent statistically significant preference to avoid summer outages, while the NSW subset had a weak preference to avoid

[47] Climate zone 3 also includes the southern NT.

winter outages. The South Australian subset of this group is also physically separate to the NSW subset. For these reasons we chose to divide climate zone 5 suburban and CBD into separate cohorts for South Australia and NSW.

Other subdivisions we considered but ultimately did not pursue due to minor statistically significant differences in choice modelling results were:

- splitting the large sample we had for climate zone 6 CBD and suburban into:
    - a NSW CBD and suburban segment, and
    - a Victoria and South Australia CBD and suburban segment
- splitting climate zone 5 regional by state similar to what was done for climate zone 5 CBD and suburban
- splitting the large suburban samples in climate zones 2, 5 and 6 into metro and non-metro groups based on Australia Post classifications.

Northern Territory

For the NT we received 212 responses in the NT North and 45 in the NT South. The choice modelling results of these two cohorts were not significantly different. Given this and the small sample size for NT South we decided to combine the two cohorts into one segment.

5.1.4 Detailed results and assumptions

The residential survey uses a combination of contingent valuation and choice modelling survey techniques to estimate standard outage (up to 12 hours duration) VCRs for residential and business customers. The two techniques are used together in the following way:

- contingent valuation is used to determine the value of a baseline outage scenario[48] (defined as two localised one hour outages in a year, occurring in winter in off-peak times)
- choice modelling is used to determine the increment (or decrement) in value respondents' placed on specific outage attributes in addition to the baseline outage scenario. Attributes tested in the choice model were peak (7-10 am and 5-8 pm) and off-peak time of day, season (winter / summer), day of week (weekday / weekend), severity (localised / widespread) and duration (1 hour, 3 hours, 6 hours, 12 hours).

The contingent valuation and choice modelling results can be combined to derive the dollar value which customers placed on specific outage scenarios.

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48 This baseline scenario was chosen for two reasons. Firstly it maintained consistency with AEMO 2014, which used the same baseline scenario. Secondly it was expected to be a relatively benign scenario for most consumers, based on the AEMO 2014 results. For example, it is of short duration and occurs in off-peak times rather than peak times. Choosing a relatively benign baseline outage simplified the design of the choice modelling, by allowing us to assume only discounts needed to be offered for outages that differed from the baseline scenario.

5.1.4.1 Contingent valuation (WTP)

As described in section 3.2.2 the response to the follow-up open-ended WTP question was used to calculate respondents' WTP.

If a residential respondent answered higher than $22 to our open-ended question we did not use that value. Instead we used the response to the back-up generation question as the respondent's WTP.

- For those who answered YES to the $22 WTP back-up generation question we used $22 as the respondent's WTP.
- For those who answered NO to the $22 WTP back-up generation question we asked a further question regarding how much they would be WTP for back-up generation.
    - If the response to the follow-up open-ended back-up generation question was $22 or less we used the value of that response.
    - If the response to the follow-up open-ended back-up generation question was more than $22 we capped the respondent's WTP at $22.

In total 41 percent of respondents had a WTP of zero. Less than one per cent (0.6 per cent) of responses were capped at $22.

The WTP for a residential segment was calculated using a straight line average of survey responses, consistent with the approach used by AEMO in 2014.

The average WTP across the NEM and NT is $3.51 and ranges from $2.79 to $4.20 across the twelve residential customer segments, as set out in Table 5.4 below. This differs from AEMO's 2014 WTP which ranged from $1.34 to $2.50 across states.[49] We note that higher WTP results do not necessarily result in higher overall VCR values. This is because final $/kWh VCR $ values are derived by combining the WTP and choice modelling WTA results and also take into consideration unserved energy and outage probabilities. The effect of an increase in WTP may be offset by all these factors.

One observed trend was that within the same climate zone, regional segments had a slightly lower WTP compared to CBD and suburban segments.

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49 AEMO 2014 WTP nominal values of $1.24 and $2.32 adjusted to real $2019 of $1.34 and $2.50 using ABS CPI, All Groups, Weighted average of Capital cities June 2019 and December 2014 quarters.

Table 5.4: Residential WTP by segment[50]

Residential customer segment	Number of respondents	Aggregate residential WTP ($/month)
Northern Territory	257	3.33
Climate Zone 1 Regional	195	2.85
Climate Zone 2 CBD & Suburban	1039	3.43
Climate Zone 2 Regional	410	3.15
Climate Zone 3&4 Regional	352	3.73
Climate Zone 5 CBD & Suburban NSW	1013	4.06
Climate Zone 5 CBD & Suburban SA	597	3.30
Climate Zone 5 Regional	245	2.88
Climate Zone 6 CBD & Suburban	2131	3.70
Climate Zone 6 Regional	513	2.79
Climate Zone 7 CBD & Suburban	211	4.20
Climate Zone 7 Regional	463	3.21
Total (simple average)	7246	3.51

5.1.4.2 Choice modelling (WTA)

Statistical models known as multinomial logit models (MNL) were used to produce the choice modelling results, including willingness to accept (WTA) dollar estimates for the outage attributes tested.[51] WTA instead of WTP was used as this was consistent with the choice modelling hypothetical scenario presented, which asked respondents to trade-off between a change in the outage characteristics from the baseline outage scenario and different levels of bill discount.

50 The WTP is the amount a customer would be willing to pay to avoid the baseline outage scenario. As the baseline outage scenario is defined as two outages, the estimate is the $/month per two outages.

51 Please see the KPMG main survey report', page 45 for further details about the MNL model used. The report is available on the AER website: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability-vcr.. To ensure confidence, the MNL choice modelling results were independently produced by the AER and KPMG, cross-checked and also reviewed by MEI.
The MNL model was used to produce willingness to accept (WTA) dollar estimates for the test outage attributes for the residential segments. Dollar estimates are calculated by dividing the coefficient outage attribute coefficient value by the bill discount coefficient value and multiplying by minus one. Section 5.1.3 details how these segments were developed.

Tables 5.5 to 5.7 below set out the attribute estimates derived from the choice modelling results that we included in the calculation of VCR values. The estimate for each attribute is the incremental amount of compensation a customer would require to accept an outage attribute (such as duration and timing) in addition to the baseline outage scenario. For ease of reading, the estimates are expressed in WTP form.[52]

In developing the VCRs set out in this chapter, outage variables were included where the choice modelling regression coefficients had at least 99 per cent statistical significance and $/month estimates derived from the coefficients had at least 90 per cent statistical significance (significance criteria). Inclusion of other variables that did not meet this criteria were considered on a case by case basis. This means for most attributes there is less than a one per cent chance the relationship found between the survey responses and outage attributes is random and that there is also a high level of confidence in the dollar estimates.

Table 5.5 - Residential choice model estimates ($/month[53]) expressed in WTP form

Outage variable	NT	CZ1 regional	CZ2 CBD & suburban	CZ2 regional
Widespread	-	-	-	-
Duration 3 hours	0.74[54]	7.02	6.48	5.98
Duration 6 hours	6.38	9.23	10.11	11.43
Duration 12 hours	10.86	12.61	13.17	16.45
Peak	2.78	2.17	3.67	4.46
Summer	3.82	2.56	-	-
Weekend	-	-	-	-

52 WTA dollar values are presented as negative where there is incremental value placed on a particular attribute. For the ease of reading we have presented these as positive values (WTP) instead.

53 The estimates for each attribute is the incremental amount of compensation a customer would require for experiencing that outage attribute in addition to the baseline outage scenario. As the baseline outage scenario is defined as two outages, the estimate is $/month per two outages.

54 This attribute was not statistically significant for this segment but has been included in the calculation of the VCR values.

Table 5.6 - Residential choice model estimates ($/month[55]) expressed in WTP form

Outage variable	CZ3&4 regional	CZ5 CBD & suburban NSW	CZ5 CBD & suburban SA	CZ5 regional
Widespread	-	-	-	-
Duration 3 hours	5.47	6.89	7.21	5.45
Duration 6 hours	10.08	11.96	14.67	10.69
Duration 12 hours	14.94	15.80	18.51	12.86
Peak	3.14	4.04	2.27	4.44
Summer	3.98	-0.82[56]	2.50	-
Weekend	-	-	-	-

55 The estimates for each attribute is the incremental amount of compensation a customer would require for experiencing that outage attribute in addition to the baseline outage scenario. As the baseline outage scenario is defined as two outages, the estimate is $/month per two outages.

56 The negative value means that customers in this segment favour summer outages over winter outages (for example, they would pay more to avoid an outage in winter).

Table 5.7 - Residential choice model estimates ($/month[57]) expressed in WTP form

Outage variable	CZ6 CBD & suburban	CZ6 regional	CZ7 CBD & suburban	CZ7 regional
Widespread	-	-	-	-
Duration 3 hours	4.54	5.08	7.26	7.20
Duration 6 hours	9.88	8.95	11.03	10.92
Duration 12 hours	12.33	14.16	17.89	13.69
Peak	2.95	3.06	4.13	3.54
Summer	-	-	-2.19[58]	-3.04[59]
Weekend	-	-	-	-

Findings and analysis

- For the majority of residential segments the severity, duration and peak attributes had 99 per cent statistical significance. Results were in line with expectations. There was a preference for localised over widespread outages, shorter duration outages over longer duration outages and off peak time outages over peak time outages. This is largely consistent with AEMO's 2014 review findings that duration and peak attributes had 99 per cent statistical significance across all their state residential segments.
- NT's 3 hour duration attribute was the only duration attribute level that was not statistically significant. However, given the small $/month value of this attribute, to maintain consistency we chose to include it in the calculation of VCRs.
- The most valued outage variable attribute across all residential segments was duration, which is also consistent with the AEMO's 2014 review findings. In all the residential segments the WTA estimate increases as duration increases. However as duration increases the WTA does not increase as fast.
- The summer attribute results were in line with expectations based on climate. Hotter climate zones had a statistically significant preference to avoid summer outages. This

57 The estimates for each attribute is the incremental amount of compensation a customer would require for experiencing that outage attribute in addition to the baseline outage scenario. As the baseline outage scenario is defined as two outages, the estimate is $/month per two outages.

58 The negative value means that customers in this segment favour summer outages over winter outages (for example, they would pay more to avoid an outage in winter).

59 The negative value means that customers in this segment favour summer outages over winter outages (for example, they would pay more to avoid an outage in winter).

preference generally weakened for cooler climate zones. Both climate zone 7 residential segments, which has the coldest climate, showed a statistically significant preference to avoid winter outages over summer outages. We have included the climate zone 7 suburban attribute result in the calculation of the VCR values because while the attribute coefficient was not 99 per cent statistically significant, it was statistically significant at 95 per cent for both the coefficient and WTA estimate. This result highlights the advantage of segmenting by climate zones rather than by state as AEMO did in 2014. The AEMO 2014 residential choice modelling returned mixed results for the summer attribute. This may reflect that states can be made up of various climate zones, meaning residential customers grouped by state are less likely to have common preferences for the summer attribute in particular. AEMO found that of its state residential segments, Tasmania had the most statistically significant results. Tasmania only has one climate zone, which may have assisted in it recording a stronger and more consistent preference over the season attribute than other states with a mixture of climate zones.

- Like the AEMO 2014 review, we have had difficulty incorporating the severity attribute into the residential $/kWh VCR values as the attribute is described qualitatively and we do not have supporting data to indicate which outages should be considered severe. We have not included the severity attribute in the calculation of VCR values.
- The weekend attribute was not statistically significant in any residential segment except climate zone 1 regional where although it was statistically significant it did not meet our significance criteria. Accordingly, we have not included the weekend attribute in the calculation of $/kWh VCR values. Similarly, the AEMO 2014 review did not include the attribute when calculating residential VCRs as none of their state segments had a 99 per cent statistical significance for this attribute.
- Although our segments are not identical to AEMO's, our WTA duration attribute values, which is one of the main drivers of the VCR values, are lower compared to the WTA attribute values from AEMO's 2014 review. For example, the highest WTA attribute value for this review is 12 hour duration for SA CBD and suburban at $18.51/month. In AEMO's 2014 review, the highest WTA attribute value was duration 12 hours for Tasmania at $37.56/month. The lower WTA values have the effect of contributing to lowering our VCR values even though our WTP values for the base case outage (as determined by our contingent valuation question) are higher than the WTP values from AEMO's 2014 review. Table 5.8 compares the AER and AEMO outage duration attribute results for NEM residential segments.

Table 5.8 - comparison of AER 2019 and AEMO 2014 residential segment choice modelling duration attribute values (NEM only)

Outage attribute	Range of $/month results for AER 2019 VCR Review	Range of $/month results for AEMO 2014 VCR review (nominal)
Duration 3 hours	4.54 - 7.26	12.21 - 17.04
Duration 6 hours	8.95 - 14.67	21.22 - 28.24
Duration 12 hours	12.33 - 18.51	31.01 - 37.56

5.1.5 Calculating residential $/kWh VCR values

To convert the residential survey results into $/kWh VCR values for each segment we used the same overall process as AEMO in 2014 with the following steps:

- use the residential survey contingent valuation and choice modelling attribute results to calculate dollar values for 32 unique outage scenarios[60]
- convert the dollar values for each of the outage scenarios into $/kWh using estimates of unserved energy. These $/kWh outage scenario values for each residential segment are set out in the VCR Final report appendix
- develop a probability weighting for each outage scenario and then sum the probability weighted outage scenario $/kWh VCR values to derive the $/kWh values.

Each of these steps is discussed below.

5.1.5.1 Outage scenarios

The contingent valuation and choice modelling results can be used to create VCR values for 32 unique outage scenarios consisting of combinations of the following characteristics:

- summer or winter
- off peak or peak
- weekend or weekday
- outage duration of 3 minutes to one hour, one to three hours, three to six hours and six to twelve hours

5.1.5.2 Estimating unserved energy of residential customers

60 AEMO used 24 outage scenarios as they did not include outage scenarios which consisted of peak and weekend attribute levels. We have included outage scenarios with peak and weekend attribute levels as these were tested separately in the choice model (i.e. peak was defined as 7-10 am and 5-8 pm and not by reference to whether it was weekday or weekend).

We used a combination of data sources to estimate the unserved energy associated with each outage scenario for each residential cohort. This includes energy not only supplied from the grid but also energy that would be lost as a result of an outage. The annual consumption amounts for each residential segment are based on the 2017 Energy Consumption Benchmarks for residential customers.[61] For each residential segment, we first created a 'base' annual consumption for a 2.6 person household[62] by combining the annual consumption amounts associated with 2 person and 3 person households. We then adjusted these annual consumption amounts to account for residential solar generation in order to estimate gross demand.[63] We made these adjustments by calculating a 'solar factor' for each state, which was the difference in average annual consumption amounts for households without solar and for all households (including households with solar) surveyed in the Energy Consumptions Benchmark.[64]

We further adjusted these annual consumptions where applicable, to take into account the proportions of households in each segment that have gas,[65] swimming pools[66] and slab heating.[67] For the relevant residential cohorts, we made these adjustments by combining the annual 'solar factor' adjusted consumption amounts associated with 2.6 person households for houses with and without gas, swimming pools and slab heating, and developed a weighted average annual consumption reflecting the proportion of households surveyed in the Energy Consumptions Benchmark with and without these dwelling characteristics. These annual consumption amounts are set out in Table 5.9.

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61 Electricity and gas bill benchmarks for residential customers 2017, ACIL Allen report commissioned by the AER. https://www.aer.gov.au/retail-markets/retail-guidelines-reviews/electricity-and-gas-bill-benchmarks-for-residential-customers-2017

62 2.6 is the average dwelling size according to the 2016 ABS census.

63 This is because the majority of residential customers with solar PV cannot use the energy generated by their system during an outage.

64 ACIL Allen Consulting, Energy Consumption Benchmarks, 13 October 2017, p.26.

65 Climate Zone 3+4.

66 Climate Zones 2, 5 and 6.

67 Climate Zone 7.

Table 5.9 Annual Consumption by Residential Segment (kWh)

Residential customer segment	Annual Consumption (kWh)[68]
CZ1 Regional	8274
CZ2 Suburban	5467
CZ2 Regional	5467
CZ 3&4 Regional	7884
CZ5 Suburban NSW	5649
CZ5 Suburban SA	5649
CZ5 Regional	5649
CZ6 Suburban	6109
CZ6 Regional	6109
CZ7 Suburban	7465
CZ7 Regional	7465
Northern Territory	8207

To construct consumption profiles[69] for each residential segment we used a separate data set containing 30 minute interval consumption data, taken from bill benchmark previous developed by the AER, for households in climate zones 2, 5, 6 and 7 disaggregated to individual postcodes. Climate zones 1 and 3 & 4 consumption profiles were based on the interval data from the most comparable climate zones available in the dataset.[70] We multiplied these consumption profiles by the relevant annual consumption amount to estimate the unserved energy associated with each of the 32 outage scenarios for each residential segment.

The estimates of unserved energy for each of the 32 outage scenarios for each residential segment are set out in the VCR Final report appendix.

68 Annual consumption was estimated for each climate zone. It was not separately estimated for different remoteness levels. Therefore the same annual consumption is reported for each segment in a given climate zone.

69 That is, the percentage amount of annual consumption falling into our 32 outage scenarios

70 Climate Zone 1 summer consumption profile used Climate Zone 2 summer interval data. Climate Zone 1 winter consumption profile used Climate Zone 6 summer interval data. Climate Zone 3+4 summer consumption profile used a combination of Climate Zone 2 and 5 summer interval data. Climate Zone 3+4 winter consumption profile used a combination of Climate Zone 2 and 6 winter interval data.

5.1.5.3 Outage probability profiles

Outage probabilities for each of the 32 unique outage scenarios were derived using 2018 distribution network Category Analysis Regulatory Information Notice (CA RIN) data collected by the AER. This source of information captures customer loss of supply caused by outages. In 2014, AEMO used the same source of information to calculate outage probabilities, considering it to be a more credible and public data source compared to survey respondents' actual experience with outages.[71]

To develop the required outage probabilities for each residential segment the following criteria was applied to the distribution network 2018 RIN data:

- outages must be unplanned
- outages must be 3 minutes[72] or more in duration and not longer than 12 hours duration[73]
- outages must affect a minimum of one customer
- outages must take place in summer or winter.

For each applicable outage event reported in the CA RIN, we considered the time of the outage and the duration of the outage. Each outage was classified into one of the outage duration blocks and each minute of the outage was identified as being in summer or winter, on a weekday or weekend, and during peak time or off-peak time.

A number of outages fell across different outage scenarios. For example, a six hour outage starting at 8 am and ending at 2 pm in summer on a weekday would have two hours falling within the peak period (8 am to 10 am), and four hours falling within the off-peak period (10 am to 2 pm). In this example, 120 minutes were allocated to the Summer-Weekday-Peak-6 Hour Duration outage scenario, and the remaining 240 minutes were allocated to the Summer-Weekday-Off Peak-6 Hour Duration outage scenario.

To calculate the likelihoods of the 32 outage scenarios, we calculated the number of 'customer minutes' affected for each outage falling into each outage scenario. Using the above example, the number of customers affected by the outage was multiplied by the corresponding number of minutes to derive the customer minutes for each applicable outage scenario.

We then allocated these customer minutes among each residential cohort based on the postcode of the customers served by the feeder that experienced the outage. This was done with the assistance of network businesses. Each feeder was assigned to the relevant climate zone and remoteness categories by mapping each feeder according to the postcodes of its supply area.[74] Where a feeder was found to cover more than one residential cohort, its customer minutes were split among the cohorts based on their share of customer connections to the feeder.

71 AEMO, Value of Customer Reliability Review – Final Report, September 2014, p. 22.

72 This is to ensure consistency with the definition of momentary which is defined as an outage of less than 3 minutes.

73 Outages greater than 12 hours duration fall outside the definition of standard outages

74 The feeder location data, including customer number connected, were sourced from the electricity distribution networks via a voluntary information request.

With approximately 99 per cent of customer minutes for applicable outages in the NEM allocated into the 32 outage scenarios for each residential cohort,[75] we aggregated customer minutes for each outage scenario within a cohort. We then calculated, for each residential cohort, the likelihood of each outage scenario by dividing the total number of customer minutes associated with that outage scenario by the total number of customer minutes across all 32 outage scenarios.

The outage probabilities for each residential segment are set out in the VCR Final report appendix.

5.2 Business survey results

Our survey collected responses across all 19 ABS ANZSIC sector groupings. Using these responses we have calculated VCR values for agricultural, commercial and industrial business segments, further broken down by business consumption sizes. The two electricity consumption size thresholds used were less than 100 MWh per annum (small and medium) and 100 MWh or more per annum (large).

These results are set out in Table 5.10 below and how they compare to the VCRs for the corresponding business segment from the AEMO 2014 Review.

75 The remaining customer minutes not being accounted for in calculating outage probabilities in the residential sector is due to missing feeder location data or missing customer connection data.

Table 5.10 Business VCR values and comparison to AEMO 2014 Review ($2019)

Business customer segment	AER 2019 business VCR ($/kWh) ($2019)	AEMO 2014 business VCR ($/kWh) real $2019
Agriculture - Overall	37.87	51.34
Agriculture - Small and Medium	57.64	59.09 (small) 55.80 (medium)
Agriculture - Large	33.69	49.97
Commercial - Overall	44.52	48.16
Commercial - Small and Medium	68.29	61.52 (small) 61.68 (medium)
Commercial - Large	39.92	45.37
Industrial - Overall	63.79	47.45
Industrial - Small and Medium	79.37	75.02 (small) 69.39 (medium)
Industrial - Large	62.86	42.15

5.2.1 Findings and observations

- Our results are broadly consistent with two observed trends from the AEMO 2014 review and other VCR studies:
    - business VCRs are higher than the residential values
    - the large businesses in each segment had lower VCRs compared to small and medium businesses. As larger businesses use more energy, their relative cost per kilowatt hour is likely to be lower than small and medium businesses.
- Compared to the AEMO 2014 results, there has been a considerable drop in the agriculture VCR, a small decrease in the commercial VCR, and a noticeable increase in the industrial VCR.

5.2.2 Sample characteristics

A total of 1,821 business customers in the NEM and NT were sampled in the main survey.

321 business customers were also surveyed in the pilot survey. We have not used these responses in calculating the business VCRs due to the changes made to the main survey (in part informed by the results of the pilot).

We hypothesized that key drivers of business customer reliability preferences were business activity types rather than location. Business customers were sampled accordingly across ABS ANZSIC sectors with the aim of combining the responses into different business sector groupings comprising one or more ANZSIC sectors. Initially this sample plan was applied to NEM businesses only. To accommodate Power and Water Corporation's and the Utilities Commission's preferences for NT VCRs to be developed using only NT customer survey responses, we sought to recruit a separate sample of commercial businesses located in NT regulated networks. However, business survey recruitment in the NT proved challenging and it was not possible to obtain the minimum sample of NT–only business responses to develop NT specific business VCRs. Thus, a decision was made to add NT business responses to the broader sampling plan for the main business survey.

Table 5.11 below sets out the business customers recruited across ABS ANZSIC sectors.

Table 5.11 - Main survey business responses by ABS ANZSIC sectors

ANZSIC sector	ANZSIC Description	Responses
A	Agriculture, forestry and fishing	123
B	Mining	33
C	Manufacturing	134
D	Electricity, gas, water and waste service	27
E	Construction	121
F	Wholesale trade	84
G	Retail trade	200
H	Accommodation and food services	80
I	Transport, postal and warehousing	53
J	Information media and telecommunications	109
K	Financial and insurance services	99
L	Rental hiring and real estate services	42
M	Professional, scientific and technical services	242
N	Administrative and support services	109
O	Public administration and safety	14
P	Education and training	113
Q	Health care and social assistance	130
R	Arts and recreation services	73
S	Other services	35[76]

76 Business responses in this category consist of either businesses that fall within the ANZSIC sector definition of 'Other services' or could not be categorized into any of the other ANZSIC sectors based on the information provided in the survey.

5.2.3 Business customer segmentation

5.2.3.1 Segmentation approach

The Choice modelling survey technique provides flexibility in grouping responses as it is not based on pre-determined segments or cohorts. This allows for customers with similar reliability preferences to be identified and grouped together as a segment. The main constraint of choice modelling is that it requires a minimum sample size of responses before statistically significant relationships can be reliably identified.

We sought to segment business customers by combining responses into business sector groupings made up of one or more ANZSIC sectors. The AEMO 2014 review segmented businesses into agriculture, commercial and industrial sector groups. Based on stakeholder feedback, we sought increased granularity, particularly for commercial sector VCRs. As a starting point for our analysis, we created the following six sector segments grouped by ANZSIC sectors that we considered may have broadly similar reliability preferences. These are set out below.

- Agriculture (consisting of ANZSIC sector A)
- Manufacturing and Construction (ANZSIC classification C, E)
- Energy, supply chain logistics (ANZSIC classification D,F,I,J)
- Retail, hospitality, arts and recreation (ANZSIC classification G,H,R)
- Professional, administrative and support, education services (ANZSIC classification K,L,M,N,P,O (administration subset))
- Critical health and safety services (ANZSIC classification Q,O (safety subset))

To determine the appropriate level of segmentation we considered:

- what segments would be viable given the responses collected across ANZSIC sectors. We considered potential segments would need to have a sample size of at least 100 to be viable, particularly given the heterogeneity of businesses (even within the same ANSZIC sector)
- whether combinations would make sense within the energy context and the applications of VCR
- whether there were statistically significant differences in the choice modelling results between potential segment groups. We determined where there are no significant differences between groups they can be merged together unless there are strong reasons to keep them separate (for example, it would be easier for the purposes of application).

5.2.3.2 Segmentation analysis

We found there is no a strong case for increasing granularity of business segments, with few statistically significant differences between the ANZSIC sectors. Thus, we decided to retain business segments for agricultural, industrial and commercial sectors adopted by AEMO in its 2014 review.

Our agricultural segments comprise responses from ANZSIC sector A - agriculture, forestry and fisheries. We obtained enough responses in ANZSIC sector A to run a robust choice model.

Our industrial sector definition comprises four ANZSIC sectors - mining (B), manufacturing (C), Electricity, gas, water and waste services (D) and construction (E). Despite manufacturing and construction responses both having over 100 responses, these are still relatively small samples, especially given the heterogeneity of businesses. More statistically robust results were achieved when ANZSIC sectors D and E were added to the original proposed industrial grouping of B and C. Analysis also showed few statistically significant differences in attribute preferences between the four sectors. These ANZSIC sectors represent many of the more energy intensive businesses.

Our commercial business segment comprises the remaining 14 ANZSIC sectors and contains the most diverse range of businesses compared to the other two segments. As noted in section 5.3.1, we initially sought to create more disaggregated business sectors. However, the analysis identified few statistically significant differences in outage preferences between the 14 ANZSIC sectors. We also did not identify major advantages that more disaggregated segments would have for application purposes. For these reasons we decided to combine the 14 ANZSIC sectors into one commercial segment rather than develop more granular commercial segments.

5.2.4 Detailed results and assumptions

Like the residential survey, the business survey uses a combination of contingent valuation and choice modelling survey techniques to estimate standard outage (up to 12 hours duration) VCRs for residential and business customers. The two techniques are used together in the following way:

- contingent valuation is used to determine the value of a baseline outage scenario[77] (defined as two localised one hour outages in a year, occurring in winter in off-peak times)
- choice modelling is used to determine the increment (or decrement) in value respondents' placed on specific outage attributes in addition to the baseline outage scenario. Attributes tested in the choice model were peak (7-10 am and 5-8 pm) and off-peak time of day, season (winter / summer), day of week (weekday / weekend), severity (localised / widespread) and duration (1 hour, 3 hours, 6 hours, 12 hours).

The contingent valuation and choice modelling results can be combined to derive the dollar value which customers placed on specific outage scenarios.

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77 This baseline scenario was chosen for two reasons. Firstly it maintained consistency with AEMO 2014, which used the same baseline scenario. Secondly it was expected to be a relatively benign scenario for most consumers, based on the AEMO 2014 results. For example, it is of short duration and occurs in off-peak times rather than peak times. Choosing a relatively benign baseline outage simplified the design of the choice modelling, by allowing us to assume only discounts needed to be offered for outages that differed from the baseline scenario.

5.2.4.1 Contingent valuation (WTP)

As described in section 3.2.2 the response to the follow-up open-ended WTP question was used to calculate respondents' WTP.

If a respondent answered with higher WTP than their monthly bill to our open-ended question we capped the response at 100 per cent of the respondent's last bill.

In total 24 per cent of respondents had a WTP of zero and four per cent of responses were capped at 100 per cent of the last bill.

The WTP for each business segment was calculated using a straight line average of survey responses, consistent with the approach used by AEMO in 2014. The average WTP for each business segment and the overall business WTP is set out in Table 5.12 below.

The average WTP of business respondents was 14.2 per cent of their bill. This is higher than AEMO's 2014 average WTP, which was 5.5 per cent across all business sectors. While some of this difference can be attributed to the methodological changes made to the contingent valuation question, our analysis, summarised in Attachment 4, indicates the change appears to be driven by a change in reliability preferences.

Table 5.12 - Business contingent valuation WTP results[78]

Business customer segment	Number of respondents	Aggregate residential WTP % of bill)
Agriculture	123	13.5
Industrial	368	17.5
Commercial	1330	13.5
Overall	1821	14.2

5.2.4.2 Choice modelling (WTA)

Like the residential survey results, MNL models were used to produce the choice modelling results. As with the residential survey, outage variables were included in the calculation of VCR values where regression coefficients had at least 99 per cent statistical significance and percentage of bill estimates had at least 90 per cent statistical significance (significance criteria). Inclusion of other variables that did not meet this criteria was considered on a case by case basis.

78 The WTP is the amount a customer would be willing to pay to avoid the baseline outage scenario. As the baseline outage scenario is defined as two outages, the estimate is the $/month per two outages.

Table 5.13 below sets out the attribute estimates derived from the choice modelling results that we included in the calculation of VCR values. The estimate for each attribute is the incremental percentage of bill amount a customer would require to experience that attribute in addition to the baseline outage scenario. For ease of reading, the estimates are expressed in WTP form rather than WTA[79].

Table 5.13 - Business choice model estimates (% of bill[80]) expressed in WTP form

Outage variable	Agriculture	Industrial	Commercial
Widespread	-	-	-
Duration 3 hours	1.08	0.51[81]	2.35
Duration 6 hours	2.21	2.36	2.94
Duration 12 hours	2.90	2.39	3.10
Peak	-	-	0.8
Summer	-	-	-
Weekend	-	-1.45[82]	-

Findings and analysis

- The majority of duration attributes were found to be 99 per cent statistically significant across all three business segments
- The industrial segment's three hour duration attribute was the only duration attribute not statistically significant. However, given the small percentage of bill estimate of this attribute, and to maintain consistency we have chosen to include this attribute in the calculation of VCRs
- Across all three segments the WTA estimate for duration six hours compared to 12 hours duration is very similar, indicating businesses did not value avoiding a 12 hour outage substantially more than avoiding a six hour outage
- No attributes outside of duration were consistently statistically significant across all three segments.
- For the industrial segment the weekend attribute was the only other attribute that met the significance criteria for inclusion in the calculation of VCR values.

79 WTA dollar values are presented as negative where there is incremental value placed on a particular attribute. For the ease of reading we have presented these as positive values (WTP) instead.

80 The estimates for each attribute is the incremental amount of compensation a customer would require for experiencing that outage attribute in addition to the baseline outage scenario. As the baseline outage scenario is defined as two outages, the estimate is % of bill per two outages.

81 This attribute was not statistically significant but has been included in the calculation of $/kWh VCR values.

82 For industrial customers weekend outages are preferred to weekday.

- For the commercial segment the peak attribute was 99 per cent statistically significant and the severity attribute was 95 per cent statistically significant. However, for the same reasons outlined in the residential WTA results, the severity attribute has not been incorporated into the business VCR calculations.
- Similar to what was observed with the residential WTA results, the WTA duration attribute values, which is one of the main drivers of the VCR values, are lower compared to the WTA attribute values in obtained by AEMO in its 2014 review. The attribute with the highest WTA was 12 hours duration for commercial customers with 3.10 per cent of bill, where the WTP contingent valuation results ranged from 13.4 - 17 per cent of bill. By comparison, the AEMO 2014 business results had lower WTP contingent valuation results, ranging from 5 - 7.2 per cent, but much higher WTA choice modelling results.[83] Table 5.14 compares the AER and AEMO outage duration attribute results for business segments.

Table 5.14 - comparison of AER 2019 and AEMO 2014 business segment choice modelling duration attribute values

Outage attribute	Range of % of bill results for AER 2019 VCR Review	Range of % of bill results for AEMO 2014 VCR review
Duration 3 hours	0.51 - 2.35	3.60 - 5.92
Duration 6 hours	2.21 - 2.94	5.13 - 8.39
Duration 12 hours	2.39 - 3.10	5.20 - 12.52

5.2.5 Calculating business $/kWh VCR values

To convert the business survey results into $/kWh VCR values for each segment we used the same overall process as AEMO in 2014 with the following steps:

- use the business survey contingent valuation and choice modelling attribute results to calculate percentage of bill values for 32[84] unique outage scenarios
- convert the percentage of bill values for each of the outage scenarios into dollar values using the average bill amounts from survey respondents
- convert the dollar values for each of the outage scenarios into $/kWh using estimates of unserved energy. These $/kWh outage scenario values for each business segment are set out in the VCR Final report appendix

83 For example, in the AEMO 2014 review the duration attribute results across all business segments ranged from 3.60 - 12.15% of bill.

84 AEMO used 24 outage scenarios as they did not include outage scenarios which consisted of peak and weekend attribute levels. We have included outage scenarios with peak and weekend attribute levels as these were tested separately in the choice model (i.e. peak was defined as 7-10 am and 5-8 pm and not by reference to whether it was weekday or weekend).

- develop a probability weighting for each outage scenario and then sum the probability weighted outage scenario $/kWh VCR values to derive the $/kWh values.

Each of these steps is discussed below.

5.2.5.1 Outage scenarios

The contingent valuation and choice modelling results can be used to create VCR values for 32 unique outage scenarios consisting of combinations of the following characteristics:

- summer or winter
- off peak or peak
- weekend or weekday
- outage duration of three minutes to one hour, one to three hours, three to six hours and six to 12 hours.

5.2.5.2 Converting WTA as percent of bill to VCR dollar values

The dollar values were calculated by multiplying the relevant WTA estimates from the choice modelling by the average bill amounts for small and medium, and large respondents within each cohort.

We note AEMO used different bill amounts for small sized businesses and medium sized businesses. We have decided to merge small and medium businesses as they tend to be charged a similar effective cents per kilowatt hour (c/kWh) rate[85] and when this is applied to the same set of percent of bill survey results, we find small business and medium business customers have almost identical VCRs. See section 5.2.5.3 for further information.

The average bill amounts are set out in Table 5.15.

Table 5.15 - Business average annual bills ($/year)

Size	Agriculture	Industrial	Commercial
Small and Medium	$4,490	$4,807	$3,935
Large	$171,653	$653,610	$164,414

5.2.5.3 Estimating unserved energy of business customers

We originally intended to use consumption data from NMIs provided by survey respondents to develop consumption profiles for each business cohort. Unfortunately, we did not receive a sufficient number of valid NMIs from survey respondents to construct consumption profiles.

85 The effective c/kWh is calculated by dividing the dollar amount of a customer bill by the amount of electricity consumed in that bill. The ACCC has calculated the effective c/kWh price (ex-GST) for small and medium businesses to be 27.2 c/kWh and 15.9 c/kWh for large customers, Inquiry into the National Electricity Market - August 2019 Report, ACCC, pp.95-96.

We calculated the average amount of unserved energy for small/medium and large customers within each cohort by first calculating the average small/medium and large annual consumptions for each cohort. These were estimated by dividing the average annual bill amounts for small/medium and large survey respondents by the respective volume weighted average effective c/kWh rate for small/medium enterprise and large commercial and industrial customers calculated by the ACCC in its electricity market monitoring reports.[86] The average annual consumption amounts are set out in Table 5.16.

Table 5.16 - Business average annual consumption (kWh/year)

Size	Agriculture	Industrial	Commercial
Small/Medium	15,007	16,066	13,152
Large	981,437	3,737,052	940,047

We then converted these annual consumption amounts to average hourly consumptions for small/medium and large customers within each cohort. Lastly, we adjusted the average hourly consumption amounts by summer/winter, peak/off-peak and weekday/weekend factors specific to each cohort to reflect variation in usage throughout the year. These factors were estimated by comparing the differences in operational demand among NEM regions due to differences in the composition of industrial, agricultural and commercial customers among NEM regions. These factors are set out in the Appendix to this Final Report.

5.2.5.4 Outage probability profiles

Business customer outage probabilities for each of the 32 unique outage scenarios were derived using the same outage data sources and outage filter criteria as those used for the residential outage probability profiles discussed in 5.1.5.3.

The outage probabilities for the different business segments were calculated using different subsets of the outage data for distribution Service Target Performance Incentive Scheme feeder classifications.[87] The outage probabilities for agricultural customers are based on the subset of outages affecting customers served by rural short and rural long feeders, reflecting the typical agricultural business located in regional Australia, rather than urban or CBD locations. The outage probabilities for commercial customers are based on all outages affecting customers served by all feeder classifications. This is because the commercial sector covers a broad range of business types that cannot be generalised to a particular remoteness category or categories. The outage probabilities for large industrial customers are based on the subset of outages affecting customers served by CBD feeders[88] whereas

86 Inquiry into the National Electricity Market - August 2019 Report, ACCC, pp.95-96.

87 This piece of information is available from CA RIN outage data.

88 This is the same approach used by AEMO in 2014. The rationale for this approach is that relative outage probabilities for CBD feeders better represent the higher level of reliability that large industrial customers generally tend to experience. This approach does not suggest that large industrial customers are typically located within CBDs. See also AEMO, *VCR Final Report*, September 2014, page. 27. Available at: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Value-of-Customer-Reliability-review.

the outage probabilities for small/medium industrial customers are based on the subset of outages affecting customers served by CBD and urban feeders.[89]

5.3 Very Large business customers

5.3.1 VCR values

Table 5.17 - Direct cost survey VCR values, $/kWh

Segment	$/kWh VCR values
Services	10.54
Industrial	117.99
Metals	19.86
Mines	35.16

The VCR values in Table 5.17 were calculated from customer survey responses indicating the expected costs incurred by respondents for an outage of 10 minutes, 1 hour, 3 hours, 6 hours and 12 hours. We used the reported costs and the consumption data we obtained for each survey response (at the permission of respondents) to calculate load weighted $/kWh values for each outage duration for each survey response. To derive VCR values for each sector we summed the $/kWh hour values for each outage duration for each sector.

We have grouped the responses into the following sectors: services, industrial, metals, and mines. We decided on these sector groupings as they corresponded to the sectors from which we received survey responses. Also, they are similar to AEMO's sectors, though as discussed in section 5.3.3 are not directly comparable. We consulted with our VCR Consultative Committee as to whether to further divide these into transmission and distribution segments, but members considered sector groupings were more preferable for most application purposes.[90]

Given the differences in the VCR values in the different sectors, we consider these useful for granular planning applications that directly impact on such large business customers. However, for the purposes of deriving NEM, state or regional VCR values it would be preferable to use the indicative transmission and distribution values in the absence of detailed information to load weight the sector VCR values. These values are set out in section 5.4.

5.3.1.1 Consumption data

As mentioned, we derived the VCR values by dividing the outage costs by each respondents' consumption. The consumption data was obtained from grid-facing meter

89 This is to reflect that small/medium industrial customers do likely not receive the higher levels of reliability experienced by their large industrial counterparts.

90 Members also noted given these are very large users of energy most would directly negotiate their network connection arrangements and the reliability it provides.

readings. Some of these readings indicated negative amounts for energy exported to the grid from onsite generation. For these businesses, the value they place on reliability should ideally take account of total energy - that is, onsite consumption and exports. In this way, both imports and exports would be factored into a business' outage costs. In our survey however, we did not prompt respondents to include both of these costs and are therefore unclear whether the outage costs reported by respondents' factor in the cost of loss of export revenue to the grid for relevant businesses. Also, the meter readings we obtained are net readings (that is, consumption minus exported energy). Therefore, we do not know the total energy amount (that is, imports plus exports). This is something we will need to consider when conducting future reviews. To mitigate the effects of imperfect information for this review we have made the following assumptions:

- negative meter readings were removed from business' consumption data (we set these to zero) to remove the effect of export data on reducing the consumption figures
- for those businesses with substantial cogeneration, we included the exported energy as a positive amount to better estimate the total energy amount
- respondents with substantial generation are assumed to have factored this into the outage costs they reported in the surveys.

5.3.1.2 Outage probabilities

To combine the load weighted $/kWh values into a single figure for each customer segment we weighted by the relative frequency of each outage duration occurring. To calculate the weights we analysed the number and length of outages occurring in the transmission system between 2010 and 2019, and used this data to develop outage probabilities as indicated in Table 5.18. The transmission outage data was provided by AEMO and is based on incidents which meet the criteria reviewed by AEMO under clause 4.8.15 of the Rules.

Table 5.18 - Outage probabilities

Outage duration	10 minute outage	1 hour outage	3 hour outage	6 hour outage	12 hour outage
Weighted frequency in percentage	4.4%	44.3%	29.5%	11.8%	10.0%

We applied these frequencies to the load weighted $/kWh values to give the duration weighted $/kWh values set out in Table 5.19. These transmission derived outage probabilities were applied to both distribution- and transmission-connected customer responses. We consider this is a reasonable assumption given distribution-connected businesses using above 10 MVA peak demand would have high voltage connections and are likely to experience similarly high levels of reliability to transmission-connected businesses. High Voltage distribution connections usually have similarly high levels of reliability to transmission customers due to the designed redundancy in their connections and the high level of reliability of the high voltage distribution network. In developing this approach we consulted with the VCR Consultative Committee.

5.3.1.3 Duration weighted $/kWh values

Table 5.19 - Duration weighted $/kWh VCR values

Segment	10 min $/kWh	1 hour $/kWh	3 hour $/kWh	6 hour $/kWh	12 hour $/kWh	Total of all durations
Services	1.30	2.26	1.28	1.74	3.97	10.54
Industrial	36.75	62.50	14.26	3.05	1.42	117.99
Metals	3.95	12.16	2.81	0.62	0.32	19.86
Mines	10.00	18.09	4.66	1.44	0.96	35.16

Table 5.19 shows the $/kWh cost for each outage duration for each customer segment. The column on the right sums the cost of each outage duration for each segment to give an overall $/kWh VCR value for each customer segment (also see Table 5.17). Each segment includes both distribution- and transmission-connected sites.

As demonstrated in Table 5.19, the relatively high cost of 10 minute and 1 hour outages reflect the 'fixed costs' of an outage, that is, the unavoidable costs incurred for an outage of any length by some businesses. For example, procedures undertaken to restart a plant after an outage may take a certain amount of time to execute, possibly exceeding the length of the outage itself. The fixed cost nature of an outage was also reflected in the high, unvarying costs indicated by some respondents to an outage of any length between 10 minutes and 48 hours. Most respondents however, indicated costs growing at a slower rate the longer the outage persisted, suggesting that after accounting for the initial fixed costs of an outage, costs incurred for lost production are more limited. This results in lower VCRs the longer the outage duration.

5.3.2 Sample characteristics

We understand there were approximately 300 sites that met the consumption threshold of 10 MVA peak demand per annum making them eligible to receive the survey. We received 67 completed surveys from a range of businesses including metals processing, mines, manufacturing (various industries) and service sector businesses. Of these, only three do not operate 24 hours a day. None reported differences in costs incurred for outages occurring at different times of the day.

The information provided by respondents regarding the costs they incur for outages of different durations, and consumption information, were used to produce $/kWh VCR values. We note that some respondents advised they were unable to provide outage cost information, mentioning difficulties in calculating intangible or variable costs. Some respondents advised their customers – rather than the owners themselves – incur costs from outages. 40 of the 67 completed surveys included outage cost data from which we could calculate the VCR values. All responses, including those without outage cost or NMI data, are included in the qualitative analysis provided below.

The survey responses were divided as follows to produce each business sector VCR number:

- Mines: 16
- Metals: 8
- Services: 3
- Industrial: 13

In the survey we also sought information to help us better contextualise the outage costs experienced by businesses. This included asking about types of costs businesses incur during an outage, whether they have sought to mitigate outage costs, for example, by installing back-up generation, or whether they intend to do so within the next five years, whether there is a worse time for outages to occur for their business, whether outage costs are mitigated when information on likely outage duration is provided, and any other impacts experienced by businesses resulting from outages.

This information can be summarised as follows:

- the costs incurred by businesses resulting from outages are mainly for lost production, damage to equipment and overtime costs. As most businesses operate continuously, they advised lost production cannot be made up for at a later time
- the majority of the businesses surveyed experience increasing costs as duration increases, though some reported high flat costs regardless of outage length. This relates mainly to smelters and metals refineries who reported permanent plant damage caused by outages. The effect of the increase in costs may be not apparent from the $/kWh figures in Table 5.19. This is because the increase in costs is offset by increase in unserved energy. VCR is by definition is expressed as the dollar value per kilowatt hour of unserved energy.
- 90 per cent of respondents reported momentary outages would cause disruption to their businesses. Momentary outages require equipment to be reset, shutting down operations. Some businesses reported that a momentary outage can cost the same as an outage of 1-4 hours, requiring that amount of time to restart operations
- Only nine per cent of businesses indicated there is a worse time for outages to occur – typically summer or weekends, and 89 per cent indicated the impact of an outage is the same regardless of temperature
- 28 per cent of businesses have made investments to reduce the risk/impact of momentary outgas on the business. 72 per cent have installed back-up power (either a battery, back-up generator, or other). Of these, 11 per cent have installed a battery. Another ten per cent intend to install some form of back-up power in the next five years, either to augment existing back-up power or install some where they have none now. 28 per cent of businesses routinely generate their own electricity.
- The chief uses for existing back-up power is to protect essential and costly equipment from damage during an outage and to wind down operations safely. Six per cent of sites use back-up power to continue operating as normal.

- 47 per cent have not experienced an outage of ten minutes or more in the last 12 months. 23 per cent experienced one outage in the last 12 months. Of these, two businesses received information about the outage they experienced that helped manage or reduce the cost of the outage.
- Most transport responses indicated they do not incur costs directly. Instead, costs are considered to be borne by transport users. These responses are included in the 27 mentioned above that could not be used to calculate the VCR values.

It is also important to recognise these values in relation to reported levels of satisfaction with current reliability levels. In particular, we note survey respondents reported a high level of satisfaction with their current level of electricity reliability. 78 per cent indicated they are satisfied with their reliability, and 40 per cent advised they are very satisfied. 18 per cent advised they are unsatisfied with their reliability, but of these 50 per cent advised they have never experienced an outage or have not experienced one in the past 5 years. 77 per cent of respondents included in our industrial segment reported they are satisfied with their current levels of reliability. 38 per cent reported having experienced an outage in the past year.

5.3.3 Differences to AEMO's direct cost survey results

We have used the same calculation method as AEMO in its 2014 review to calculate direct cost survey VCR values. However, AEMO only surveyed transmission customers and received 13 responses. These were divided into three segments: metals, mines and wood, pulp and paper. The results of AEMO's 2014 direct cost survey results are presented in Table 5.20.[91]

Table 5.20 - AEMO’s 2014 direct cost VCR values

Segment	$/kWh VCR values
Metals	5.70
Mines	16.10
Wood, pulp and paper	1.55

Our results differ from AEMO's because we have a larger and more diverse range of businesses in our sample having extended our survey to large distribution-connected businesses. For example, though AEMO had mines and metals segments, they are not equivalent to ours which include distribution-connected sites in addition to transmission-connected sites.

Other differences are due to the particular responses we received to our survey. For example, we could not maintain a separate wood, pulp and paper segment due to a lack of responses. Rather, we have included responses received from this sector in an industrial

91 Note that AEMO’s questions about the cost of outages differ from ours. AEMO requested cost information for a ‘base case’ consisting of two 10 minute outages occurring in a year, and the incremental costs if outages extend to 1 hour, 6 hours and 12 hours.

segment that includes a broad range of industries. Also, a service sector VCR was not previously published by AEMO. Having extended our survey to large distribution-connected customers our sample size is also larger than AEMO's (40 compared to 13). Our sample includes a much wider variety of businesses that exhibit large variations in reported outage costs and energy use. Therefore, because of these segmentation and sample differences, our VCR values are not directly comparable to AEMO's.

While we note our values are not directly comparable with AEMO's, we recognise they are higher. Some general characteristics of our sample may help to explain this. For example:

- there are highly variable outage costs, including extremely high costs reported by some, and relatively high energy consumption amongst metals businesses compared to businesses in our other sectors
- the service sector includes similar variability in outage costs to the metals sector, though most reported lower costs and much lower energy consumption than the metals sector. This has produced a relatively low VCR compared to the other sectors.
- the industrial sector is composed of manufacturers and other businesses from a range of sectors that demonstrate highly variable costs, with some reporting very high fixed costs regardless of outage length. Businesses in our sample also reported average energy usage of less than ten per cent of the average energy usage of a metals business in our sample. The high costs and lower energy usage have resulted in relatively high VCR value for this sector
- outage costs reported by mines were also variable, with a number indicating very high flat costs for outages regardless of length. Many commented that even short power outages resulted in long restart delays due to procedural restart processes. Their energy usage was on average, approximately 30 per cent that of the metals businesses.

5.3.4 Aggregate transmission and distribution VCRs

To be able to establish a NEM-wide and state VCR values (see section 5.4) we also calculated VCR values for the transmission-connected and distribution-connected customers using the same approach set out in section 5.3.1 to derive sector VCR values. These are set out in Table 5.21.

Table 5.21 - Transmission and distribution VCR values

Segment	$/kWh VCR values
Distribution	56.69
Transmission	26.44

To calculate these transmission and distribution VCR values we calculated the load weighted average of the transmission-connected respondents and the distribution-connected respondents.

In its 2014 review AEMO also produced a single VCR figure for their direct cost segment of $6.05/kWh.

5.4 Developing NEM and regional VCR values

5.4.1 NEM and state residential VCRs

To calculate state/territory VCR values we weighted the remoteness and climate zone groupings using a combination of population and consumption data. This was done using the following steps:

- calculating regional populations within each NEM state and territory using ABS data.[92] This gives the estimated regional population in each Statistical Area 2 (SA2). We then mapped each SA2 region to postcodes in that area.[93]
- using the postcodes, we assigned to each SA2 region a climate zone and remoteness category
- summing the estimated regional population associated with each climate zone/remoteness combination to get the estimated populations in each state residing in each climate zone/remoteness combination. The results were divided by 2.6 to give the average number of dwellings (according to the 2016 census each household has 2.6 occupants on average).
- multiplying dwellings by the average residential consumption in each climate zone. This gives the total energy load for each residential segment in each state, which can be used to calculate residential VCR values per state.

5.4.2 NEM and state VCRs

5.4.2.1 General approach

The residential, business and large business VCRs can be used to develop area specific aggregate VCRs. For example, the VCR results could be used to derive the aggregate VCR of a distribution network, state/territory or the NEM. This is done by summing the VCRs of the relevant customer segments weighted by the proportion of total load for that area. This could be expressed as:

$$Area\, VCR = P1(residential\, VCR) + P2(business\, VCR) + P3(very\, large\, business\, VCR)$$

Where *P* is the proportion of total load made up for by the relevant customer segment.

Where an area consists of more than one type of residential, business or very large business segment they are added together separately in proportion to their contribution to total load. For example, if an area consists of residential customers from climate zone 6 suburban and climate zone 6 regional, the residential contribution to area VCR should be the load weighted sum of both residential segment VCRs.

92 ABS data series: Catalogue Number 3235.0 - Regional Population by Age and Sex, Australia, 2018 - Population Estimates by Age and Sex, Regions of Australia, Table 3.

93 We referred to ABS: 2017 Locality to 2016 SA2

5.4.2.2 NEM and State VCRs

We have calculated the representative NEM wide VCR to be $40.99/kWh using the same approach AEMO used to weight their VCR values.

This value is a load weighted average VCR comprising:

- A Transmission-connected VCR - $26.44/kWh (approximately 22% of NEM load)
- A Distribution-connected VCR - $45.06/kWh (approximately 78% of NEM load)

We calculated the NEM loads using RIN data provided by Transmission and Distribution Network Service Providers (NSPs).

This Transmission-connected VCR of $26.44/kWh is the load weighted average of the transmission-connected respondents that completed the Direct Cost survey. The individual respondent load weightings are based on the actual consumption amounts of each of these respondents.

The Distribution-connected VCR of $45.06/kWh is the load weighted average of the different segment VCRs derived from the main survey, being:

- Residential VCR - $24.08 (34.3% of distribution load)
- Agricultural VCR - $37.87 (0.7% of distribution load)
- Commercial VCR - $44.52 (25.5% of distribution load)
- Industrial VCR - $63.79 (39.5% of distribution load)

These load weightings are based on two data sources. We used Distribution RIN data to split distribution loads into Residential (34%) and Non-Residential (66%). We then further split the Non-Residential load into Agricultural, Commercial and Industrial loads using data from the Department of the Environment and Energy.[94]

We have also used this above approach to estimate representative load weighted VCRs for each NEM region. This is set out in Table 5.22 which also compares them to AEMO's 2014 NEM and State VCR values.

94 Australian Energy Update 2019, Table F: Australian energy consumption in Australia, by state, by industry, and fuel type, energy units.

Table 5.22 - NEM and State VCR values and comparison to AEMO 2014 results

NEM region	AER 2019 VCR ($/kWh) ($2019)	AEMO 2014 ($/kWh) (Nominal)	AEMO 2014 ($/kWh) (real $2019)
NSW+ACT[95]	42.12	34.15	36.78
VIC	41.21	32.62	35.13
QLD	40.03	34.91	37.60
SA	43.23	34.06	36.68
TAS	32.16	25.62	27.59
NEM	40.99	33.46	36.03

95 Separate values for ACT and NSW could not be derived using Department of the Environment and Energy as ACT consumption data is not separated out from NSW

6 Validation and robustness of results

This chapter sets out the different methods we have used to check the validation and robustness of results, and better understand the underlying drivers of the results. This includes:

- face validity or 'sense' checks
- sample demographic checks against general population statistics
- comparison to modelling approaches
- our quality assurance process
- our data sources and data cleaning process.

6.1 Face validity checks

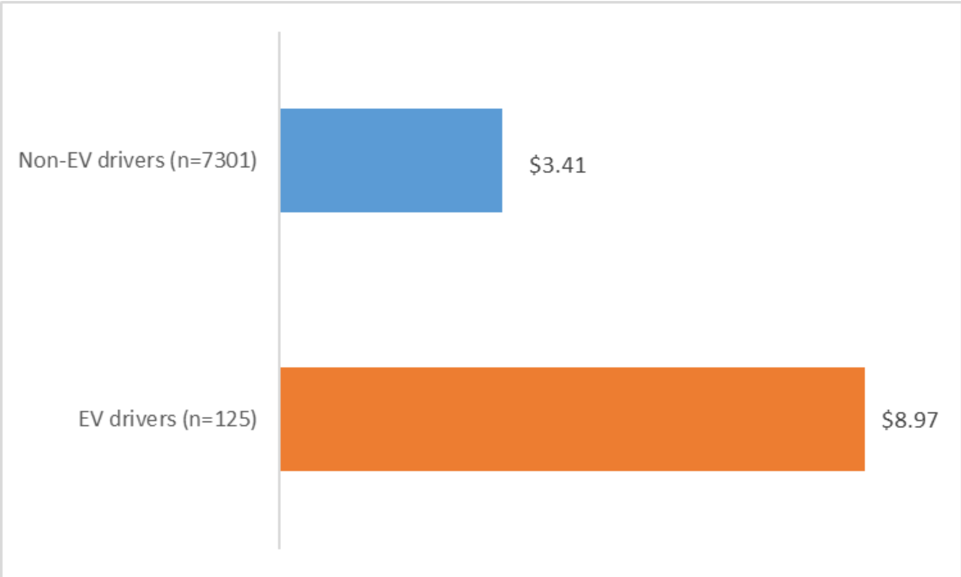
As a check of our survey data KPMG/Insync considered whether the data from the survey has "face validity".[96] By observing the WTP of different residential electricity customers we can see whether the results of the survey are consistent with what one might assume about the WTP of different customers. Broadly, it was found these observations are consistent with expectations. For example, residential owners of electric vehicles and those who live more comfortably are willing to pay more for reliability than other customers. As these observations of the data are in line with general expectation, we consider this lends face validity to the data we collected.

Electric vehicles (residential)

Analysis of WTP survey data shows that residential customers with electric vehicles have a higher WTP than those who do not. One factor this may reflect is owners of electric vehicles are likely to be more reliant on the availability of electricity at their residence for some of their transport needs than residential customers who do not own electric vehicles.

96 Face validity is a term used in the survey industry to test whether a survey result accords with reasonable expectations of a likely result.

Chart 6.1: Electric vehicles (residential customers) WTP ($/month)

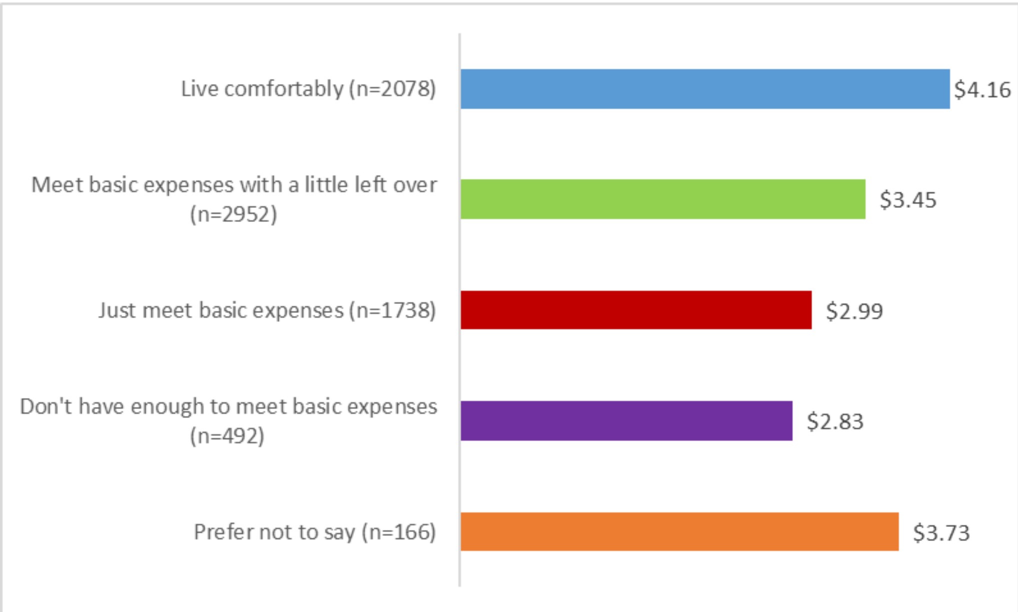


Source: KPMG/Insync analysis

Current financial situation (residential)

We found those who live comfortably had a higher WTP than those who meet basic needs.

Chart 6.2: Current financial situation (residential customers) WTP ($/month)

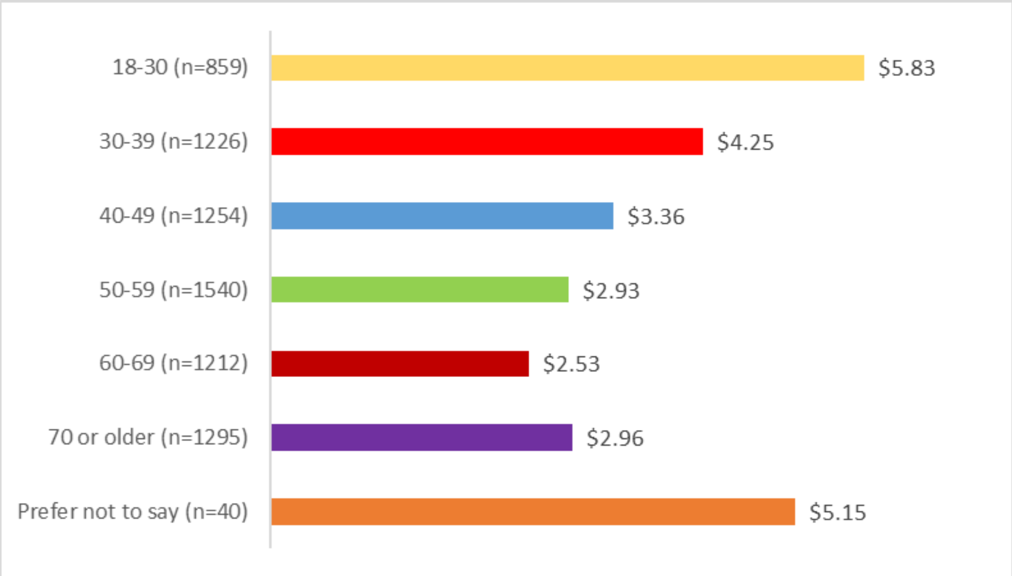


Source: KPMG/Insync analysis

Age group (residential)

We found younger age groups are WTP more than older age groups.

Chart 6.3: Age group (residential customers) WTP ($/month)



Source: KPMG/Insync analysis

6.2 Sample demographics

As part of our analysis, we segmented the survey sample based on different demographic characteristics. As a check on the robustness of the results, we compared these to general population statistics for broad consistency (noting there are a number of reasons why the proportions may reasonably diverge). This allowed us to check if different demographics were appropriately represented in the sample, and whether there were sufficient responses to robustly consider segmented VCR values.

Tables 6.1 to 6.5 show the segmentation of our sample based on different demographic characteristics, and the corresponding general population segmentation. This shows:

- The VCR sample segments are reasonably consistent with general population statistics.
- There are some segments of the VCR sample that, consistent with general population statistics, have a small proportion of respondents. This includes remote and very remote Australia, and people with a non-binary gender or who prefer not to say. As such, stand-alone VCRs for these segment categories may not be robust.

Table 6.1 - Remoteness classification (ARIA index)

Remoteness classification	Proportion of VCR survey sample (%)	Proportion of AU population (%)
Major cities of Australia (inc. CBD)	68	72
Inner regional Australia	22	18
Outer regional Australia	10	8
Remote Australia	1	1
Very remote Australia	0	1

Source: AER calculations; KPMG, Insync, *Value of customer reliability main survey report*, November 2019, p. 39; ABS, *3218.0 - Regional Population Growth, Australia, 2017-18*, Table 1, March 2019.

Table 6.2 - Age

Age (years)	Proportion of VCR survey sample (%)	Proportion of AU population (%)
18-30	12	17
30–39	17	14
40–49	17	13
50–59	21	12
60–69	16	10
70 or older	17	11
Prefer not to say	1	-

Source: AER calculations; KPMG, Insync, *Value of customer reliability main survey report*, November 2019, p. 40; ABS, *3101.0 - Australian Demographic Statistics, Mar 2019, Tables 8* and 59 September 2019.

Table 6.3 - Gender

Gender	Proportion of VCR survey sample (%)	Proportion of AU population (%)
Female	58	51
Male	41	49
Prefer to self-describe or prefer not to say	1	0*

Source: AER calculations; KPMG, Insync, *Value of customer reliability main survey report*, November 2019, p. 40; ABS, *2071.0 - Census of Population and Housing: Reflecting Australia - Stories from the Census, 2016 Table 3*, March 2018.

Note * ABS data reports data by male/female sex only. However, the 2016 census articles noted there were 1,260 people who gave an intentional and valid sex and/or gender diverse response. This was included in the proportion of AU population statistics in this table. See https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by Subject/2071.0~2016~Main Features~Sex and Gender Diversity: Characteristics of the Responding Population~103.

Table 6.4 - Household size

Household size	Proportion of VCR survey sample (%)	Proportion of AU population (%)
Single person	20	25
Multiple people	80	75

Source: AER calculations; KPMG, Insync, *Value of customer reliability main survey report*, November 2019, p. 41; ABS *65230DO009_201718 Household Income and Wealth, Australia: Summary of Results, 2017–18, Table 9.3*, July 2019.

Table 6.5 - Business segment

Cohort	Proportion of VCR survey sample (%)	Proportion of AU population (%)
Agriculture	7	8
Industrial	20	28
Commercial	73	63

Source: AER calculations; KPMG, Insync, *Value of customer reliability main survey report*, November 2019, p. 42; ABS, *8165.0 - Counts of Australian Businesses, including Entries and Exits, June 2014 to June 2018, Table 1*, February 2019. .

6.3 Comparison to model based approaches

6.3.1 Leisure time approach

The main modelling approach proposed during the course of the VCR review was the "leisure time" approach, by Energy Consumers Australia. This is an alternative method of calculating an energy consumers' WTP to avoid outages using the value of a customer's leisure time. Leisure time is the amount of time not devoted to working or personal care (sleeping, eating, personal hygiene etc.). This method is outlined by Cambridge Economic Policy Associates (CEPA) in their analysis of Value of Lost Load (VoLL) in Europe.[97] CEPA use this approach to calculate VoLL (VCR), which is based on the assumption that the VoLL of households is largely driven by the interruption of leisure (for example, leisure time requires electricity and so, without it, the value of leisure time decreases).

This approach requires assumptions to be made about the proportion of leisure activities dependent on electricity, as well as the leisure value of the unemployed and retirees. This approach does not consider the value residential customers place on personal care (for example, cooking) or on working from home.

Applying CEPA's approach and assumptions and using Australian data[98] results in an average residential VCR of $20.6/kWh. This is broadly consistent with our NEM residential VCR of $24.08/kWh.

6.4 Quality assurance process

We undertook extensive quality assurance of the VCR values. This was based on internal and external review of the VCR value results, calculations, code and/or input data, including the following:

- contingent valuation results
- choice modelling results
- business and residential bill and consumption profiles
- peak factors (for business)
- residential and business customer outage probabilities
- residential customer $/kWh VCR calculations
- business customer $/kWh VCR calculations
- direct cost survey outage probabilities
- direct cost survey $/kWh VCR calculations

The contingent valuation and choice modelling results were independently calculated by the AER and KPMG/Insync and cross checked to identify and reconcile discrepancies. MEI

97 Study on the Estimation of the Value of Lost Load of Electricity Supply in Europe, CEPA, July 2018, pp. 82-85.

98 ABS Catalogue numbers 6202, 6302, 2071, Australian Taxation Office Weekly Tax Table 2018-19, AER Energy Consumption Benchmarks for residential customers.

independently ran pooled residential and business models to verify results. MEI also reviewed the calculations and input data used by the AER to derive the VCR $/kWh calculations.

The AER internal reviews were performed by AER staff members and internal experts from the ACCC's Legal and Economic Division.

6.5 Data sources and data cleaning process

6.5.1 Data sources

We used a number of public data sources for several aspects of the VCR review. We also received some non-public data from AEMO and DNSPs. We have set out these data sources below.

Deriving Residential annual consumption amounts and consumption profiles to calculate USE for each outage scenario

- Interval data provided by ACIL Allen [unpublished]
- AER, Energy Consumption Benchmarks, https://www.aer.gov.au/retail-markets/retail-guidelines-reviews/electricity-and-gas-bill-benchmarks-for-residential-customers-2017

Assigning proxy climate zone consumption profiles for climate zones 1 and 3

- Bureau of Meteorology
    - o 30-year average daily mean, maximum and minimum temperatures July and February, http://www.bom.gov.au/jsp/ncc/climate_averages/temperature/index.jsp
    - o 30-year average monthly relative humidity 9am and 3pm, July and February http://www.bom.gov.au/jsp/ncc/climate_averages/relative-humidity/index.jsp

Assigning Climate Zones to postcodes

- ABCB Climate Zones by Local Government Area
    - o Climate Zone map: Australia Wide, https://www.abcb.gov.au/Resources/Tools-Calculators/Climate-Zone-Map-Australia-Wide
    - o Climate Zone map: New South Wales and Australian Capital Territory, https://www.abcb.gov.au/-/media/Files/Resources/Tools-and-Calculators/ClimateZoneMapNSW.pdf
    - o Climate Zone map: Victoria, https://www.abcb.gov.au/-/media/Files/Resources/Tools-and-Calculators/ClimateZoneMapVIC.pdf
    - o Climate Zone map: Queensland, https://www.abcb.gov.au/-/media/Files/Resources/Tools-and-Calculators/ClimateZoneMapQLD.pdf
    - o Climate Zone map: South Australia, https://www.abcb.gov.au/-/media/Files/Resources/Tools-and-Calculators/ClimateZoneMapSA.pdf
    - o Climate Zone map: Tasmania, https://www.abcb.gov.au/-/media/Files/Resources/Tools-and-Calculators/ClimateZoneMapTAS.pdf

- Climate Zone map: Northern Territory, https://www.abcb.gov.au/-/media/Files/Resources/Tools-and-Calculators/ClimateZoneMapNT.pdf

- Correspondences between Local Government Areas and Postcodes
  - Australian Government, ASGS Coding Indexes 2016, https://www.data.gov.au/dataset/ds-dga-1646f764-82ad-4c21-b49c-63480f425a4a/details, 2017 Locality to 2017 LGA coding index
- Australia Post, Find a Postcode, https://auspost.com.au/postcode/

Assigning remoteness categories to postcodes

- ABS, 1270.0.55.005 - Australian Statistical Geography Standard (ASGS): Volume 5 - Remoteness Structure, July 2016, Correspondence, 2017 Postcode to 2016 Remoteness Area, Table 3
- Australia Post, Find a Postcode, https://auspost.com.au/postcode/

Deriving Outage scenario relative probabilities (Residential and Business)

- Data reported to AER
  - Category Analysis Regulatory Information Notice 2018 from each DNSP
  - Annual Reporting Regulatory Information Notice 2018 from each DNSP
- For residential probabilities only - Data provided to AER by DNSPs
  - Postcode location data and customer number data for customers served by each feeder [unpublished]

Deriving Outage scenario relative probabilities (Direct Cost survey)

- AEMO list of transmission reliability events [unpublished]

Weighting VCR Residential Numbers to State, Territory and NEM values

- Australian Government, ASGS Coding Indexes 2016, https://www.data.gov.au/dataset/ds-dga-1646f764-82ad-4c21-b49c-63480f425a4a/details, 2017 Locality to 2016 SA2 coding index
- ABS, 3235.0 – Regional Population by Age and Sex, Australia, 2018 - Population Estimates by Age and Sex, Regions of Australia, Table 3
- AER, Energy Consumption Benchmarks, https://www.aer.gov.au/retail-markets/retail-guidelines-reviews/electricity-and-gas-bill-benchmarks-for-residential-customers-2017

Weighting small/medium and large business VCRs into business VCRs

- AEMO, Market Settlement and Transfer Solutions, NMI counts and consumption amounts by state and customer type [unpublished].

Weighting residential, business and direct cost survey VCRs into state and NEM VCRs (to be calculated)

- AEMO, Market Settlement and Transfer Solutions, NMI counts and consumption amounts by state and customer type [unpublished].

- Australian Energy Update 2019, Table F: Australian energy consumption in Australia, by state, by industry, and fuel type, energy units https://www.energy.gov.au/publications/australian-energy-update-2019
- AER RIN data on load weightings between Transmission and Distribution NSPs

Deriving Business usage factors for different outage scenarios

- 2018 Operational Demand by NEM region
- Weighting between sectors for each NEM region
- Australian Energy Update 2019, Table F: Australian energy consumption in Australia, by state, by industry, and fuel type, energy units https://www.energy.gov.au/publications/australian-energy-update-2019

Estimating surveyed businesses annual consumption based on surveyed average bill amounts

- ACCC: Effective c/kWh Small/Medium Enterprise and Commercial and Industrial, Inquiry into the National Electricity Market – August 2019 Report, pp. 95-96.

Estimating Leisure Value

- Study on the Estimation of the Value of Lost Load of Electricity Supply in Europe, CEPA, July 2018, pp. 82-85.
- ATO, Australian Taxation Office Weekly Tax Table 2018-19, https://www.ato.gov.au/uploadedFiles/Content/MEI/downloads/Weekly-tax-table-2018-19.pdf
- ABS, 6202, Labour Force, Australia, Tables 1 and 19, January 2019
- ABS, 6302, Average Weekly Earnings, Table 2, November 2018
- ABS, 6291, Labour Force, Australia, Detailed, Table 2, December 2018
- AER, Annual Report on Compliance and Performance of the Retail Energy Market 2017-18 (Consumption amounts)

Generating visual maps of residential VCR cohorts

- ABS digital boundaries
  - ABS, 1270.0.55.001 – Australian Statistical Geography Standard (ASGS): Volume 1 – Main Structure and Greater Capital City Statistical Areas, July 2016, State and Territory (STE) ASGS Ed 2016 Digital Boundaries in ESRI Shapefile Format
  - ABS, 1270.0.55.003 - Australian Statistical Geography Standard (ASGS): Volume 3 - Non ABS Structures, July 2016 , Postal Areas ASGS Ed 2016 Digital Boundaries in ESRI Shapefile Format
- **Converting AEMO results from Nominal 2014 to $2018-19 Real**
- ABS, 6401.0 – Consumer Price Index, Australia, all groups index numbers, June 2019

Survey demographics analysis

- ABS, 3218.0 – Regional Population Growth, Australia, 2017-18, Table 1, March 2019
- ABS, 3101.0 – Australian Demographic Statistics, Mar 2019, Table 8, September 2019
- ABS, 2071.0 – Census of Population and Housing: Reflecting Australia – Stories from the Census, 2016, Table 3, March 2018
- ABS, 6523.0 – Household Income and Wealth, Australia: Summary of Results, 2017-18, Table 9.3, July 2019.
- ABS, *8165.0 - Counts of Australian Businesses, including Entries and Exits, June 2014 to June 2018, Table 1*, February 2019
- ABS, 3235.0 – Regional Population by Age and Sex, Australia, 2018 - Population Estimates by Age and Sex, Regions of Australia, Table 3

6.5.2 Data cleaning process

KPMG/Insync undertook a review of the survey responses to check for responses with potential problems. Responses were reviewed to check issues such as:

- responses from outside the NEM and NT (using postcodes provided by respondents)
- bill amounts that did not appear to match other information provided in the survey
- survey completion time
- comments provided in open text boxes[99].

Identified issues were flagged to the AER for review. Several responses were removed as they related to residential and/or business sites in Western Australia.

For the business survey we also reviewed with KPMG/Insync responses that selected 'other' when asked to identify which ANZSIC sector grouping best describes their business. A review of the descriptions of their business was undertaken to determine whether they should be reclassified into another ANZSIC sector group or remain in the 'other' grouping. This process resulted in the majority of 'other' responses being reclassified into one of the other ANZSIC sector groupings.

99 This was only done for open link survey responses and CATI to online responses. Online panels did not have a free text box at the end.

7 Preliminary views on application of VCRs and Next steps

7.1 Application of VCRs - preliminary views

We intend to monitor the application of the published VCR values to check they are being applied correctly. We encourage those applying the published VCR values to contact us to work through any application issues they identify.

If stakeholders have any questions about any information contained in this report or would like to discuss application issues with the AER please contact aerinquiry@aer.gov.au.

Some of the applications of VCR are outlined below with our preliminary views on how they should be applied in those contexts.

7.1.1 Application to network planning

VCR plays an important role in network planning to estimate the reliability benefits associated with proposed network and non-network investments. For example, in the regulatory investment test VCR is used to estimate the market benefits associated with changes in involuntary load shedding. We consider that standard outage VCRs are sufficient for the majority of network planning applications.

Importantly, any investment decisions where VCR is applied should use a VCR value reflective of the affected customer composition on the network. For example, an investment decision in a substation should reflect the composition of residential and business customer types at that substation. Our values suggest network investments in residential areas will face a higher cost benefit hurdle than an area dominated by industrial customers because of the lower value of residential VCRs.

7.1.2 Review of NEM reliability standard

The Energy Security Board (ESB) has been tasked to by the COAG Energy Council to provide advice on the implementation of interim measures to preserve reliability and system security in the National Electricity Market, including reviewing the reliability standard, during the transition to the 2025 market design. This is to be achieved by using existing mechanisms where possible, and the ESB advice is to be provided for Council consideration and decision by March 2020. The ESB review of the reliability standard should, among other things, include a cost/benefit analysis and impacts on prices for consumers by jurisdiction.[100] The VCR may form an input into the ESB review of the reliability standard.

[100] The ESB scope of work can be found at http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Reliability%20and%20Security%20Measures%20-%20Scope%20of%20work.pdf.

Under the NER, the Reliability Panel is tasked with the standing review of the NEM reliability standard. The basis of this review is set out in the rules and the Reliability Standard and Settings Review Guidelines. In the context of the NEM, VCR is used by the Reliability Panel:

- as one of the two key factors to consider in determining whether there would be a material benefit in reassessing the reliability standard. The other consideration is any changes made to the way which consumers use electricity that suggests a large number of customers may place a lower or higher value on the reliable supply of electricity in the NEM (for instance, due to the technology change such as the take up of roof-top solar and residential batteries)
- to help calibrate the level of the standard by understanding the value which customers place on reliability so this can be considered against the cost of providing that reliability. The Panel is: "to have regard to estimates of the value placed on reliability by customers when exercising its judgement as to the level of the standard. The reliability settings (including the market price, cumulative price threshold and administered price cap) should be sufficient to support the level of investment necessary to deliver the standard, over the long run.

Further information on how the VCR is used in the Reliability Panel's assessment of the NEM reliability standard and market settings can be found in the Guidelines published by the Reliability Panel.[101]

The VCR values published in this report could assist reviews of the NEM reliability standard and settings by helping to understand the value customers place on certain interruptions to supply which they would likely experience as a result of the reliability standard not being achieved. The relevant interruptions to supply would be those that fall within the definition of standard outages for which the published VCR values in this report are applicable. More severe interruptions to supply may be valued using widespread and long duration VCRs, provided they fall within the definition of widespread and long duration outages which we have used[102]. Our VCR values for widespread and long duration outages will be published in early 2020.

7.1.3 Reliability and Emergency Reserve Trader (RERT)

From 26 March 2020, VCR will also play a role in the operation of the Reliability and Emergency Reserve Trader (RERT) mechanism, when a number of enhancements to the RERT will come into effect. The RERT is the NEM's strategic reserve and has formed part of the reliability framework since the start of the NEM. The RERT allows AEMO to procure 'standby' emergency reserves when a supply shortfall is forecast; and to date, has typically been used when extreme heatwaves are predicted. The RERT is used as a last resort to help avoid larger and more widespread blackouts from occurring. One enhancement is the creation of a new principle that provides AEMO with guidance when entering into RERT

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101 Available at https://www.aemc.gov.au/sites/default/files/content/4d5fb7a2-5143-4976-a745-217618b49e73/REL0059-Final-guidelines.PDF.

102 The VCRs on widespread and long duration outages cover outages with a total unserved energy ranging from 1 to 15 GWh. These VCRs quantify the socio-economic costs associated with the loss of supply caused by the outage. Importantly, we do not explore what the probability of widespread and long duration outages occurring is.

contracts; with the principle being that the RERT costs should not exceed the average VCR. This is intended to provide guidance to AEMO when entering into emergency reserve contracts to consider whether or not the costs associated with these are reasonable.

To give effect to these changes AEMO is currently consulting on updates to their procedures for the exercise of RERT. This includes consultation on the basis for determining the average VCRs. AEMO published a draft decision on 6 December which proposed the use of energy-weighted average aggregate VCRs (or equivalent) published for each region.

We have not had the opportunity to give detailed consideration to what the appropriate average VCR would be from our published results. We think it is likely that an important factor to take into account when determining average VCR is that the purpose of the RERT is to avoid manual load shedding. We therefore consider that the VCR used for this purpose should consider the composition of load which would be shed were RERT services not to be deployed.

7.2 VCR confidence intervals for sensitivity analysis

Where VCR values are applied in analysis, confidence intervals can be used to determine how sensitive the results are to changes in VCR.

Confidence intervals for our choice modelling results are published in the VCR Final report appendix. It is not appropriate to use these confidence intervals to determine confidence intervals for the published VCR values, because there is no information on the standard errors and confidence intervals of other data inputs used to derive the VCR values.

Given the number of data inputs used to produce the $/kWh VCR estimates, we consider that sensitivity ranges of up to +/- 30 per cent could be used. This is broadly consistent with the confidence interval ranges applied to VCR estimates produced in previous studies. Taking into account the contexts where VCR is applied (such as network planning), large ranges will often be required as small changes in VCR will often not change the outcome of an assessment.

7.3 VCRs for widespread and long duration outages

We are currently continuing our work on VCRs for widespread and long duration outages and intend to publish our results, including the underlying model, in early 2020.

7.4 Annual adjustment of published VCRs

Both the VCR values published in this and the VCRs for widespread and long duration outages will be updated annually in accordance our VCR methodology.

Attachment 1 - AER VCR methodology

Table A1.1: Methodology for standard outages

Standard outages	
Residential and business customers with a peak demand of less than 10 MVA	Stated preference surveys using combined contingent valuation and choice experiment techniques. *Contingent valuation* The contingent valuation technique asks a respondent two closed questions followed by one open-ended question about their willingness to pay (WTP) to avoid two unexpected power outages a year (the baseline scenario) affecting either the home of a residential customer or the specified place of business of a business customer. Each unexpected outage in the baseline scenario occurs on a different random weekday in winter and lasts for one hour during off-peak times. Each outage only affects the local area. The closed questions present a respondent with a bill increase of $x and ask the respondent to indicate (YES or NO) as to whether they would be willing to pay the $x bill increase to fund network investment and avoid the baseline scenario. The bill increase of $x for the first closed question is randomly selected. The second closed question is double the first cost prompt if the respondent answers YES to the first question and is half the first cost prompt if the respondent answers NO to the first question. The initial cost prompts for residential customers are the following monthly bill increase amounts: $2, $3, $4, $5, $6, $7, $8 and $9. The initial cost prompts for business customers are the following bill increase percentage amounts: 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9% and 10%. The open-ended question following the closed questions asks respondents to indicate the maximum bill increase they would be willing to pay to avoid the baseline scenario. Responses to the open-ended question are capped. For residential customers the cap is $22 per month, which is the approximate cost of a backup power system which can supply a household for the duration of the baseline scenario.[103] Where a respondent enters a value more than the cap, they will be asked a follow up question as to whether they would be willing to pay $22 per month to install the described backup power system. If the respondent answers NO, they will then be presented with an open-ended question asking them how much they

[103] Appendix 4 of our *Draft decision* discusses how we set the cap of $22 per month.

	would be willing to pay to install the described backup power system. For business customers the cap is equal to 100 percent of their indicated electricity bill. *Choice experiment* The choice experiment technique asks respondents to identify their most preferred option out of a series of choices with different outage characteristics such as duration, severity (widespread / localised), time of day, time of week and time of year they occur in. The trade-offs customers make in choosing between options with different characteristics are used to determine the relative value respondents place on each of these attributes. The choice experiment technique presents respondents with eight different sets of three hypothetical outage scenarios that ask respondents to select their preferred outage scenario in each set. Each outage scenario includes a specified bill discount which a customer would receive if they choose to accept the outage scenario. Each set of outage scenarios contain the baseline scenario with no bill discount. The other two scenarios in each set are variations of the baseline scenario with changes to the severity (level) of one or more attributes (characteristics) of the outage. The attributes and levels tested in the choice experiment are: • Outage duration: 1 hour, 3 hours, 6 hours and 12 hours • Geographic impact: 'localised' and 'widespread' • Time of day: Peak time and Off-peak time • Season: Summer or Winter • Day of the week: Weekday or Weekend • Bill discount (residential): no change, \$3 per month, \$7 per month and \$15 per month • Bill discount (business), no change, 1%, 2% and 3%.
Business customers with peak demand of equal or greater than 10 MVA	*Direct cost survey* The direct cost survey asks respondents to outline and quantify the actual costs they expect to incur as a result of an unplanned outage affecting their identified business site. There are two versions of the survey - one for business sites with continuous 24/7 operations and one for business sites with non-continuous operations. For customers with continuous 24/7 operations, respondents are asked to outline and quantify the costs they would expect to incur in an unplanned outage of the following durations: 10 minutes, 1 hour, 3 hours, 6 hours, 12 hours, 24 hours and 48 hours. For customers with non-continuous operations, respondents are asked to outline and quantify the costs they would expect to incur for: • unplanned outages that start at peak times (between 7am and 10am, or 5pm and 8pm on a weekday) for the following durations: 10

	minutes, 1 hour, 3 hours and 6 hours • unplanned outages that occur at off-peak times (anytime except between either 7am and 10am or 5pm and 8pm), on a weekday for the following durations: 10 minutes, 1 hour, 3 hours and 6 hours • unplanned outages that start at any time and have the following durations: 12 hours, 24 hours and 48 hours.

Table A1.2: Methodology for widespread and long duration outages

Widespread and long duration outages	
All customers	Macro-economic modelling of outage scenarios supplemented by other appropriate approaches. The set of outage scenarios include outages of increasing severity from 1-2 GWh to 15 GWh of unserved energy. The modelling of outage scenarios estimates economic costs associated with the outage scenarios. To the extent possible, the modelling also seeks to capture social costs that may be incurred. This modelling may be informed by supplementary information from ex-post reviews of comparable historical outages. With the costs of different outage scenarios modelled, we will derive a curve that best fits the modelled costs of these different outage scenario that describes the impact of increasing severity of outages on VCR.

Table A1.3: Methodology for annual adjustment mechanism

Annual adjustment mechanism
Published values will be adjusted on an annual basis using a CPI-X approach, where X is set to zero. This ensures that in economic terms, real values of VCR are maintained between VCR reviews. Due to the lack of available information on what the key drivers of changes in customer reliability preferences are and how they affect VCR, X is set to zero. We consider these difficulties are likely to remain an impediment to calculating a non-zero X in the near future. The AER welcomes further discussions with stakeholders on how real changes in VCR could be monitored annually, prior to the next review. To measure CPI changes we will apply the annual percentage change in the Australian Bureau of Statistics' (ABS) consumer price index (CPI) all groups, weighted average of eight capital cities, for the four quarters preceding the most recently reported figure.[104] For example, to publish annual adjustments in December, we will use the reported CPI figures for the four quarters preceding

[104] ABS, Catalogue number 6401.0, Consumer price index, Australia. We note this measure is consistent with our approach to indexation employed elsewhere by the AER, for example to index network business' regulatory asset bases.

September, which are the most recently reported figures available.

ΔCPI_t is the annual percentage change in the ABS CPI All Groups, Weighted Average of Eight Capital Cities[105] from the September quarter in regulatory year t–2 to the September quarter in regulatory year t–1, calculated using the following method:

> The ABS CPI All Groups, Weighted Average of Eight Capital Cities for the September quarter in regulatory year t–1
>
> divided by
>
> The ABS CPI All Groups, Weighted Average of Eight Capital Cities for the September quarter in regulatory year t–2
>
> minus one.

For example, for the 2021 regulatory year, t–2 is September quarter 2019 and t–1 is September quarter 2020; and for the 2022 regulatory year, t–2 is September quarter 2019 and t–1 is September quarter 2020 and so on.

Table A1.4: Methodology for converting VCR survey results into dollars per kilowatt hour ($/kWh) VCR values and aggregating values

Converting survey results into dollars per kilowatt hour ($/kWh) and aggregating values	
Deriving $/kWh standard outage VCR for each residential segment	For each residential customer segment, the contingent valuation and choice experiment results are combined to produce a dollar value for a range of outage scenarios relevant for customers in that segment. To convert into $/kWh values, the dollar value are divided by an estimate of the consumption which a residential customer would have consumed over the period had the outage not occurred. This estimate is based on residential consumption data obtained from one or more of the following sources: • the residential survey • network business data, or • other available sources (actual or estimated) of residential consumption data. An aggregate $/kWh for each residential cohort is derived by summing the probability-weighted $/kWh VCR of each outage scenario. The probability for each outage scenario is based on estimates derived from historical network outage data.
Deriving $/kWh standard outage VCR	The contingent valuation and choice experiment results for

105 If the ABS does not or ceases to publish the index, then CPI will mean an index which the AER considers is the best available alternative index.

for each business segment with a peak demand of less than 10 MVA	each business segment are in % of bill terms. These results are converted to dollar terms using estimates of business customer bills. Different bill assumptions may be used to account for consumption size and/or business sector. The dollar contingent valuation and choice experiment results are combined to produce a dollar value for a range of outage scenarios relevant for customers in that segment. To convert into $/kWh values, the dollar value is divided by an estimate of the consumption which a business customer would have consumed over the period had the outage not occurred. This estimate is based on business consumption data obtained from: • the business survey • network business data, or • other sources (actual or estimated) of business consumption data. An aggregate $/kWh for each business cohort is derived by summing the probability-weighted $/kWh VCR of each outage scenario. The probability for each outage is based on estimates derived from historical network outage data.
Deriving $/kWh standard outage VCR for business customers with peak demand greater than or equal to 10 MVA	The responses from the direct cost survey produce a dollar value for the outage scenarios asked in the survey. To convert into $/kWh vales, the dollar value for each outage is converted using energy consumption data obtained from the direct cost survey. An aggregate $/kWh for each business customer is obtained by summing the probability-weighted $/kWh VCR of each outage scenario. The probability for each outage is based on estimates derived from historical network outage data. The aggregate $/kWh for each response is load-weighted with other direct cost survey response, on the basis of industry or sector groupings, to produce a combined industry or sector $/kWh VCR.
Aggregating VCRs	Aggregate VCRs for a particular area or region are derived by load-weighting the relevant aggregate residential and business cohort VCRs (including combined aggregate industry or sector $/kWh VCRs for business customers with peak demand greater than or equal to 10 MVA).

Attachment 2 - Main survey choice set design

The key inputs, settings and parameters used in NGENE for designing the main residential and business choice sets were as follows.

- Separate D-efficient designs were constructed for residential and business customers
- Residential and business pilot survey choice modelling results were used to give prior parameter values informing the relative importance of attributes, improving the efficiency of each design with the use of the SC (swapping and cycling) algorithm to generate the choice sets
- 40 choice set exercises, each with three outage scenarios, were created using a standard logit model and using the blocking column feature to divide the exercises into 5 blocks. MEI analysis using NGENE found that 40 choice set exercises, divided into 5 blocks with 8 exercises each, was sufficient to provide the variation needed to produce estimates
- The design were optimised for main effects and not interaction effects
- The 'no change' level for the 'change in your bill' attribute was only included in the baseline outage scenario. Otherwise the distribution of attribute levels across the choice sets was approximately balanced

Attachment 3 - Climate zone and remoteness mapping

Mapping Climate Zones to postcodes

We used the following data to map Climate Zones to postcodes:

- ABCB Climate Zone maps and tables for each NEM region[106]
- ABS coding index that maps 2017 postcodes to 2017 Local Government Areas[107]

The ABCB has adapted Bureau of Meteorology climactic data to designate eight separate climate zones to each Local Government Area (LGA) in Australia. In our analysis, we combined Climate Zone 8 (alpine) into Climate Zone 7 (cool temperate). A small number of LGAs, due to their large size, have been designated two different climate zones. For these LGAs, we have assigned the Climate Zone that occupies the majority of the area within the LGA. This approach results in a designation of one of seven climate zones for each LGA.

We then used an ABS coding index that maps postcodes to LGAs to assign a climate zone to each postcode. A number of postcodes feature complex boundary shapes and can be situated within multiple LGAs. A subset of these postcodes fall into a set of LGAs that have been designated different climate zones. In these instances we assigned to the postcode the climate zone of highest heat stress. This approach results in a designation of one of seven climate zones for each postcode in the ABS coding index.

We made a small number of further manual adjustments to climate zone designations for some postcodes reflecting that some postcodes in the NEM:

- are unincorporated and do not have an LGA,
- do not appear in the ABS coding index, or
- feature particularly complex boundaries, such as non-contiguous shapes.

For these postcodes we assigned the same climate zone as the neighbouring postcodes in a manner that is most consistent with the ABCB Climate Zone mapping.

The full list of Climate Zones by postcode can be found in the VCR Final report appendix.

Mapping Remoteness to postcodes

We used ABS data[108] to map remoteness to postcodes. This data provides the proportion of land within each postcode falling into one or more of five remoteness categories. These remoteness categories are based on the Accessibility and Remoteness Index of Australia

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106 Maps for Australia and each State and Territory can be found at ABCB, Climate Zone map: Australia Wide, https://www.abcb.gov.au/Resources/Tools-Calculators/Climate-Zone-Map-Australia-Wide.

107 Australian Government, ASGS Coding Indexes 2016, https://www.data.gov.au/dataset/ds-dga-1646f764-82ad-4c21-b49c-63480f425a4a/details, 2017 Locality to 2017 LGA coding index.

108 ABS, 1270.0.55.005 - Australian Statistical Geography Standard (ASGS): Volume 5 - Remoteness Structure, July 2016, Correspondence, 2017 Postcode to 2016 Remoteness Area, Table 3.

(ARIA+) produced by the Hugo Centre for Migration and Population Research at the University of Adelaide.[109] The remoteness categories are Major Cities of Australia, Inner Regional Australia, Outer Regional Australia, Remote Australia and Very Remote Australia

Where a postcode has areas falling into multiple remoteness categories, we assigned the least remote category to the postcode. We have subdivided the Major Cities of Australia remoteness category into CBD and suburban subcategories and have designated particular postcodes with the CBD category based on discussions with Network Service Providers and feeder location data provided by NSPs.[110]

The full list of remoteness categories by postcode can be found in the VCR Final report appendix.

[109] The Hugo Centre, University of Adelaide, Accessibility/Remoteness Index of Australia, https://www.adelaide.edu.au/hugo-centre/services/aria

[110] We assigned a CBD category to postcodes where a majority of customers within the postcode were served by feeders that have been designated CBD feeders per the Service Target Performance Incentive Scheme.

Attachment 4 - Analysis of business WTP results

The average WTP of 14.2 per cent of business customers <10MVA peak demand per annum is higher than the average WTP of business customers calculated by AEMO in its 2014 review of VCR. This could in part be explained by a change in methodology. The AEMO 2014 methodology differed in three key ways:

1. The AER 2019 survey asked closed questions and an open-ended follow-up question for all respondents. AEMO asked closed questions and an open-ended follow-up only for those responding NO-NO or YES-YES.

2. AEMO used minimal assumptions for those responding NO-YES or YES-NO. The minimal assumptions used the minimum possible WTP consistent with the answers to the closed questions. The effect of this assumption is likely to understate WTP.

3. on average AEMO used lower initial cost prompts

However, in addition to these methodology differences, our analysis suggests the different results are also partly explained by a real change in business WTP since 2014.

We examined the results where the AER 2019 and AEMO 2014 methodology is exactly the same. That is, where respondents were given the same initial cost prompt and responded NO-NO or YES-YES. In this situation both the AER and AEMO followed up with an open-ended question and used it as the WTP result. We found that, on average, the response to the AER 2019 question is higher, indicating a real change in customer responses to this question. This is indicated in the table below.

Table 1 - AEMO 2014 WTP responses compared to AER 2019 WTP responses

NO-NO or YES-YES	Average maximum WTP (% of bill)	Average maximum WTP (% of bill)
Initial cost prompt	AEMO 2014	AER 2019
1% of bill	5.7	10.9
3% of bill	7.0	14.1
5% of bill	11.6	16.3
7% of bill	11.2	15.1
9% of bill	15.4	17.8

Source: AER staff analysis