VALUE OF CUSTOMER RELIABILITY ISSUES PAPER

PREPARED BY: Corporate Development

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FINAL

Contents

1 Executive Summary

AEMO's National Value of Customer Reliability (VCR) Review will deliver values of customer reliability (VCRs) which can effectively be applied for use in revenue regulation, planning and operational purposes in the NEM.

VCRs are proxies for the level of reliability that customers desire, and are important to NEM development.

AEMO is undertaking this review for a number of reasons:

- In response to the MCE's Review of the Effectiveness of NEM Security and Reliability Arrangements in light of Extreme Weather Events.[1]
- A detailed survey on VCR has not been undertaken in Victorian since VENCorp's (now AEMO's) 2007 survey.
- There are no regional or sector-specific VCRs that could be used for planning and revenue setting purposes.
- Reconciliation is required between the Victorian and NSW VCRs following the AEMC's work on developing a NSW VCR through its NSW workstream on Distribution Reliability Standards and Outcomes.[2]

This Issues Paper is designed to canvass stakeholder views on how to best determine VCRs and under which NEM circumstances planners, system/network operators, regulators and policy makers should apply the values.

To achieve this, several aspects need to be specifically considered for AEMO to develop and calculate more informative VCRs. These relate to:

- Application of VCRs to network planning and regulation
- Relevance to the wholesale energy market
- Approaches to deriving VCRs
- Shortcomings and potential improvements to the development of VCRs

It is expected this review will assist in the development of VCRs that better reflect customer values, which will ultimately drive more efficient market outcomes.

[1] SCER terms of reference, revised in August 2009: http://www.scer.gov.au/workstreams/energy-market-reform/extreme-weather-events/

[2] AEMC review available at http://www.aemc.gov.au/market-reviews/completed/review-of-distribution-reliability-outcomes-and-standards.html

2 Stakeholder consultation process

Stakeholders are invited to submit written responses on the issues and questions identified in this paper by Friday 19 April 2013.

AEMO's indicative timeline for the review is outlined below.

Deliverable	**Timeline**
Issues Paper published	11 March 2013
Submissions due on Issues Paper	19 April 2013
Draft Report published	17 May 2013
Submissions due on Draft Report	14 June 2013
Final Report on methodology and approach published	19 July 2013
Measure VCRs in accordance with the methodology and approach	July – November 2013
Final calculated VCRs published	End December 2013

Where practical within the above review timelines, AEMO will also accommodate requests for meetings with individual stakeholders or public meetings.

AEMO's contact for any queries or further information is Reena Kwong, telephone 03 9609 8492, email *reena.kwong@aemo.com.au*.

AEMO prefers that submissions be forwarded by email as they will be published on AEMO's website. These should be emailed to *reena.kwong@aemo.com.au.*

3 Background

3.1 Purpose of this Issues Paper

In its role as Victorian transmission system planner, AEMO has applied an economic approach to planning which uses VCRs to help value unserved energy. This value is compared to augmentation costs required to meet the unserved energy level, to assess whether proposed augmentations are expected to yield net market benefits in accordance with the criteria in the Regulatory Investment Test for Transmission (RIT-T).

AEMO is developing national VCRs to use across the entire NEM in a move towards determining reliability standard levels that accurately reflect customer reliability expectations in all regions. The first step in developing national VCRs is to determine the methodology and approach to be adopted. The choice of methodology and approach adopted to measure VCRs may be influenced by the use of those VCRs. This Issues Paper is therefore designed to canvass stakeholder views on questions surrounding the determination and use of VCRs by AEMO and a range of potential other parties in the NEM.

These questions fall under the following topics:

- What is the appropriate role and scope of VCRs?
- How have VCRs been derived in the past in Australia and internationally?
- How could determination of VCRs be improved?

The remainder of this Issues Paper discusses these topics in turn.

AEMO notes that the SCER has requested the AEMC, as part of its Extreme Weather Events review, to identify if there is a link between the Reliability Standards and Reliability Settings with a VCR and how these Reliability Standards and Settings (principally the Market Price Cap (MPC)) should be amended to reflect a VCR. Although this Issues Paper will not explore specifically the correlation between a VCR and MPC, it does consider how this could be measured if such a link existed.

Further, the SCER have directed the AEMC to review transmission and distribution reliability national frameworks. These reviews must consider an approach to setting reliability requirements that reflect economically efficient outcomes based on values customers place on electricity supply reliability.[3] The distribution review must be submitted to the SCER by 27 September 2013 while the transmission review is to be submitted by 1 November 2013. The VCRs to be determined through this process may be important in the reliability requirements determined by the AEMC.

AEMO is working collaboratively with the AEMC on these reviews.

3.2 Structure of this Issues Paper

This Issues Paper is structured as follows:

- Section 4 outlines the role and scope of VCRs.
- Section 5 discusses the methodologies that have been used for deriving VCRs.
- Section 6 details the shortcomings of some VCR measures and potential improvements.

[3] SCER Terms of Reference: http://www.aemc.gov.au/Market-Reviews/Open/review-of-the-national-framework-for-transmission-reliability.html

4 Role and scope of VCRs

AEMO acknowledges that the AEMC have been tasked to determine the full role and scope of how the VCR should be used in setting the MPC and the national transmission and distribution reliability standards. Consultation with the AEMC suggests that the VCR will be used to inform the MPC and the national transmission and distribution reliability frameworks.

This section explores the application of VCRs on a broader level.

4.1 Application to network planning

AEMO uses regional VCRs when undertaking transmission planning in Victoria as part of its economic planning process. These VCRs assist AEMO to determine whether a transmission augmentation is likely to yield benefits (such as avoided unserved energy, fuel and capital cost savings) in excess of the augmentation costs across a range of reasonable scenarios. In this way, the VCRs enable AEMO to determine whether a given augmentation satisfies the RIT-T criteria.

To date, most other transmission planners in Australia have applied deterministic planning standards for reliability. Under the former regulatory test, planners were obliged to meet deterministic standards at least cost. This meant they were not obliged to explicitly consider the value of customer reliability, as any reductions in unserved energy other than those necessary to meet deterministic standards did not need to be included.

However, the new RIT-T obliges Transmission Network Service Providers (TNSPs) to consider all of the material benefits and costs of an augmentation. This means that changes in unserved energy beyond those required to meet deterministic standards must be measured and valued. Accordingly, VCR measures are now relevant to all TNSPs in the NEM.

VCRs are currently used by Victorian and South Australian DNSPs for network investment planning, and this may eventually be extended to all DNSPs in the NEM.

A firm belief is evident among other NEM institutions that VCRs will likely become an important part of justifying new distribution investments. For example, the Issues Paper published in January 2013 by the AER on the Regulatory Investment Test for Distribution (RIT-D)[4] notes that distribution planning standards become more output-based when applying VCRs to justify new investment (similar to the RIT-T). Also, the AEMC's Draft Report on Distribution Reliability Outcomes and Standards review recommends that VCRs be used in setting DNSP distribution reliability targets.

Fundamentally, the need for VCRs in network planning arises from the absence of a transparent, real time mechanism for electricity customers to signal the value they place on the continuous supply of electricity. This requires network service providers to estimate the value customers place on continuous supply. Methods by which VCRs have or could be calculated are discussed in Sections 5 and 0 below.

Question 1: In what planning contexts should the VCR be applied?

4.2 Application to distribution network regulation

The AER's current service target performance incentive scheme (STPIS) for distribution network service providers (DNSPs) uses VCR measures to set the incentive rate applicable under the scheme. The VCRs to be used are set out in the AER's November 2009 STPIS guidelines as:

- CBD network segments – $95,700/MWh ($95.7/kWh) adjusted by the CPI from the September quarter 2008
- Other network segments – $47,850/MWh ($47.85/kWh) adjusted by the CPI from the September quarter 2008.

[4] AER review of the RIT-D available at http://www.aer.gov.au/node/19146

The AER's transmission STPIS does not employ VCR measures, perhaps because it already includes a market-impacts component.

Question 2: In what network regulation contexts should the VCR be applied?

4.3 Relevance to the wholesale energy market

The concept of VCRs is relevant to other aspects of the NEM design in addition to network planning. This relevance results from electricity's 'commodity' characteristics – its inability to be stored and the constant supply/demand balance required at all times to maintain system security.

In markets for other commodities and services, consumers can exercise choice around what quantities they choose to buy given different prices in real time. If supply of any given commodity is interrupted or reduced, prices rise and consumers can choose to consume less. The lower demand which results from higher prices helps moderate any price increase and the 'rationing' effect of high prices results in continued consumption only by those who most value the commodity.

Electricity supply operates differently; partly due to its characteristics and partly because consumers typically pay prices set well in advance of their actual consumption. Together, these factors mean that wholesale electricity prices can vary dramatically in real time and there is presently little ability or incentive for consumers to alter consumption in line with fluctuating wholesale prices.

This means that unlike other commodity markets, prices could rise infinitely if an event unexpectedly curtails supply.

4.3.1 Spot market price cap

The NEM is designed to address this potential for an infinite wholesale price by capping prices using the MPC. The MPC allows the market to clear when electricity demand exceeds available supply. The MPC is set by the AEMC Reliability Panel at a level which seeks to ensure that returns are adequate to support sufficient generation to meet the NEM reliability standard.

The NEM reliability standard is that no more than 0.002% of annual energy should be unserved due to a lack of available capacity. The MPC for 2012–13 is $12,900/MWh and it is indexed according to the Consumer Price Index (CPI).

In some respects, the MPC plays a similar role in the wholesale NEM as VCRs play in transmission planning. Both should ideally reflect the price at which consumers would be willing to forego supply—due to insufficient generation or network capacity, respectively—rather than pay more to avoid interruption.

Question 3: If the VCR was to be used for informing the MPC, should it be calculated differently from how it would be calculated for planning and revenue-setting purposes?

4.3.2 Non-market ancillary services

Another aspect of the NEM which requires a value to be placed on supply reliability is the procurement of non-market ancillary services (NMAS). This currently includes the following:

- System restart ancillary services (SRAS), also known as 'black start' services.
- Network control ancillary services (NCAS).

Under the NER, AEMO is obliged to procure primary and secondary SRAS from generators to facilitate a power system restart following an event leading to black system conditions. This raises the question of how much AEMO should pay–on behalf of customers–to procure these services.

Since 2006, AEMO has procured SRAS through a tender process that determines the prices paid. The lack of strong competition evident in this process has contributed to steep increases in SRAS costs, particularly in New South Wales and Tasmania.

The high prices paid for SRAS in Australia compared with many international jurisdictions has raised the question of establishing a cap on the prices that AEMO agrees to pay.

There are some grounds for proposing that AEMO's SRAS costs should use VCRs. However, the nature and implications of events occasioning a black system are likely to differ from the conditions likely to cause interruptions a due to insufficient network infrastructure. For example, black system events tend to be rare and involve relatively long periods of non-supply. In contrast, insufficient network infrastructure generally leads to more frequent, shorter interruptions.

NCAS procurement raises similar issues, however the economic regulation of networks (which mainly supply NCAS) has prevented NCAS costs rising as dramatically as SRAS costs. Using VCRs to cap payment for these ancillary services may be worth considering.

Question 4: To what extent should the methodology for setting VCRs be similar to or different from that used to determine procurement prices for NMAS (such as SRAS)?

Question 5: Are there other NEM contexts where the VCR should be applied?

5 Methodologies for deriving VCRs

5.1 Regional VCRs

To date VCRs have been calculated on a regional basis. However this may not be the best approach in the future given the importance of the differing customer sector-types within each region in determining the VCR.

AEMO's previous consultation process highlighted stakeholder preference for more refined VCRs that reflected more precise details about the type of customer responding and the conditions they face. The AEMC's VCR estimate for NSW (see Section. 5.3.2 below) also considered sector-specific VCRs.

More refined or granular VCRs could be used to assess network investments with localised effects on reliability, particularly distribution network investments. The AER supported greater granularity of VCR measures, suggesting separate VCRs for different feeder classifications (e.g., CBD, urban, long rural and short rural) to help develop its distribution STPIS. As noted above, AER's current distribution STPIS incorporates specific hard-coded values for the CBD and non-CBD VCRs used to set incentive rates.

Additionally, more granular VCRs could be developed based on specific sectors nationally and re-weighted accordingly to their location. This level of detail would require significant information and transparency on customer-type disaggregation (explored further in Section 6.2.2 below). Should there not be sufficient information at present then there will need to be some compromise on the level of granularity of sector-specific VCRs. However, this review would be a valuable platform in obtaining a higher level of customer-type disaggregated information so that more accurate sector-specific VCRs can be calculated in future years.

Question 6: For AEMO's 2013 review, should VCRs be calculated on a regional or sector-specific basis? Why?

Question 7: How could sector-specific VCRs be re-weighted to reflect geographical considerations?

5.2 Type of interruptions from loss of supply

VCR measures are intended to reflect the cost of unserved energy caused by supply interruptions. These costs may take a variety of forms, including the following:

- Inconvenience, stress and discomfort (e.g., loss of home entertainment, cooking facilities, heating and cooling).
- Lost production and/or sales.
- Loss of livestock for agricultural operations.
- Spoiled perishable products.
- Damaged plant and equipment.
- Payment for substitute goods and services (e.g., candles or a restaurant meal).

The costs of a supply interruption (in $/kWh of energy unserved) are likely to vary depending on the type of customer and the timing and duration of the interruption. For example:

- Customer type – residential customers are more likely to suffer non-financial losses, such as inconvenience and discomfort; agricultural, commercial and industrial customers are likely to experience production and sales losses.
- Timing – a business day interruption is likely to cause greater loss to customers than an early morning interruption on a public holiday. Likewise, a hot summer day interruption will

likely cause greater losses than a mild day. Importance of timing is likely to vary by customer type.

- Duration – an interruption may impose substantial one-off costs (such as resetting and restarting equipment), meaning that several short interruptions may result in a greater aggregate loss than a single interruption of the same total duration. Importance of interruption duration is also likely to vary by customer type.

The impact of unserved energy costs will vary per customer depending on the timing and duration the interruption, and this can be described using a Customer Damage Function (CDF).[5] The nature and distribution of supply interruptions combined with the nature and distribution of customers and CDFs influence VCR calculations.

5.3 Approaches to deriving VCR

Two options are available for deriving VCRs:

- A survey-based approach, which involves asking customers questions to gauge their VCR, can involve:
    - Direct Cost Approach (DCA) – this estimates direct costs by asking customers about lost production or sales due to an interruption. DCAs tend not to value non-financial costs, such as stress, discomfort and inconvenience.
    - Economic Principle of Substitution (EPS) – this estimates the financial cost of substituting energy-consuming activities by asking customers about their actions (and costs) in response to an interruption. Like DCA, EPS tends not to place a value on residual inconvenience and discomfort where customers choose to 'put up with' interruptions.
    - Contingent valuation surveys – customers are asked how much they would be willing to pay (WTP) to avoid an interruption or how much they would be willing to accept (WTA) to experience an interruption. This method can provide an indication of non-financial loss of utility from interruptions, such as inconvenience, stress and physical discomfort.
    - Choice modelling – this involves asking customers to pick or rank service/price bundles in order to understand the trade-offs customers are willing to make.
- Model-based approaches, which seek to estimate VCRs based on the opportunity cost of outages, such as gross natural product (GNP) per kWh electricity consumed.[6]

In addition to AEMO's (and previously VENCorp's) measures for Victoria and other NEM jurisdictions, VCR measures have been developed on behalf of the AEMC for NSW and ESCOSA for South Australia, as well as internationally in Sweden, the United States, Canada, Europe and many developing countries.

Most VCR estimates have been developed using the survey-based approach. While surveys may produce biased results (for reasons discussed in Section 0 below), they are capable of capturing a wider range of CDF costs and differences than model-based approaches. The model-based approach cannot easily measure indirect costs or distinguish between costs at different times or durations.

Each survey-based option has advantages and disadvantages, some of which are outlined below.

- **DCA:** As noted above, DCA focuses on direct financial costs and does not measure indirect or intangible costs such as inconvenience and discomfort. This makes DCA more suitable for estimating losses borne by business customers than residential customers (although business customers are also likely to experience some inconvenience also). The advantage

[5] Productivity Commission Electricity Network Regulatory Frameworks Draft Report, p473
[6] Productivity Commission Electricity Network Regulatory Frameworks Draft Report, p473

of a DCA approach is that it requires less hypothetical reasoning than the contingent valuation survey and therefore may be more reliable and consistent.

- **EPS:** This approach captures some indirect costs by estimating the cost of goods or services customers might purchase to limit their fall in utility. For example, one survey asked whether residential customers faced with a one-hour interruption would choose to buy ice ($8) to keep food cool or eat at a restaurant ($50). Customer willingness to incur these expenditures can indicate the dollar value of inconvenience and discomfort caused.

  However, one drawback is that substitute purchases may provide different levels of benefit to the continuous supply of electricity. For example, many customers may prefer eating a restaurant meal to cooking at home, so the $50 price that they are willing to pay does not necessarily reflect their net loss from the interruption. It may be that in the absence of a supply interruption, they would value the meal at $40, so their implied value of the one-hour of unserved energy is actually only $10 ($50 minus $40).

- **Contingent valuation:** This approach seeks to estimate the subjective value of reliability by gauging changes in customer WTP or WTA according to level of reliability they face. This approach is far better suited to estimating non-financial losses than DCA and EPS because customers themselves place a financial value on their non-financial costs.

  One key drawback is the degree of hypothetical and abstract reasoning demanded of respondents, who may not be accustomed to placing a dollar value on the intangible implications of an interruption. As noted by the Productivity Commission, the academic literature on contingent valuation shows that respondent WTA is around three times the WTP even though, theoretically, they should be the same. However, studies show that WTA results typically converge with WTP results over time as customers become more familiar with the nature of the trade-offs they are asked to make. Contingent valuation studies also reveal a preference for status quo levels of reliability.

- **Choice modelling:** By offering customers choices between specific options across both reliability and cost dimensions, customers need not engage in as much hypothetical reasoning as required in a contingent valuation survey. This can better reveal true customer WTP for different levels of reliability. The drawback with choice modelling is that it can be more complex, time-consuming and expensive than other approaches.

Question 8: How should AEMO assess which approach (or combination of approaches) is the most appropriate to deriving VCR while considering the contexts of its application?

Question 9: Which approach (or combination of approaches) to deriving VCR should AEMO consider employing? Are there any other possible approaches not listed?

5.3.1 AEMO's VCR estimates (previously VENCorp's)

5.3.1.1 Methodology

To date, the approach used to derive VCRs on behalf of VENCorp/AEMO has been survey-based. The Victorian methodology was originally developed by Monash University for VENCorp. It was implemented by VENCorp in 1997 and then by consultants *CRA* in 2002 and 2007.

The approach employed by CRA in 2007 involved sending questionnaires to customers classed within the following categories:

- Residential
- Agricultural
- Major commercial

- Small commercial
- Major industrial
- Small industrial

The types of questions asked of different customer categories varied:

- For residential customers, an EPS approach was adopted. Survey respondents were asked to select from a list of preparatory actions and associated costs they might undertake or incur to mitigate the impact of supply disruptions at various times and of varying durations.
- For all business customers, a DCA was adopted. Survey respondents were asked to assign dollar values to a set of generic cost categories relevant to their business. This included assigning values for interruptions of differing duration at the worst time for their business. Respondents were also asked to nominate the worst times for an interruption in terms of time of day, day of the week and month of the year.

CRA used the responses to derive sector-specific VCRs and a weighted-average state-level VCR (see below)[7].

CRA also sought to estimate the social disruption cost of interruptions, including certain costs incurred by community and social services such as emergency services.

In 2011, while developing consistent national VCRs, AEMO requested consultants *Oakley Greenwood* to derive VCRs (in current dollars) for each NEM region using the data derived from the Victorian surveys conducted in 2007.

5.3.1.2 Results

The calculated Victorian VCRs are:

- $28.89/kWh by Monash in 1997.
- $29.60/kWh by CRA in 2002.
- $47.85/kWh by CRA in 2007.

The 2007 figure was derived by weighting the following sector-specific VCRs (in 2007 dollars):

Table 1 – Sector-specific VCRs ($/kWh)

Customer sector	VCR
Residential	$13.25
Industrial	$36.07
Commercial	$90.76
Agricultural	$111.06

While the agriculture sector was found to have the highest VCR (largely due to the high cost of two-hour interruptions), it made the smallest contribution to the overall Victorian VCR due to its relatively small share of state electricity consumption.

Additional social disruption costs were estimated at approximately $1/kWh.

In 2011, Oakley Greenwood calculated the following regional VCRs (in 2010–11 dollars):

[7] The calculation of the weighted average was based on the electricity consumption of each sector

Table 2 – Regional-specific VCRs ($/kWh)

State	VCR
Queensland	$44.31
New South Wales	$41.53
Victoria	$57.29
South Australia	$44.30
Tasmania	$50.97

5.3.2 AEMC estimates for NSW

5.3.2.1 Methodology

In August 2012, the AEMC commenced a review of Distribution Reliability Outcomes and Standards for New South Wales which included a VCR assessment by consultants Oakley Greenwood.[8] The VCR survey was designed to provide specific VCRs for the following:

- Three customer sectors (residential, small business, medium-to-large business).
- Each of the three feeder types maintained by the state's DNSPs.
- The three DNSPs – Ausgrid, Endeavour Energy and Essential Energy.
- The state as a whole.

Like the AEMO–CRA approach, Oakley Greenwood's VCR assessment employed EPS for residential customers and DCA for business and farming customers. Oakley Greenwood used interview techniques to determine the costs that different customer groups experience when their electricity supply is interrupted.

In addition, a simplified list of questions was included in the survey relating to customer WTP for increased reliability and residential customer WTA for a lower reliability level.

5.3.2.2 Results

The results of Oakley Greenwood's survey are shown below in Table 3.

Oakley Greenwood stated that it is not possible to accurately identify why the results for small business NSW customers (< 160 MWh per annum) are much higher than for similar customers in Victoria without undertaking further analysis. The review did suggest it might be useful to consider using the EPS for small business customers or to use EPS for half the small business sample and DCA with the other half to compare VCR results.

Responses to the WTP and WTA questions indicated that customers would require a discount of twice as much to accept an additional 60 minutes outage per annum as they would be willing to pay to for 60 minutes less outage per annum. Oakley Greenwood observed that this sort of asymmetry between WTP and WTA measures is often found to exist in the empirical literature. As noted above, the Productivity Commission made a similar observation in its review but commented that WTA results typically converge with WTP results over time.

[8] The Oakley Greenwood report is available on the AEMC website: http://www.aemc.gov.au/market-reviews/completed/review-of-distribution-reliability-outcomes-and-standards.html

Table 3 – NSW VCRs by DNSP and sector ($/kWh)

Customer sector	State-wide	Ausgrid	Endeavour Energy	Essential Energy
Residential	$20.71	$22.77	$19.75	$17.82
Business <160 MWh per annum	$413.12	$408.48	$563.46	$202.82
Business ≥ 160 MWh per annum	$53.30	$34.83	$33.99*	$130.57*
Total	**$94.99**	**$86.79**	**$110.71**	**$90.71**

* Oakley Greenwood have noted that these VCRs have less statistical validity as they are based on a smaller sample size (≤ 30). These values have been provided for illustrative purposes and should be used with caution.

Oakley Greenwood converted the average state-wide residential VCR (from the EPS conducted) to a value of one hour of unserved energy in order to compare against the hourly unserved energy values implied by the WTP and WTA questions. The VCR measure converted to an unserved energy value of $14.56/hr, which is similar to the WTP value of $12.34/hr. However, the WTA value was nearly double, at $28.54/hr. If the WTP figure is more robust (as indicated by previous studies), this suggests that the two approaches yielded reasonably consistent results.

5.3.3 South Australia

In its 2005 price review, ESCOSA commissioned consultants KPMG to assess the appropriateness of the then-existing performance incentive scheme; in particular, to assess whether it accurately reflected customer WTP for incremental improvements in service. While the review was able to estimate the average customer value of reducing the duration or number of power interruptions, it did not go as far as producing values of unserved energy and was not designed for this purpose.

5.3.4 International estimates

The Productivity Commission noted that Australian VCR measures are generally high by international standards. Some of the developed country VCRs tabled by the Commission were approximately as follows (in 2009 Australian dollars)[9]:

Table 4 – Country VCRs ($/kWh)

Country	VCR
France	8
New Zealand	16
Great Britain	26
USA and Ontario, Canada	37
Ireland	76

[9] Productivity Commission Electricity Network Regulatory Frameworks Draft Report, p475

The Productivity Commission also highlighted evidence from a US meta-analysis, which found that the interruption costs (in $/kWh unserved) fell spectacularly and monotonically from a momentary interruption to interruptions of increasingly longer durations. For example, the cost of unserved energy to medium and large commercial customers fell from $173/kWh for a momentary interruption to $39/kWh for a 30-minute interruption, $25/kWh for a one-hour interruption, and just $14/kWh for an eight-hour interruption. This indicates that the shape of the average CDF in the US meta-analysis was steeply declining.

Carlsson and Martinsson of Gothenburg University estimated the WTP of Swedish households in 2004 using a contingent valuation methodology.[10] The authors noted that one advantage of contingent valuation, particularly when estimating residential customer VCR, is that it considers 'non-market welfare effects'. For example, it directly considers the loss of welfare that customers experience by not being able to watch a particular television program or cook a meal at a particular time. That said, the authors acknowledged that estimating WTP was "cognitively more demanding" for customers than responding to DCA questions.

The Carlsson and Martinsson survey asked respondents their maximum WTP to avoid outages of various lengths starting at 6pm on a January (winter) evening. The results were reported in absolute amounts (in Swedish Krona, SEK) rather than on a per kWh basis, making comparisons with the above VCR measures difficult. However, some key findings of interest were:

- WTP to avoid planned outages was higher than to avoid unplanned outages. For example, customer WTP to avoid a one-hour planned outage was 6.3 SEK compared to 9.4 SEK for an unplanned outage.
- For planned outages, WTP increased more than proportionately as outage duration increased. For example, WTP to avoid a one-hour outage was 6.3 SEK while WTP to avoid a four-hour outage was 28.5 SEK (4.5 times more) and WTP to avoid a 24-hour outage was 189.3 SEK (30 times more).
- For unplanned outages, WTP increased about proportionately as outage duration increased – WTP to avoid a one-hour outage was 9.4 SEK while WTP to avoid a four-hour outage was 37.3 SEK (four times more) and WTP to avoid a 24-hour outage was 223 SEK (23.7 times more).
- Inflation-adjusted WTP had increased substantially since a similar 1994 study.
- There was considerable diversity in WTP to avoid short outages, with the mean WTP to avoid a one-hour *planned* outage being 6.3 SEK, but 90% of respondents were unwilling to pay anything. Even more stark, the mean WTP to avoid a four-hour *unplanned* outage was 37 SEK but more than two-thirds of customers were unwilling to pay anything.

The relatively time-proportionate shape of the Swedish CDFs in the Carlsson and Martinsson study compared with the steeply declining shape of the US CDF (highlighted above) could perhaps be explained by the likely impact of the outages. Swedish respondents' concerns about outages were most focused on the loss of heating in the middle of winter, when a longer outage could be expected to have much more severe impacts than a short outage.

In the authors' view, the emphasis on the discomfort and inconvenience faced by respondents demonstrated the benefits of using a contingent valuation approach over DCA.

Question 10: Are there any other international VCR studies worth examining to inform the current process?

[10] Carlsson, F. and Martinsson, P., "Willingness to Pay among Swedish Households to Avoid Power Outages – A Random Parameter Tobit Model Approach", Working Papers in Economics No.154, December 2004, Department of Economics, Gothenberg University (Carlsson and Martinsson).

5.4 Indexing VCR

In 2008, VENCorp published a Consultations Paper to seek views from interested parties on applying a measure of indexation to VCRs to account for changes in the value consumers place on energy. This paper proposed two approaches:

- Consumer Price Index (CPI)
- Straight-line indexation

VENCorp engaged NERA Economic Consulting to provide a recommendation on the most appropriate form of indexation, given the varied response from submissions received to the Consultations Paper. Upon considering the factors that influence VCR estimates, NERA identified four principal methodologies to annually adjust VCRs:

- 'Top-down' statistical approach
- Straight-line extrapolation
- General consumer and producer price indices
- Income/economic growth indices

NERA's findings concluded that the income/economic growth approach was the most appropriate approach, and VENCorp adopted this for future VCRs.[11]

In 2011, AEMO's Issues Paper suggested there was little justification and no support offered for applying specific indexing of VCR measures between surveys or for updating VCRs on a regular basis.

The risk with specific indexing is that a new survey measure could produce a significantly higher or lower figure than the indexed extension of the previous survey measure. It is therefore proposed that VCR measures should only be indexed using a non-changing general price index such as the CPI.

Question 11: Should specific indexing of VCR measures be applied? If so, what types of indexing would be appropriate and how often should the index be applied?

[11] VENCorp's Methodology for Extracting VCRs between Surveys 2008/–09 to 2011–12 available on AEMO's website: http://www.aemo.com.au/Electricity/Policies-and-Procedures/~/media/Files/Other/planning/0400-0007%20pdf.ashx

6 Shortcomings and potential improvements to existing survey-based VCR methodologies

Previous Australian and international VCR estimates and existing academic literature highlight a range of shortcomings with existing VCR measures and raise the prospect of potential improvements. These can be categorised as follows:

- Addressing survey anomalies and biases.
- Addressing survey omissions and limitations.
- Improving survey administration.

These topics are discussed below.

6.1 Addressing survey anomalies and biases

Existing VCR surveys appear to raise several anomalies and biases. Some of these are briefly discussed below.

6.1.1 Apparent anomalies

The most obvious issue with survey-based VCR estimates is that surveys are based on hypothetical circumstances and the costs incurred are subjective. Validation of damage costs estimated in this manner is exceedingly difficult and AEMO is not aware of any studies that have attempted to do so. As such, VCR estimates based on survey data inherently contain uncertainty.

VCR surveys highlight several apparent anomalies in the response data. For example:

1. CRA's 2007 survey found the following with regard to agricultural sector losses for two-hour interruptions:
   - On a $/kWh USE basis, they were more than four times the losses from a one-hour interruption ($204/kWh compared to $47/kWh).
   - On a total dollar basis, they were only 20% less than the losses from a four-hour interruption, assuming constant electricity consumption over the period.

   At face value, these data suggest that agricultural businesses face huge discontinuities in costs as interruptions stretch from one to two hours and suffer relatively small additional losses as interruptions stretch from two to four hours. Note also that the two-hour figure is far in excess of the results of CRA's 2002 survey and Monash's 1997 survey.
2. Oakley Greenwood's survey of NSW distribution networks found that customers consuming less than160 MWh per annum faced interruption costs on average eight times greater than larger businesses. This appears to be a significant divergence. At the same time, the US meta-analysis of VCRs presented in the Productivity Commission report found even larger divergences between small commercial customers and medium and large customers.

   While these apparent anomalies may reflect genuine cost differences, it is also possible that they are the result of survey biases.

6.1.2 Costs assessed at 'worst time'

Many VCR surveys ask respondents to estimate their interruption losses or express their WTP or WTA to avoid interruptions should they occur at the worst possible time. For example, the CRA survey asked this of residential and business customers and the Oakley Greenwood survey for NSW also asked respondents to consider this. Finally, the Swedish contingent valuation survey asked customers about their reactions if power was interrupted at 6pm on a winter evening.

Given that power interruptions do not always occur at the worst time and given that different customers will have different 'worst times', these VCR surveys tend to significantly overstate the true costs of interruptions.

6.1.3 Risk of double-counting or overstating costs

The DCA used to estimate the costs of interruptions to commercial and industrial businesses in the CRA and Oakley Greenwood surveys may promote double-counting or overstatement of costs. For example, consider the cost categories offered to commercial businesses in CRA's questionnaire:

1. Costs of operating backup electrical equipment
2. Spoilage of perishable products
3. Damage to plant or equipment
4. Paid staff unable to work
5. Overtime labour costs
6. Loss of sales or custom during the failure
7. Costs to bring business back to normal operation
8. Costs to repair possible damage to the environment
9. Costs to recover data lost from computer systems
10. Other

Category four may double-count other losses. For example, paid staff being unable to work leads to paying for overtime, so categories four and five may count some of the same losses. Similarly, given that a key loss from paid staff being unable to work is lost sales (e.g., in retail), categories four and six may count some of the same losses.

More generally, lost sales during a failure may be neither permanent nor sector-wide. Prospective customers who cannot make purchases during an interruption will likely spend the same money either at the same business at a later time, or at another, similar business. In these circumstances, the true cost of the interruption would be inconvenience to the customer not a real loss to businesses in the sector.

6.1.4 Social disruption costs

Another question is whether the inclusion of 'social disruption costs' in some surveys could lead to double-counting issues or understatement of true costs. CRA's 2007 survey attempted to measure interruption costs arising in emergency services, health care, transport, and water supply and waste disposal. For example, an interruption may lead to more emergency callouts, health impacts, flight disruptions or sewerage processor problems.

Including estimates of these costs in the VCR raises the risk of double-counting customers' private costs. For example, the 2007 CRA survey indicated that the cost of flight disruptions to airlines was included in the calculation of social costs.[12] However, such costs may already be counted in a DCA survey of airlines.

On the other hand, the scope for double-counting may be limited in practice and social disruption costs may be understated as they do not include losses in some areas such as educational institutions (i.e. schools, pre-schools, universities).

6.1.5 Disregard of inconvenience

The EPS approach used to estimate the cost of interruptions to residential customers in the CRA and Oakley Greenwood surveys may not adequately account for the inconvenience of power interruptions or customer loss of utility more generally. For example, the CRA residential questionnaire explicitly attributes a zero dollar value to the response "put up with having no electricity". This is likely to materially understate the welfare losses borne by these customers.

[12] CRA survey Table 27, p.39.

The zero value placed on inconvenience may encourage come customers to distort their responses. Most customers are unlikely to take very costly actions for an isolated one-hour interruption, so it is surprising that CRA's residential CDF declines as rapidly as it does. (In other words, it is surprising that residential $/kWh unserved energy results so high for a one-hour interruption compared to the results for longer interruptions.)

By contrast, the Swedish contingent valuation study found that residential customer WTP to avoid peak time interruptions tended to increase (in $/kWh terms) over time, which is perhaps more along the lines of what could be expected.

Question 12: What strategies or approaches should be used to overcome apparent anomalies and biases in previous VCR surveys?

Question 13: Should contingent valuation or other survey methodologies be used to allow higher values to be placed on residential customer inconvenience from interruptions?

6.2 Addressing survey omissions and limitations

Previous CRA and Oakley Greenwood surveys excluded a number of potential VCR cost categories and applications of VCRs. Some of these are briefly discussed below.

6.2.1 Momentary interruptions

A key issue raised in AEMO's previous consultation is the absence of any consideration of momentary outages. Such outages can be relatively costly, as they may cause equipment failure or require equipment to be reprogrammed or restarted.

Oakley Greenwood found that nearly four times the number of surveyed residential customers would prefer distribution network investments to reduce the incidence of interruptions (59%) compared to those preferring investments to reduce interruption duration (16.8%).

Should VCRs be used mainly for transmission planning, there may be little benefit in devoting further effort to estimating the cost of momentary interruptions. Conversely, should VCRs be applied to distribution planning, additional work on the cost of momentary interruptions could be quite beneficial. This is discussed further below.

Question 14: Is survey data on the cost of momentary interruptions likely to be useful to the transmission planning process? What applications of VCRs are likely to benefit most from more information about momentary interruption costs?

6.2.2 Lack of customer-type disaggregation

Section 5.1 above considered the potential benefits from focussing the assessment of the VCR applicable to different customer sectors rather than different regions and then calculating the VCR to apply to a particular region or local area based on the proportion of each customer sector in that area. The data and logic seems to suggest that the VCR would be very dependent on the type of customer rather than which state they live in. If AEMO was to adopt an approach along these lines, the granularity in VCR of the chosen customer sectors would need to be matched with data on the relative consumption of those sectors in each region, area or connection point. Therefore the ability to calculate VCRs at this level is dependent on the transparency and accessibility of such information in the market.

Question 15: Is greater customer-type disaggregation necessary or preferable for setting VCRs?

Question 16:To what extent is the disaggregated customer information that network businesses and retailers currently have able to support the calculation of VCRs based on assessing the specific VCRs for more customer sectors?

Question 17: For businesses and retailers that currently have this type of information, what additional information (and how much) would be required to accurately calculate such granular VCRs?

6.2.3 Interaction between transmission and distribution network investment

During the previous consultation, AEMO noted comments from Visy that, due to the generally greater reliability of transmission networks than distribution networks, a higher VCR for transmission planning may simply lead to an over-built, higher-cost transmission network rather than providing real benefits to customers.

A similar observation can be made about the wholesale energy market operation (see Section 4.3). There is little benefit in encouraging transmission investment and increased network reliability without sufficient generation capacity to maintain supply in the face of credible generating plant contingencies.

If transmission network planning is undertaken independently of distribution network planning and the design of the wholesale market, VCRs need to be set taking those processes as given.

This suggests that transmission planning should be conducted with regard to both the transmission VCR as well as the prevailing reliability of the distribution network and the availability of spare generation capacity. This means that if, for example, generation capacity is deficient, even high transmission VCRs may not lead to substantially greater transmission investment than lower VCRs.

However, the broader question raised by Visy was about the appropriateness of conducting transmission planning in an isolated manner. It would appear to make sense for DNSPs to plan their networks with regard to appropriate VCRs (depending on the nature of the network area). If this approach were pursued, the VCRs should be set consistent with the transmission VCRs to help avoid potential perverse outcomes, however consideration should be given to the different requirements of the two levels of network and the impacts that decisions at one level has on the other. For example, the AEMC's Distribution Network Planning and Expansion Framework Rule change[13] includes provisions for DNSPs to consider VCRs when undertaking a RIT-D. The outcomes of the RIT-D process will be sensitive to the VCR adopted.

Planning transmission and distribution networks consistently should promote economic efficiency, because it would ensure that least-cost options for improving overall network reliability are addressed first. Under the current arrangements, it may well be the case that more expensive transmission options are pursued before cheaper distribution options. AEMO notes that any move towards output-based reliability targets for distribution and the use of cost-benefit analysis in distribution planning is ultimately a matter for the AEMC and the SCER[14].

Another interaction between the networks was raised in the Productivity Commission review. Given that distribution networks can be damaged by equipment failures on transmission networks, calculating VCRs for transmission planning purposes may need to take this into account.

Question 18: Should VCRs be set in the same way for transmission and distribution networks? If not, what features warrant different consideration and how should these differences be incorporated?

6.2.4 High-Impact Low Probability Interruptions (HILPs)

HILPs refer to events like cascading outages of the type that took place in the north-east United States in 2003, or interruptions following natural disasters such as the Christchurch earthquake.

[13] See the AEMC's Distribution Network Planning and Expansion Framework Final Rule: http://www.aemc.gov.au/electricity/rule-changes/completed/distribution-network-planning-and-expansion-framework.html

[14] See the AEMC's review of the national framework for distribution reliability directed by the SCER: http://www.aemc.gov.au/Market-Reviews/Open/review-of-the-national-framework-for-distribution-reliability.html

While NEM jurisdictions require VCR measures to assess non-credible contingencies such as these, it has not been established that surveys are an appropriate tool for estimating the cost of these events.

The hypothetical nature of ordinary interruptions makes it difficult enough for respondents to predict their likely reactions and cost implications. Asking customers to estimate their costs in the face of HILPs is far more likely to produce spurious outcomes.

Further, as the probability distribution of HILPs is extremely uncertain, even large variations in HILP VCRs may not affect policies designed to reduce the risk and manage the implications of HILPs.

Question 19: Can VCR surveys effectively estimate the cost of HILPs or should HILP events be captured separately within the reliability framework?

Question 20: Based on the response to Question 19, how would HILP costs be reflected in the metric development or reliability framework?

6.2.5 Low-income VCR

The Productivity Commission review and Oakley Greenwood report highlighted the issues raised by low-income customer participation in VCR surveys.

According to both papers, such customers may value reliability very highly but be unable to pay for it given income constraints. Oakley Greenwood found some evidence for this, noting that low-income customers were more likely than regular customers to endure longer outages (four hours and above) without spending money to overcome inconvenience.

The fact that low-income VCRs derived from an EPS or DCA survey are likely to be lower than those of higher income customers serves to again highlight the neglect of inconvenience costs in these surveys. If low-income customers are more likely to put up with interruptions and less likely to spend to alleviate inconvenience, then a better effort to include these costs could help equalise lower- and higher-income VCRs.

On the other hand, it is difficult to ascribe a value to inconvenience without incorporating estimates of WTP/WTA from contingent valuation or choice modelling. As higher-income customers are likely to have a higher WTP to avoid inconvenience than low-income customers, it may be that explicitly valuing inconvenience widens low- and higher-income VCRs.

The Productivity Commission's review also suggested that the extent to which VCRs varied according to income could raise equity issues in the context of the application of a single VCR.

This is because low-income customers with low VCRs could in effect be required to pay for network infrastructure justified by the higher VCRs of more affluent customers. To some extent, this is unavoidable given the need to target a particular level of reliability across different income groups and is not specific to calculating or using VCRs for network planning purposes. (i.e., a deterministic standard raises the same issues.)

6.3 Improving survey administration

AEMO's 2011 Issues Paper discussed how VCR surveys can be carried out. VCR surveys typically involve either face-to-face interviews, telephone interviews or web-based/mail questionnaires.

Face-to-face interviews facilitate the exchange of complex information, but may suffer from self-selection bias as the time commitment required may deter some people and–more importantly–certain types of people from participating. This makes it more difficult to find a random sample of customers to achieve statistically representative results. Face-to-face interviews may also suffer from interview bias, whereby the interviewer indirectly influences the answers given. This has been observed in face-to-face political polling compared with telephone polling. The final drawback with face-to-face polling is the time and cost involved.

Telephone interviews are possibly the most common survey method, chiefly because they are usually much cheaper than face-to-face. In addition, in certain circumstances, random samples of respondents can be drawn from the desired population by random digit dialling. However, the complexity of information that can be provided via verbal communication is limited and the possibility of interviewer bias still remains, as respondents react to voice cues and interviewer perceptions.

Mail questionnaires allow visual aids to assist respondent understanding of the questions and can be carried out at relatively low cost. Identification of target samples is also usually straightforward, although response rates are typically low, requiring multiple mailings and reminders to achieve acceptable levels. As there are no interviewers, all respondents experience an identical presentation so there is no interviewer bias.

Online surveys have several advantages, including presentation of more information, possibly in an interactive manner, low cost and no interviewer bias. It is also possible to automate and process the data collected in a short timeframe. However, randomly targeting the required population via the internet depends on both the number of internet users in that population, as well as spamming restrictions which rule out procedures analogous to random digit dialling in telephone surveys.

Question 21: What improvements should AEMO consider to the conduct and administration of surveys?