

Getting the Value of Customer Reliability Right



Prepared by ENERGEIA for Energy Consumers Australia

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Executive Summary

Electricity powers Australia's economy and quality of life. A reliable grid supply is therefore of high value, even where consumers may increasingly be in a position to manage some time off supply. But how valuable is grid reliability, especially as it approaches 100% and the associated costs start to rise exponentially?

The measurement of the value of reliability to customers is referred to as the Value of Customer Reliability (VCR). Under Australia's National Electricity Rules, VCR sets the threshold for electricity industry investment in reliability; getting VCRs right for Australia is therefore essential for ensuring the long-term interest of consumers, as required under Australia's National Electricity Objective (NEO)¹.

Historically, the estimation of VCR was done on an ad-hoc basis. Now for the first time it has been included as a functional responsibility of the Australian Energy Regulator (AER). The AER has begun its public consultation as part of its process for determining VCRs by 31 December 2019, which could result in changes to Australia's VCR that will impact all electricity consumers.

Scope and Approach

Given the key role of VCR in balancing the costs and benefits of grid reliability to Australian consumers and potential changes in Australian VCR drivers and international best practice methodologies, Energy Consumers Australia (ECA) engaged Energeia to undertake an initial, high-level review of Australia's key VCR drivers, issues and estimation methodology to inform its views during the AER's 2019 review.²

Energeia first reviewed Australia's VCR levels against international benchmarks, and then analysed the basis for the selection of the current methodology for insights into Australia's results. Energeia then reviewed key developments since AEMO's 2014 VCR review³ including the emergence of storage technology and electric vehicles to inform our high-level recommendations to the ECA regarding the AER's 2019 review.

Analysis of AEMO's 2014 Methodology and Estimates

Energeia's review and analysis of AEMO's 2014 VCR Review could not identify formal evaluation criteria for the selection of the adopted 2014 survey-based approach. Energeia was also unable to identify an explicit assessment of the various VCR estimation methods against Australia's National Electricity Objective (NEO)⁴.

Our analysis of contemporary international VCR estimates in the public domain from Organization for Economic Cooperation and Development (OECD) jurisdictions between 2009-2014 found that AEMO's selected approach produced VCRs that at the time were on average:

- 33% higher for residential customers and 11% lower for commercial customers than OECD VCRs estimated using a comparable Willingness-to-Pay (WTP) survey-based methodology, but
- 52% higher for residential customers and 186% higher for commercial customers than OECD VCRs estimated using a non-survey-based methodology.

¹ AEMC, "Applying the energy objectives – A guide for stakeholders", December 2016

² Detailed technical review of the 2014 methodology was out of scope for this review, as was the AER's consultation questions, which primarily focus on the 2014 methodology.

³ AEMO, Value of Customer Reliability Review Final Report, September 2014

⁴ AEMC, "Applying the energy objectives – A guide for stakeholders", December 2016

Analysis of Key Developments Since AEMO's 2014 Review

Energeia's review and analysis of the key changes since the 2014 review has found:

- A total of 12 VCR studies have been reported in the academic literature from OECD countries since 2014. 8 of have used a survey-based methodology and 4 have used a model-based methodology;
- survey-based methodologies have generated VCR estimates that are 9-75% higher for residential customers and 218-221% higher for commercial customers than model-based approaches;
- hybrid VCR estimation methodologies have emerged, and the data shows that model-based approaches are increasingly being used, especially in European jurisdictions;
- customer's reliance on the grid is being changed by behind-the-meter reliability solutions including solar PV and battery storage, and rising reliance on electricity for transportation;
- new reliability communications technologies have emerged including notifying customers of expected outage duration times, potentially reducing the cost of an outage; and
- falling technology costs and an incremental costing approach net of other benefits could lead to the cost of solar PV and storage-based reliability fall below AEMO's residential VCRs in the next 5-10 years.

Key Recommendations for 2019 Review

Based on the above analyses, Energeia recommends that the ECA should consider promoting the following recommendations to improve Australian consumer outcomes with respect to reliability costs and benefits.

1. Australia should develop and apply a VCR methodology selection criteria for the 2019 review that more explicitly reflects the NEO.
2. The 2019 VCR methodology assessment should include consideration of hybrid VCR methodologies in the methodology assessment, including those cited in this report.
3. Customer segmentation and estimated VCRs should take the impact of new reliability solutions such as transportation electrification and solar PV, storage and microgrids into account.
4. Expected future changes in the mix of key customer segments, including the widespread adoption of storage and EVs, should be factored into methodology selection, customer segmentation and weighting.

Disclaimer

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1 Background

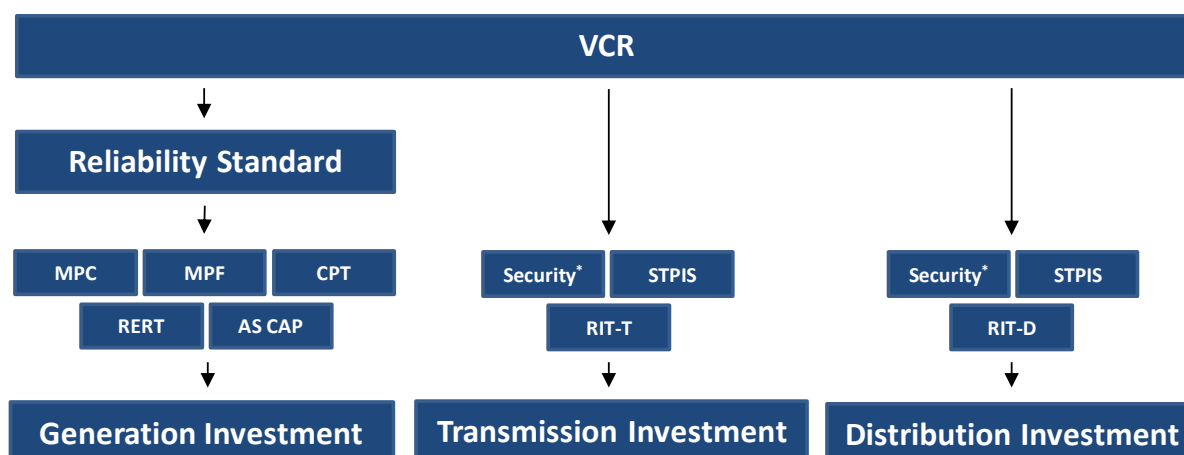
Electricity powers Australia’s economy and quality of life. A reliable grid supply is therefore of high value, even where consumers may increasingly be in a position to manage some time off supply. But how valuable is grid reliability, especially as it approaches 100% and the associated costs start to rise exponentially?

The measurement of the value of reliability to customers is called the Value of Customer Reliability (VCR).

1.1 The Role of VCR in Australia’s Electricity System

VCR informs a wide range of electricity industry reliability investment criteria, including the wholesale market’s 0.002% unserved energy reliability standard and thereby the AEMO’s activation of the emergency reserve trader (RERT). It also sets the value of reliability for networks via the Regulatory Investment Test for Transmission (RIT-T) and Distribution (RIT-D), and the Service Target Performance Incentive Scheme (STPIS).⁶

Figure 1 – VCR Impact Mechanisms Across Generation, Transmission and Distribution Investment



MPC: Maximum Price Cap; MPF: Minimum Price Floor; CPT: Cumulative Price Threshold; RERT: Reliability and Emergency Reserve Trader; AS CAP: Ancillary Services Price Cap; RIT-T: Regulatory Investment Test for Transmission; STPIS: Service Target Performance Incentive Scheme; RIT-D: Regulatory Investment Test for Distribution. *For VIC only.

Source: Energeia research

As VCRs set the threshold for electricity industry investment in reliability, getting the approach to estimating VCRs right for Australia is essential for ensuring the long-term interests of consumers, as required under Australia’s National Electricity Objective (NEO)⁷. This means that consumers do not pay any more than necessary for network investment in reliability, given their preferences.

1.2 Australia’s 2009 to 2014 VCR Reviews

A National VCR was first established by AEMO in 2009 and updated by AEMO in 2014.⁸ The NER was changed in 2018⁹ to make the Australian Energy Regulator (AER) responsible for reviewing VCR every five years, and for updating VCRs on an annual basis.

Australia’s approach to establishing VCR levels has changed since the 2009 study. The 2009 study used a combination of revealed and stated preference survey methodologies, while the 2014 study relied on stated preference and direct cost reporting methodologies.

⁶ In Victoria, VCR is used in its probabilistic network planning criteria.

⁷ AEMC, “Applying the energy objectives – A guide for stakeholders”, December 2016

⁸ AEMO, Value of Customer Reliability Review Final Report, September 2014

⁹ AEMC, Establishing VCRs, Rule determination, 5 July 2018

The 2018 Rule change made the AER responsible for the selection of the VCR methodology. It also:

- Set out a VCR objective of ensuring that the methodology and VCR estimates are fit for purpose for any current or potential future uses of VCR that the AER feels are relevant; and
- requires the methodology to include direct engagement of end-use customers (which may include surveys).¹⁰

In other words, the 2018 Rule change appears to have enshrined a survey-based methodology for calculating VCRs in Australia, or at the very least a hybrid approach that includes both survey and model-based techniques.

1.3 Developments Since AEMO's 2014 Review

Since AEMO's 2014 review, a number of technology and academic developments and have occurred that could impact on Australian VCRs, the best approach to measuring them, and which customer segments and outage situations need to be assessed.

- Model-based approaches are increasingly being used and hybrid VCR methodologies have emerged which use a combination of survey and model-based approaches,
- Consumer behaviour is changing in managing energy use – including participation in demand response, load shedding, peak shaving, etc. – facilitated by information being provided in real time via devices,
- Rising adoption of behind-the-meter generation and reliability solutions including solar PV and battery storage, and
- Greater potential usage of and reliance on electricity due to emerging technologies, such as the electrification of transportation.

The above changes could impact on the best choice of methodology for estimating VCRs in Australia, how a given VCR methodology is best implemented, the most appropriate customer segmentation approach, and/or the types of situations that should be considered.¹¹

1.4 The AER's 2019 Consultation

The Australian Energy Regulator (AER) has begun its public consultation as part of its 2019 VCR Determination, which could result in changes to Australia's VCR that will impact all electricity consumers.

The AER's 2019 VCR Determination commenced in October 2018 with the release of a Consultation Paper and is due to be completed by December 2019.¹²

The purpose¹³ of the Consultation Paper was to canvas stakeholder views on:

- The methodology for estimating VCR,
- The level of granularity for VCR estimates,
- The accuracy of the estimates of VCR,
- The current and future roles VCR should have in network planning, regulation and pricing,
- How to adjust VCR on an annual basis,
- The frequency by which VCR is updated.

¹⁰ Ibid. pages 6-7

¹¹ Each of these issues are the subject of the AER's consultation process.

¹² AER, Values of Customer Reliability (VCR) – Indicative timetable, 19 October 2018.

¹³ AER, Values of Customer Reliability (VCR) – Section 3.1, 19 October 2018.

2 Scope and Approach

Given the key role of VCR in balancing the costs and benefits of grid reliability to Australian consumers and potential changes in Australian VCR drivers and international best practice methodologies, Energy Consumers Australia (ECA) engaged Energeia to undertake an initial, high-level review of Australia's key VCR drivers, issues and estimation methodology to inform its views during the AER's 2019 review.¹⁴

Energeia first reviewed Australia's VCR levels against international benchmarks available at the time, and then analysed the basis for the selection of the current methodology for insights into Australia's results. Energeia then reviewed key developments since AEMO's 2014 VCR review¹⁵ including the emergence of storage technology and electric vehicles to inform our high-level recommendations to the ECA regarding the AER's 2019 review.

Importantly, VCRs have been transformed into 2018 Australian Dollar terms by first applying the average foreign exchange rate for the year the study was released, and then applying the consumer pricing index, or CPI, to the resulting number. While imperfect due to differences in between when the VCR study was released and the period it covered, Energeia believes this is a reasonable approach for the purpose of comparing VCRs over time and across a multitude of overseas jurisdictions with different currencies.

¹⁴ Detailed technical review of the 2014 methodology was out of scope for this review, as was the AER's consultation questions, which primarily focus on the 2014 methodology.

¹⁵ AEMO, Value of Customer Reliability Review Final Report, September 2014

3 Analysis of AEMO’s 2014 Methodology and Estimates

The following sections analyse the impact of the chosen VCR methodology on the resulting VCR estimates, the basis for AEMO’s selection of the VCR methodology applied in 2014, and what an appropriate methodology selection framework might look like for Australia for the AER’s 2019 review.

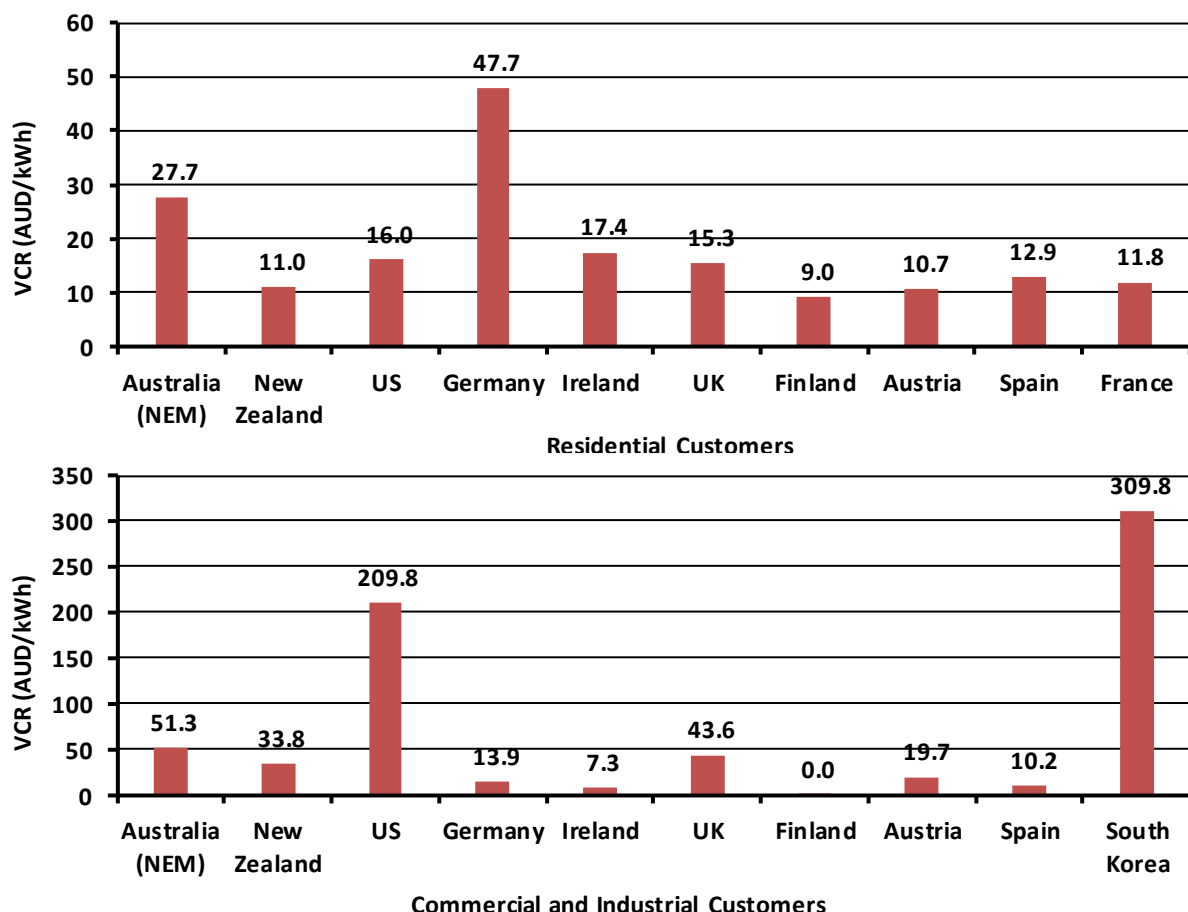
3.1 Impact of Methodologies on VCR Levels

AEMO’s 2014 study reported that its 2014 VCR results were similar to international VCR estimates using a similar methodology, as well as several ‘input-output’ approaches using data from the Australian Bureau of Statistics (ABS) and National Electricity Market (NEM).¹⁶ Based on these findings, AEMO concluded that the 2014 VCR results compared well with other VCR studies and ABS industry indicators.¹⁷

Energeia searched the academic and industry literature from comparable Organization for Economic Cooperation and Development (OECD) countries between 2009¹⁸ and 2014 to identify VCRs from comparable and alternative VCR methodologies. We identified 17 papers that published VCR estimates which could be categorised by estimation methodology and customer segment.

Figure 2 displays the reported VCR averages by residential or business segment by country. It shows Australia’s 2014 VCR settings are higher than most other comparable jurisdictions, with the exception of residential customers in Germany, and commercial customers in South Korea and the US.¹⁹

Figure 2 – Reported VCRs for Residential (top) and Business Customers (bottom) 2009-14



Source: Various VCR Studies (See Bibliography)

¹⁶ AEMO, Value of Customer Reliability Final Report, 28 November 2014, pages 32-38

¹⁷ AEMO, Value of Customer Reliability Final Report, 28 November 2014, page 37

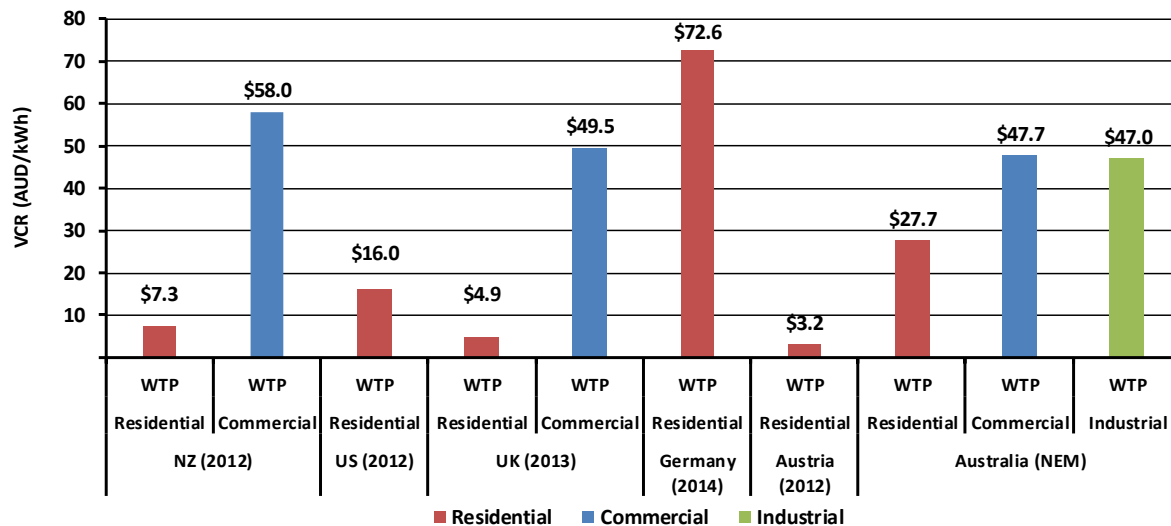
¹⁸ The impact of technology such as laptop computers, smart phones, etc. mean that older VCRs may be less relevant.

¹⁹ Energeia notes that including studies from before 2009 could explain the differences in our findings.

Energeia then grouped VCR estimates by estimation methodology to assess AEMO’s 2014 VCR estimates in light of overseas studies using the same or different methodologies.

Energeia’s comparison of AEMO’s 2014 VCR results with other willingness-to-pay (WTP) based methodologies between 2009 and 2014 is shown in Figure 3. The commercial value falls below NZ and UK values, while the 2014 residential values are much higher than those of NZ, the US and the UK, but lower than Germany. The German result is arguably an outlier, but Energeia has left it in for transparency.

Figure 3 – Comparison of Reported 2009-14 VCRs using Willingness-to-Pay Methodologies



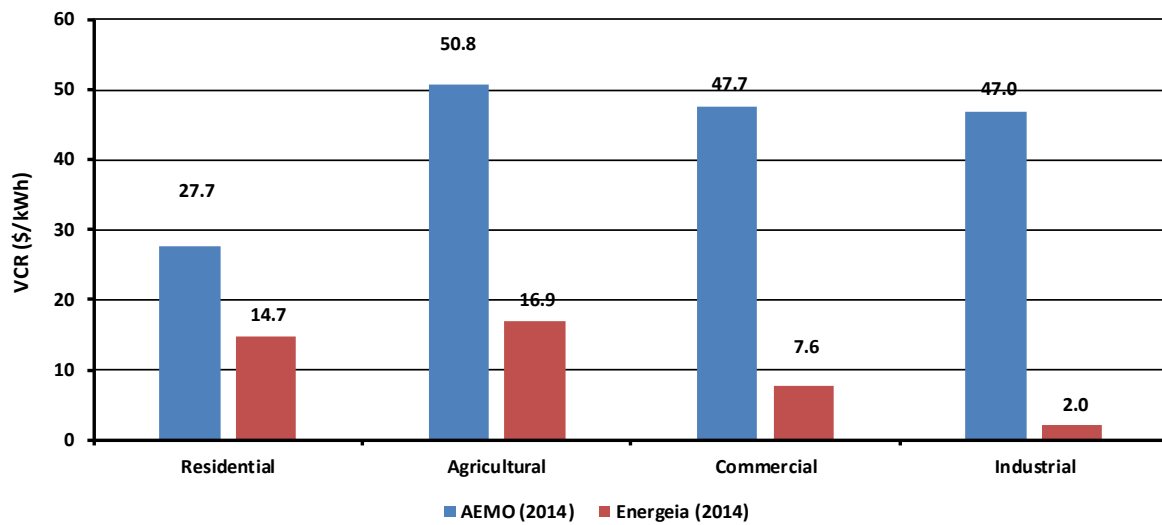
Source: Various VCR Studies (See Bibliography)

Since no model-based VCR methodology had been calculated in Australia as part of AEMO’s 2014 study, Energeia developed rough, alternative VCR estimates using contemporary ABS data of turnover and income divided by energy consumption to compare to AEMO’s survey-based estimates and international benchmarks.

Figure 4 shows AEMO’s 2014 results were around two to twenty times higher than our rough, model-based estimates. Our simplified approach used lost revenues as a proxy for the cost of an outage, overstating the losses. More sophisticated model-based approaches have focused on unavoidable spoilage, fixed costs and foregone profit.²⁰

²⁰ Sinan Küfeoglu, Matti Lehtonen, Interruption costs of service sector electricity customers, a hybrid approach, pg. 589-590, 20 Aug 2014

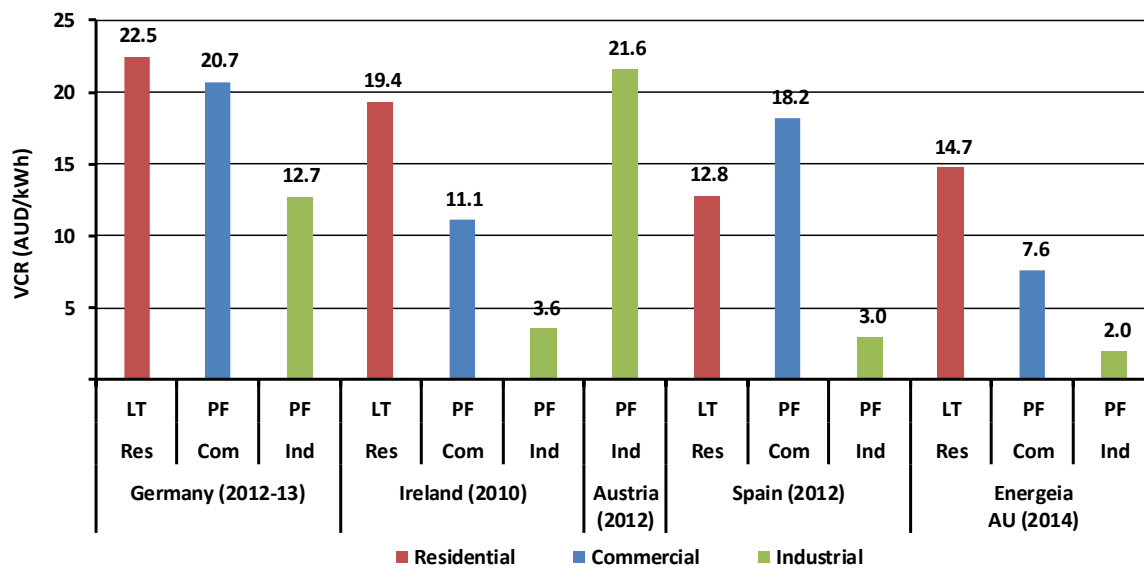
Figure 4 – Comparison of Energeia’s ABS Based VCRs with AEMO’s 2014 VCR Estimates



Source: Various VCR Studies (See Bibliography)

Given the differences found in VCRs above, Energeia also compared our rough, model-based analysis with other contemporary production function (PF) and leisure time-based (LT) studies, as shown in Figure 5. The results show our analysis to be below average compared to other residential analyses, and the lowest of all commercial and industrial customers. This is not unexpected given the very rough nature of our analysis at the time.

Figure 5 – Comparison of Reported 2009-14 VCRs using Production and Leisure Functions

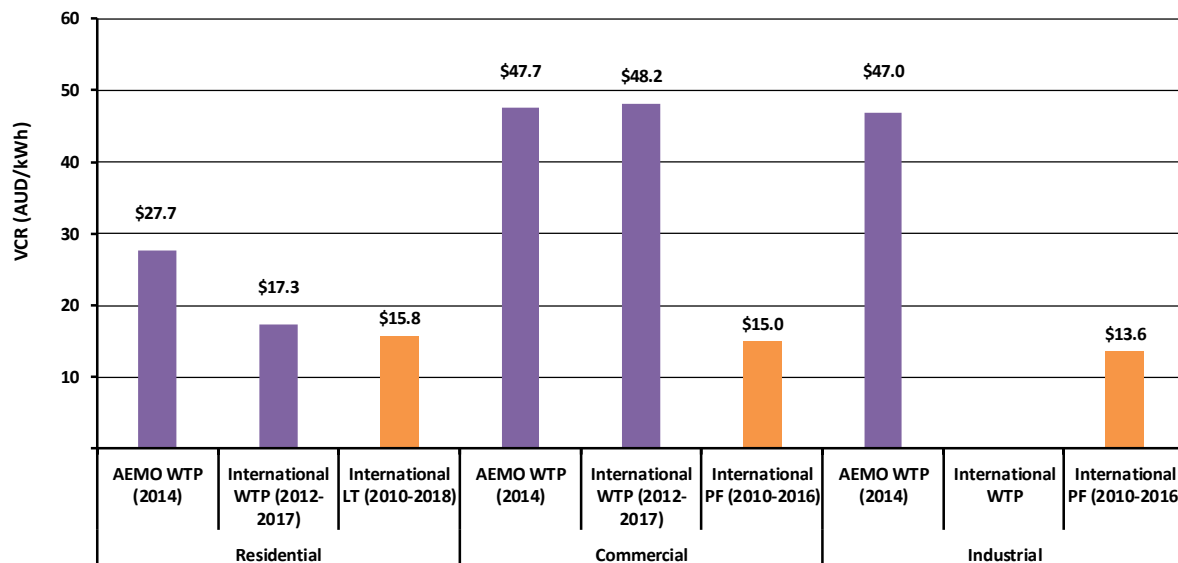


Source: Various VCR Studies (See Bibliography)

Note: PF = Production Function, LT = Value of Leisure Time

Energeia’s summary comparison of WTP and model-based approaches reported between 2009 and 2018 is reported by customer type in Figure 6. This analysis shows the significant difference in VCR values resulting from the choice of top-level estimation methodology, and that AEMO’s WTP estimates for residential customers appear to be significantly higher than the international benchmarks included here.

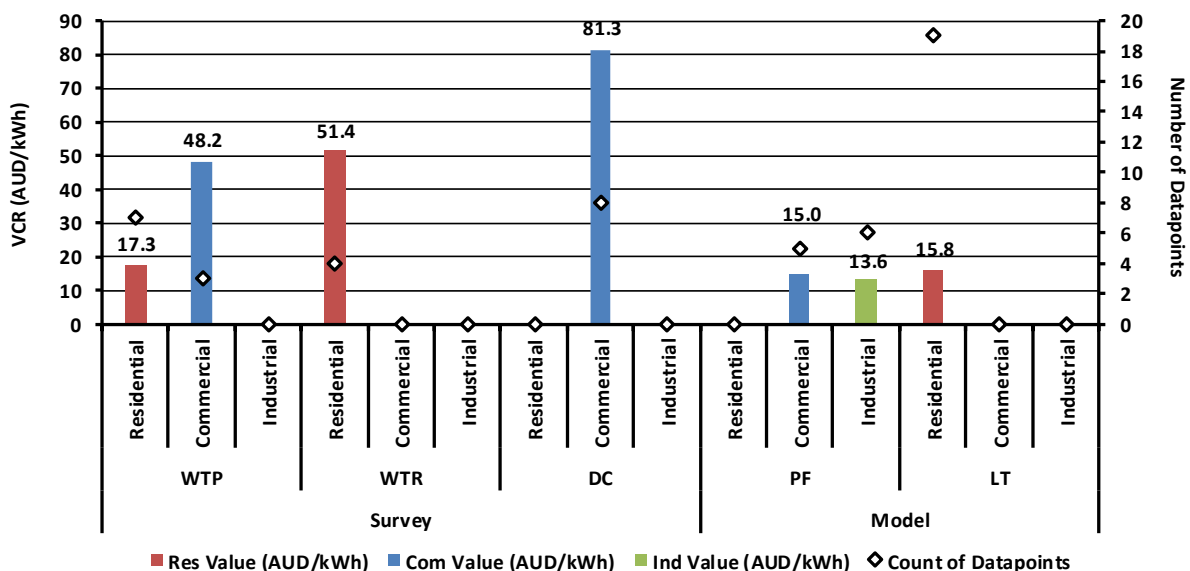
Figure 6 – Comparison of Reported 2009-18 VCRs using Production and Leisure Functions



Source: Various VCR Studies (See Bibliography)

For completeness, Figure 7 compares the VCRs from each of the reported from the 2009-18 studies (excluding AEMO) by methodology and sub-methodology, including the number of studies underpinning the estimate.²¹ The analysis shows that the direct cost (DC) method resulted in significantly higher commercial VCR estimates than WTP methodologies, and that production function methods produce the lowest commercial VCR estimates. For residential customers, willingness-to-respond (WTR) VCR estimates were three times greater than WTP, and WTP was about the same as the estimates derived using leisure time models.

Figure 7 – Comparison of Reported 2009-18 VCRs by Methodology (excl. AEMO, 2014)



Source: Various VCR Studies (See Bibliography)

Based on the above data and analysis, Energeia concludes that AEMO's 2014 results were 20% higher than international WTP benchmarks for commercial customer's VCRs and double the international benchmark for residential customer's VCRs. Energeia also concluded that DC and WTR approaches deliver estimates that are

²¹ VCR estimates were excluded in which there was only a single data point.

double that of WTP approaches. Finally, model-based approaches deliver commercial and industrial VCRs that are about half that of WTP benchmarks, while their residential estimates are comparable to WTP benchmarks.

Potential Biases in Survey Based VCR Estimates Reported in the Academic Literature

Energeia's review of the academic literature related to survey-based VCR estimation techniques has identified the following potential biases that must be mitigated to ensure the accuracy of the estimates:

- **Hypothetical Bias** – Hypothetical bias can be defined as the difference between what a person indicates they would pay in the survey or interview and what a person would actually pay.
- **Protest Responses** – Respondents may actually place a higher or lower-than-average value on VCR but refuse to pay on the basis of ethical or other reasons, e.g. it being a public good.
- **Worst Case Scenario Assumption** – Respondents assume a worst-case scenario, increasing their reported value of reliability above what may be most likely to be the case.
- **Freeriders / Strategic Responses** – Respondents report a very high value to try and influence the result, which will mostly be paid for by others.
- **Risk Aversion** – Respondents value avoiding the loss of existing performance more than they do an increase in performance, even if they represent the same change in performance.

3.2 AEMO's 2014 VCR Methodology Assessment Framework

Energeia's review of the AER's Consultation Paper²² found that it contains similar language to AEMO's 2014 Consultation Paper, requesting views as to the most appropriate methodology. It does not appear to set out the evaluation framework for its forthcoming decision regarding the most appropriate VCR estimation methodology.

Given the impact of the VCR estimation methodology on the level of VCR estimated, Energeia reviewed the basis of AEMO's 2014 VCR methodology selection framework and process in light of the 2018 AEMC Rule change and international best practice methodology selection criteria to determine whether it was likely to be fit-for-purpose for the AER's 2019 review, or if not, what an appropriate framework might look like.

3.2.1 AEMO's 2014 VCR Methodology Selection Process and Criteria

Energeia's review of AEMO's 2014 VCR Issues Paper, Directions Paper, Statement of Approach and VCR Review Final Report was unable to identify a formal evaluation framework for selecting the 2014 VCR estimation methodology. We were able to identify the following information regarding AEMO's methodology selection decision and process:

- In AEMO's Issues Paper, feedback was requested on how AEMO should assess the most appropriate approach to deriving VCR, and it lists and analyses a relatively comprehensive set of methodologies, including survey and model-based methodologies and sub-methodologies.
- In AEMO's Directions Paper, AEMO proposes to adopt a choice modelling and WTP approach, on the basis that it is better able to reveal true customer WTP because it allows estimates across reliability and cost dimensions and reduces hypothetical reasoning.²³
- In AEMO's Statement of Approach, AEMO states that all stakeholder responses supported the proposal to apply the choice modelling technique.²⁴

²² AER, Values of Customer Reliability Consultation Paper, October 2018

²³ AEMO, Values of Customer Reliability Directions Paper, pg. 9, 31 May 2013

²⁴ AEMO, Values of Customer Reliability Statement of Approach, pg. 5, 11 November 2013

In summary, popularity (stakeholder acceptance), accuracy, relevance (granularity) and feasibility (cost and timing) were among the key reasons cited by AEMO in 2014 for choosing the WTP and DC methods.²⁵

3.2.2 The Impact of the AEMC's 2018 Rule Change on VCR Selection Methodology

The AEMC's 2018 Rule change made the AER solely responsible for determining whether the VCR estimation methodology and VCR estimates adopted are fit-for-purpose for any current or potential future uses of VCR that the AER feels are relevant, as long as end-use customers were engaged (which may include surveys).²⁶

There is intentionally²⁷ no guidance by the AEMC in their determination as to how the AER is to assess whether the VCR methodology or VCR estimates are fit-for-purpose. However, given the National Electricity Law, Energeia is of the view that the VCR methodology and VCR estimates adopted by the AER must meet the NEO to be fit-for-purpose, i.e. they must be in the long-term interests of the consumer.

Under the National Electricity Law (NEL), which govern Australia's electricity supply regulations set out in the NER, changes to the Rules must advance Australia's National Electricity Objective (NEO).²⁸ The NEO is to:

"to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to:

- *price, quality, safety and reliability and security of supply of electricity.*
- *the reliability, safety and security of the national electricity system."*

As the selection methodology to date in Australia has not made explicit to reference the NEO based on our review of AEMO's and the AER's VCR consultations to date, there is little guidance as to how the NEO may be applied to evaluating VCR estimation methodologies. Energeia therefore undertook a first principles-based approach to analysing the implications of the NEO for VCR methodology selection:

- **Productive efficiency** – Productive efficiency is achieved when the industry selects the least cost mix of inputs for a given level of output. Accurate estimates of VCR that recognise the ability of consumers to purchase alternative sources of reliability are essential for achieving productive efficiency.
- **Allocative efficiency** – Allocative efficiency is achieved when pricing of a good accurately reflects its cost. Accurate estimates of VCR are therefore essential to the achievement of allocative efficiency. VCRs that are too high or too low will result in reliability consumption that is too low or too high.
- **Dynamic efficiency** – Dynamic efficiency is achieved when productivity and allocative efficiency is maintained over time as conditions change. VCR estimates that take changes in drivers of VCR into account are therefore essential, including customer behaviour, electrification and battery storage.

In other words, the VCR selection methodology and VCR estimates that best factor in different options for achieving reliability and deliver the most accurate estimates of VCR now and over time will best meet the NEO.

Energeia's investigation of whether or not one category of VCR estimation method is more accurate than another found that it has not really been addressed in the literature²⁹, probably due to the lack of an accepted, ultimate source of truth.³⁰ Most assessments speak in qualitative terms regarding the pros and cons of alternatives.

²⁵ AEMO, Value of Customer Reliability Final Report, 28 November 2014, page 9

²⁶ Ibid. pages 6-7

²⁷ AEMC, Establishing VCRs, Rule determination, 5 July 2018, pg. 12

²⁸ AEMC, National Electricity (South Australia) Act 1996, pg. 1, 13 December 2018

²⁹ Sinan Küfeoglu, Matti Lehtonen, Interruption costs of service sector electricity customers, a hybrid approach, pg. 588, 20 Aug 2014

³⁰ The relative accuracy of different technical approaches within a category or sub-category is more commonly debated.

Without an agreed methodology for determining the accuracy of a given VCR method, Energeia concludes that it is important that the selected approach guard against the risk of being inaccurate, for example by using multiple approaches (e.g. a hybrid approach) to cross-check each other and to provide insights into accuracy risk.

Finally, Energeia recognises that the long-term interests of consumers means more than maximising productive, allocative and dynamic efficiency, and therefore suggests that the ECA consider the following additional factors as important criteria for assessing the most appropriate VCR estimation methodology for Australia:

- **Delivers Stable, Predictable Estimates** – VCR stability and predictability are important for consumers to be able to plan their reliability consumption and investments. VCR estimations methodologies that deliver stable and predictable results are therefore preferable over those that do not.
- **Results in Socially Equitable Outcomes** – The distribution of financial and other benefits should be equitable across consumer segments, and not be unduly allocated to a single type of segment, nor unduly negatively impact a single type of segment, e.g. those unable to invest in grid alternatives.

3.2.3 A Proposed VCR Methodology Assessment Framework for Australia

Table 1 sets out Energeia's summary of potential selection criteria from our review of AEMO and AER consultation materials regarding VCR, and review of the academic and industry literature over the last ten years, and our understanding of the preferred selection criteria in each case.

Table 1 – Potential VCR Methodology Selection Criteria

	Inferred AEMO 2016	Energeia Proposed 2019
Methodology Selection Criteria		
Long-term Interests of Consumers (NEO):		
Delivers Unbiased / Accurate Estimates	✓	✓
Delivers Stable, Predictable Estimates		✓
Encourages Lower Cost, Non-Grid Options		✓
Anticipates Behaviour, Usage and Technology Changes		✓
Results in Socially Equitable Outcomes		✓
Granularity of Estimates:		
Targeted Customer Types	✓	✓
Targeted Outage Types	✓	✓
Targeted Location Types	✓	✓
Feasibility of Methodology	✓	✓
Transparent, Reproducible Estimates		✓
Cost of Implementation	✓	✓
Stakeholder Acceptance	✓	✓
Selected Methodology	Choice-WTP Hybrid	Survey-Model Hybrid

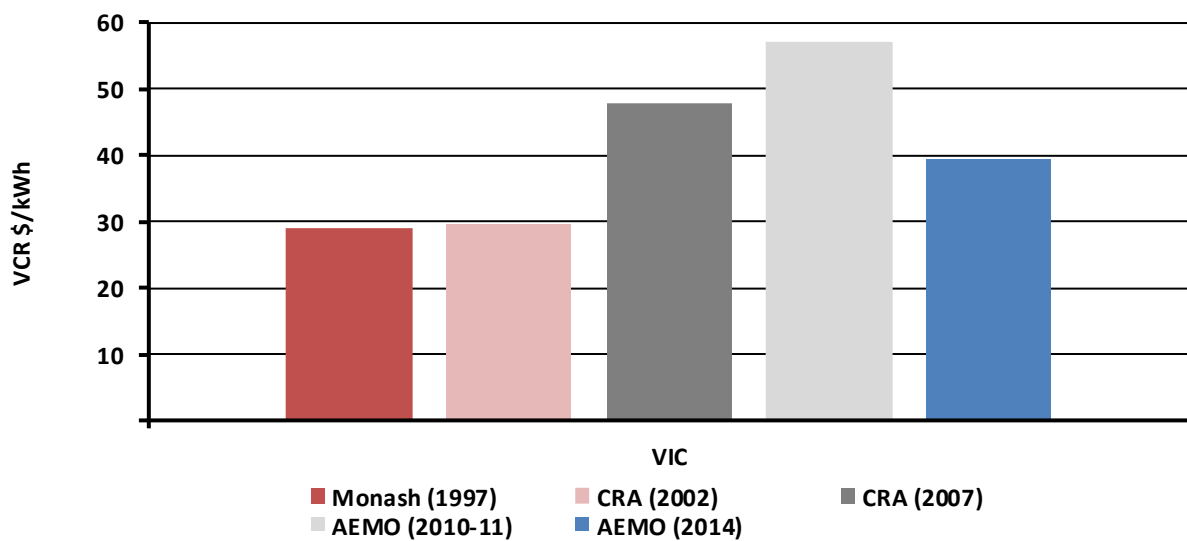
Source: Energeia

This is not a definitive or comprehensive list, rather, it seeks to identify the key NEO-linked and international best practice criteria for consideration and elaboration via the AER's consultation process.

3.2.4 The Case for a Systematic Assessment in 2019

The timetable for producing estimates has been set as 31 December 2019. However, our view is that this should not limit approaching the AER 2019 review as setting a solid foundation for VCR estimation into the future. The ad-hoc approaches to date with short time frames and limited budgets have led to significant volatility in VCR estimates over time, as is shown in the figure below for Victoria.

Figure 8 – Victorian State VCR Estimates Since 1997



Source: Victoria Reports on VCR (See Bibliography)

Assessing the best VCR approach for Australia is not without cost, and good government and business practice is to ensure that the potential benefits of an assessment outweigh the costs. If there were no new alternatives to the existing approach, or the existing conditions under which the previous approach was selected have not changed, then there would be no reason to re-assess the methodology.

However, as reported in Section 4.1.1, Energeia's review of the academic and industry literature related to international best practice in VCR estimation methodologies found increasing use of model based and hybrid survey-modelling estimation approaches, which could represent better VCR estimation methodologies for Australia, and which should therefore be assessed as part of the AER's 2019 review.

4 Analysis of Changes Since the 2014 Review

Energeia’s review of the academic and industry literature since AEMO’s 2014 assessment found that significant new VCR methods have emerged and that electricity consumer conditions have changed as follows:

- hybrid VCR estimation methodologies have emerged, and the data shows that model-based approaches are increasingly being used, especially in European jurisdictions;
- customer’s reliance on the grid is being changed by behind-the-meter reliability solutions including solar PV and battery storage, and rising reliance on electricity for transportation;
- new reliability communications technologies have emerged including notifying customers of expected outage duration times, potentially reducing the cost of an outage; and
- falling technology costs and an incremental costing approach net of other benefits could lead to the cost of solar PV and storage-based reliability fall below AEMO’s residential VCRs in the next 5-10 years.

The following sections elaborate on the results of Energeia’s investigation and analysis of each development, and our recommendations to ECA for the 2019 review.

4.1 New Developments in VCR Estimation

New developments in VCR estimation methodologies and their application overseas since 2014 provide new information regarding potential best practice VCR methodologies for Australia.

4.1.1 Methodology Popularity

Energeia’s survey of published VCR studies since 2014 has found that model-based methods are widely used, particularly in Europe, and are increasingly combined with surveying methods to mitigate biases in survey responses and to address key information gaps in models including the effects of outage duration and timing.

Table 2 tabulates the VCR methodology used since 2014 by category of method and method. Table 2 shows survey-based approaches as being the most frequent methods reported in the literature, with WTP the being the most popular. However, a number of model-based approaches have also been completed.

Table 2 – Frequency of VCR Methodology Applied by Category and Method 2014-2018

Category	Method	Count
Model	PF	2
	LT	2
Survey	DC	2
	WTP	4
	WTR	2

Source: Various VCR Studies (See Bibliography)

Table 3 shows European jurisdictions using model-based approaches more frequently, with leisure time-based studies as frequent as WTP.

Table 3 – Frequency of VCR Methodology Applied by Jurisdiction and Method 2014-2018

Jurisdiction	Method	Count
EU	DC	1
	LT	2
	PF	1
	WTP	2
	WTR	2
NZ	WTP	1
Asia	DC	1

Source: Various VCR Studies (See Bibliography), Note: Studies with multiple methods are counted for each method

4.1.2 New Approaches

One of the most interesting findings of our review of the academic and industry literature since AEMO's 2014 VCR review has been the discovery of model-survey hybrid approaches, which in our view potentially mitigate key risks and issues associated with adopting either approach on its own:

- An August 2014 study³¹ used a model-based approach to estimate VCRs using public data on key business input costs, including labour and profit, with surveying used to estimate the cost of perishables. Such an approach could be applied in Australia using ABS data.
- A major July 2018 study³² for European regulators used a model-based approach to estimate VCRs at the customer segment level, and surveys to estimate the allocation of these values by duration and time-of-use. This approach could also be applied in Australia using ABS data.

In Energeia's view, while AEMO's choice-contingent hybrid approach in 2014 helped mitigate some of the potential biases associated with surveying approaches reported in the text box in Section 3.1, the survey-model hybrid approaches described in the above studies could offer a better overall solution that we believe should be assessed as part of the 2019 review.

In particular, we believe the July 2018 study's use of a model-based approach to determine the overall VCR for a given customer segment, while using surveying to allocate that cost across different outage situations on a relative basis, is of particular interest. We believe this approach, or a similar approach, offers the best of both worlds in terms of integrating revealed (via economic data) and reported (via surveys) customer preferences.

4.2 Changes in Reliability Information and Communications

Energeia's review found that new customer outage communication techniques are emerging that appear to be having an impact on customer VCR and should therefore be considered as part of the AER's 2019 review.

4.2.1 Planned Outages

Energeia's review of the effect of reliability information and communication on VCR identified a trend towards asking customers whether pre-notification of a planned outage impacted on customer VCR. While surveying customers regarding the VCR of planned vs. unplanned outages is not yet widespread, the studies we did review demonstrated a systematic lowering of VCR for most planned outages where there was notification.

³¹ Sinan Küfeoglu, Matti Lehtonen, Interruption costs of service sector electricity customers, a hybrid approach, 20 Aug 2014

³² Cambridge Economic Policy Associates Ltd. for the Agency for the Cooperation of Energy Regulators, Study on the Estimation of the Value of Lost Load of Electricity Supply in Europe, 2018

4.2.2 Unplanned Outages

New smart grid technology referred to as Fault-Location-Isolation-and-Restoration (FLIR) is becoming more widely deployed in Australia and overseas under the general banner of smart grid investment. This new capability is able to automatically identify the location and type of fault, enabling networks to notify customers experiencing an outage regarding the expected duration of that outage within minutes of it occurring.

Armed with information as to whether the outage is likely to be for 1 hour, 4 hours or 8 hours, etc. customers are better able to plan around it, reducing its negative impacts. The effect of this information and communication is therefore expected to reduce VCR on average. However, we were unable to find any mention of the effect of this communication on customer VCR in the literature, possibly because it is relatively new.

4.3 Changes in Customer Reliance on the Grid

Consumer reliance on electricity is a key driver of the cost of outages. Consumers with a high ability to change their behaviour during an outage or substitute for electricity supplied from the grid are expected to value reliability lower than those that are 100% reliant on it.

The following sections analyse two key changes since 2014 impacting on consumer reliance on the grid.

4.3.1 Battery Storage

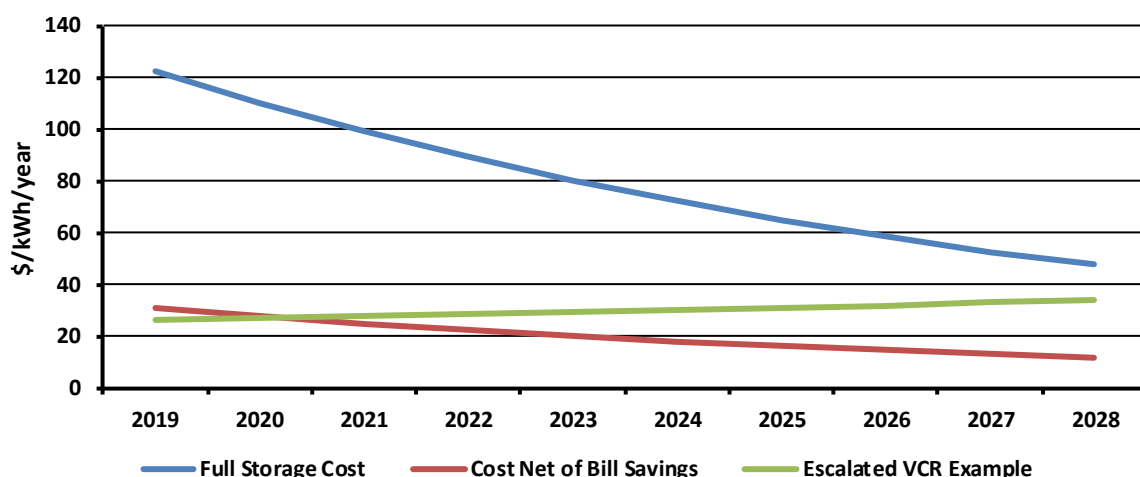
Although behind the meter solar PV adoption has been increasing in Australia since 2009, and was explicitly considered in the 2014 review³³, battery storage has really only started to take off in 2018.

Batteries offer an alternative to grid provided reliability within a range of outage scenarios. For example, a 14kWh battery, such as the Tesla Powerwall 2, can power a typical 5,000 kWh premise for 24 hours.

If the system cost is 100% allocated to reliability, today's cost would be around \$120/kWh/year, assuming an installed price of \$11,000 and 25 cent energy costs. However, adjusting the cost by bill savings of \$1,500 per year assuming 5 kWh reserved for an 8-hour outage, results in a net reliability cost of under \$30/kWh.

The figure below shows Energeia's outlook for the trajectory of battery storage delivered reliability costs on a gross and net basis, compared to AEMO's 2014 residential VCR value of \$26/kWh, adjusted for inflation. It suggests that the net cost of battery storage delivered reliability could fall below residential VCR by 2024.

Figure 9 – Illustration of Storage Delivered Reliability Costs



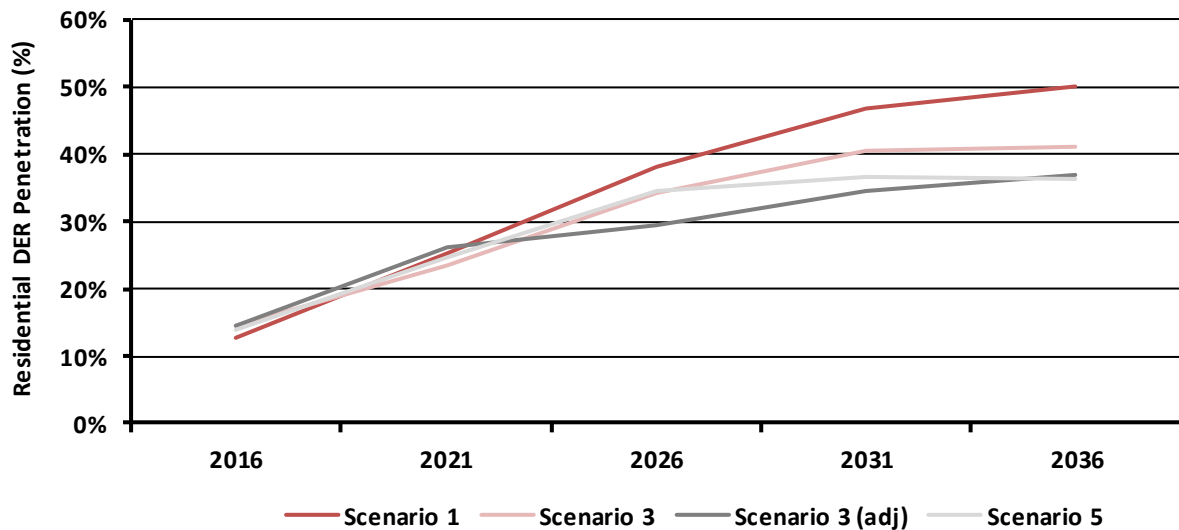
Source: Energeia Analysis

The above analysis shows how falling storage costs could impact on consumer VCRs moving forward by capping their maximum value, except in special circumstances.

³³ AEMO, Value of Customer Reliability – Application Guide Final Report, December 2014, page 14

While the above example does not yet widely apply, and there are a wide range of barriers to renters and vulnerable customers obtaining battery storage, the ENA, CSIRO and Energeia expect storage to become as widely deployed as solar PV. This could have significant implications for VCR over time.

Figure 10 – National Transformation Roadmap Forecasts of Household PV and Storage Penetration



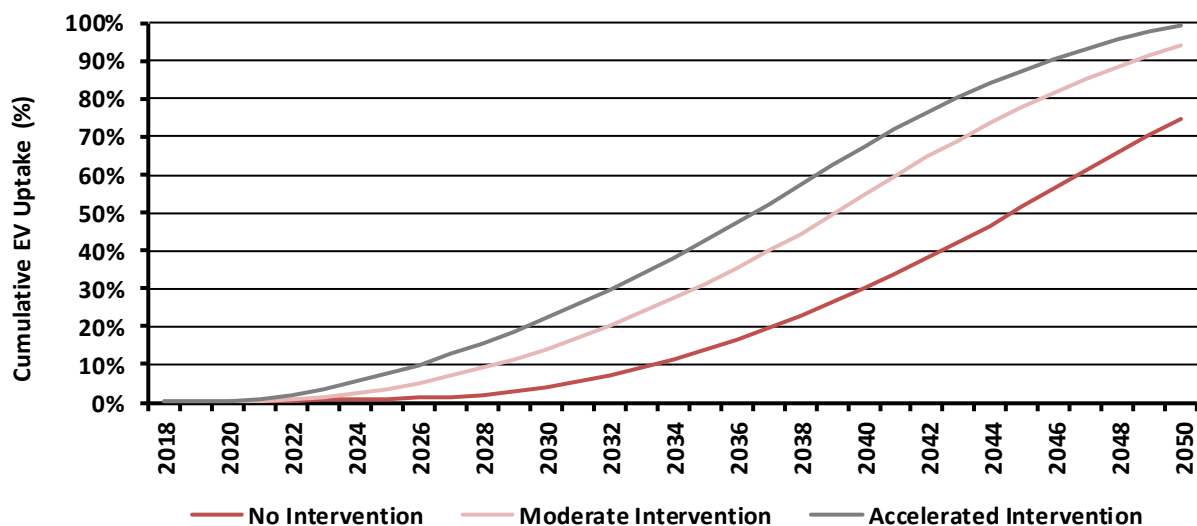
Source: ENA, CSIRO and Energeia

Based on the above analysis, Energeia recommends that the ECA consider promoting the need for careful analysis of the impact of storage technology on consumer VCRs during the 2019 review, including its potential to act as a cap on VCR for residential and business customers, including indexation.

4.3.2 Electric Vehicles

Electric vehicles (EVs) have not yet started to take-off in Australia but are expected to eventually replace internal combustion engines³⁴, and could impact on consumer reliance on grid reliability.

Figure 11 – Electric Vehicle Penetration Scenarios for Australia



Source: Energeia

EVs can impact on consumer's reliance on electricity in a multitude of ways, including:

³⁴ Energeia, Australian EV Market Study, May 2018, pg. 70

- Increasing the cost of an outage, e.g. due to preventing travelling to work, school, etc.,
- Providing additional energy storage at home/work during an outage.

As Australian drivers increasingly come to rely on EV transportation it will become possible to be stranded at home due to returning home with an empty battery to a power outage. However, this risk, which becomes increasingly remote as battery capacities increase, may be mitigated by:

- Wireless home charging keeping batteries fully charged leaving the premise,
- Onsite backup storage capable of providing sufficient energy to get to a fast charger,
- Backup generators for charging public charging infrastructure,
- Taking alternative transportation, including ride sharing.

Finally, if transportation-as-a-service catches on, consumers may choose to eschew car ownership, and charging would be conducted exclusively outside residential and most business premises. EVs would thus be reliant on public charging infrastructure, which will become critical for avoiding disruption to the transportation network.

Regarding the potential for EVs to provide additional backup energy during an outage, this technology is only just beginning to become feasible with vehicles like the Nissan Leaf. Notwithstanding, EV batteries for passenger vehicles are typically 50-100 kWh, and capable of powering residential premises for up to a week fully charged.

Energeia expects most cars to continue increasing their battery size until petrol range parity is reached in the next 3-5 years, and to come with wireless and vehicle-to-home/grid as standard within the next 5-10 years.

Based on the above analysis, Energeia recommends that the ECA consider promoting the importance of considering the impacts of EVs as part of the 2019 Review, even if the potential impacts are unlikely to become widespread in the next five years, it is important that their future implications are integrated into current thinking.

5 Key Recommendations

Based on the research and analysis presented in previous sections, Energeia recommends that the ECA consider the following key positions for the AER's 2019 VCR review:

- Develop and apply VCR methodology section criteria that reflects the long-term interests of consumers (LTIC) and the NEO,
- Include hybrid VCR methodologies in the assessment,
- Ensure the impact of new conditions are taken into consideration, e.g. communication technologies, solar PV, storage and EVs.

5.1 Australia's VCR Assessment Framework

Australia does not yet have a formal VCR methodology selection framework, nor has the basis for selecting the current approach to calculating VCRs been justified with respect to the LTIC and the NEO.

Energeia therefore recommends that the 2019 process develop a NEL and NER compliant assessment framework, i.e. one that explicitly addresses the LTIC and the NEO, to ensure that the 2019 VCR methodology will:

"promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to:

- *price, quality, safety and reliability and security of supply of electricity, and*
- *the reliability, safety and security of the national electricity system."*

Energeia has provided some suggested evaluation criteria in Section 3.1 as part of this high-level review, but recommends that a more detailed assessment, including the development of a transparent, consistent, practical and credible basis for assessing VCR estimation methodologies be prioritised as being essential to the selection of the demonstrably best VCR methodology for Australia moving forward.

5.2 Methodologies to be Assessed

Both the AEMO and AER Consultation Papers and related reports provide a high-quality summary of the range of potential VCR valuation methodologies, including analyses of strengths and weaknesses. However, neither consultation explicitly or systematically considered the potential for hybrid model-survey approaches to deliver a better overall VCR estimate, notwithstanding AEMO's decision to use a hybrid choice-WTP approach in 2014.

Given the significantly different VCR estimates between various methodologies, and particularly between survey and model-based methodologies, Energeia recommends that model-survey hybrid approaches be explicitly and systematically assessed as part of the 2019 VCR methodology selection process, including the approaches set out in the two examples referenced in Section 4.1.2.

Another important methodological issue that needs to be addressed as part of the 2019 review is the effect of widespread storage and falling storage prices on consumer VCR. Energeia recommends that the 2019 review consider, at a minimum, what the appropriate cost of reliability is for storage (e.g. net of bill benefits), how those costs vary by customer type and over time, and whether this will provide a cap on VCR, or if not, why.

5.3 Customer Segmentation

Energeia's analysis in Section 4.2 demonstrated that customers with battery storage systems or EVs are likely to be able to operate independently across the vast majority of outage scenarios. Their grid derived VCR is therefore expected to be virtually zero, even accounting for foregone revenues from selling excess PV to the grid.

Given the expected mass adoption of storage and electrified vehicles over the next 10 to 20 years, it is critical that this potentially radical change to Australia's VCR be dealt with as soon as possible. Energeia recommends accurate storage and EV adoption forecasts be included in the assessment to account for their effect over time.

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