14 Building a reliability framework in order to benchmark

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| Key points |
| * Reliable power services are essential for both households and industry. Even short and infrequent outages can have significant economic and social costs. * Standard forms of incentive regulation reward cost efficient network businesses with greater profits — mimicking the working of competitive markets. However, given network quality is not always easily identifiable, this can also create incentives for businesses to lower costs by reducing reliability. * To counter these incentives, regulated standards apply to reliability and other aspects of service quality. * Setting efficient reliability standards requires balancing the benefits to consumers of fewer and shorter power interruptions with the costs to network businesses of building and maintaining a more reliable network. * Reliability standards which do not reflect this balance — whether set too high or too low — can be economically costly, even if the standard is delivered cost efficiently by a network. * Standards that vary across networks and businesses, without good reason, can also impose significant costs on network providers and consequently on power consumers (see chapters 15 and 16). * Setting efficient standards requires accurate measures of the value that customers place on reliability. Current estimates are inadequate and more frequent and comprehensive studies should be undertaken to improve them. * Benchmarking of network businesses’ managerial performance as part of the incentive regulation regime would need to consider any continuing differences in reliability frameworks between jurisdictions. |
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Though the overall quality of electricity supply is a reflection of several factors, including safety and the level and consistency of voltage and frequency, the reliability of supply is a critical consideration. The precise meaning of ‘reliability’ can be context dependent (see box 14.1), but in general terms it relates to the likelihood that customers will be able to access power when they need it. Poor reliability — whether through frequent small, or occasional larger, power outages — can impose significant costs on households, businesses and the community more generally.

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| Box 14.1 Useful definitions |
| Discussions of reliability often use different terms and phrases to describe the same concepts or outcomes. Below are the definitions of the terms used in this report.   * **Quality:** quality of electricity supply collectively reflects a range of factors, including reliability; voltage and frequency levels; consistency and stability; and safety. * **Reliability:** reliability can be expressed in the positive or the negative. Thus, it can be used to describe the likelihood that customers will experience power interruptions, with reference to the number and/or duration of those interruptions. Alternatively, reliability can be used to describe the probability of a network, or part of a network, including one or more pieces of equipment, delivering electricity at any place and time at which it is demanded. In this context, the term ‘security’ is sometimes used instead of reliability. * **Failure:** an equipment failure is when a piece of equipment as part of a network stops working. * **Fault:** a fault is when a network, or part of a network stops working due to the failure of one or more pieces of equipment. A fault can, but does not necessarily, lead to an interruption to power supply. * **Outage:** an outage is when power supply to customers is interrupted. It can also be referred to as a power outage, power interruption, or blackout. Outages are often caused by failures and faults. * **Contingency event:** a contingency event is an event affecting the power system that the Australian Energy Market Operator expects would be likely to involve the failure or removal from operational service of one or more generating units and/or network elements. * **Redundancy:** redundancy involves the duplication of critical components to create excess capacity in a network to reduce the likelihood that a fault or failure causes an outage to occur. * **Satisfactory operating state:** a satisfactory operating state requires all network elements to be loaded within their ratings. * **Secure operating state:** a secure operating state requires the power system to be in a satisfactory operating state and to be able to return to a satisfactory operating state following the occurrence of any credible contingency. |
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Both transmission and distribution businesses endeavour to deliver reliable electricity supply by planning, maintaining and operating their networks to minimise power outages. For instance, network businesses build extra capacity (or redundancy) into their networks to ensure ‘adequate and acceptable continuity of supply in the event of failures and forced outages of plant, and the removal of facilities for regular scheduled maintenance’ (Billinton and Allan 1996, p. 1).

Governments and regulators also impose standards to ensure that network businesses maintain high levels of reliability, the costs of which are ultimately paid by customers. As the usual market mechanisms that allow customers to trade off the value of reliability against its costs are largely missing, it is important that the standard-setting process emulates those mechanisms.

This chapter outlines the key concepts germane to discussions of reliability, and maps out a framework that can be used to identify what constitutes an efficient level of network reliability. This framework is then used in the two following chapters to assess the efficacy of the reliability arrangements currently applying to Australia’s transmission and distribution networks and how they might be improved.

## 14.1 What issues does reliability raise?

More than sixty years ago, Giuseppe Calabrese (1947) wrote that:

… a fundamental problem in system planning is the correct determination of reserve capacity. Too low a value means excessive interruption, while too high a value results in excessive costs. (p 1439)

Calabrese’s analytical methods for testing reliability are still relevant today (Manohar 2009, p. 15), though their application has become far more complex as networks have become bigger and more interconnected, technologies have advanced, and the demand for power has increased considerably. The importance of reliability in electricity networks has also increased and with it, the contribution that reliability makes to required capital and operating expenditure of network businesses.

Participants in this inquiry have stated that reliability has been one of the major sources of network price increases in recent years, and have attributed this in some cases to changes in reliability standards and the costs of meeting standards as peak demand grows. The higher the standard, the more redundancy and maintenance is required on the network and the higher the capital and operating costs involved. There are also significant inter-jurisdictional variations in licence and regulatory requirements for reliability (see chapters 15 and 16), which impose additional costs on network businesses and ultimately on customers.

As discussed in chapter 1, the use of benchmarking in incentive regulation to encourage managerial efficiency must account for factors outside the control of businesses, including variations in standards set by governments and regulators. Controlling for variations in such standards also provides a direct measure of the cost implications of those differing standards. More broadly, to the extent that it is possible to identify an efficient standard that appropriately represents the preferences of customers (a benchmark in its own right), there will then be a basis for informed reform of standards — and, in particular, one freed from the political pendulum of expressions of concern about the costs of reliability and the aversion to particular instances of unreliability (such as widespread and extended, but rare, blackouts).

The influence of reliability settings on the way that electricity networks are operated, planned, and regulated is well recognised, and has prompted several reviews since the National Electricity Market (NEM) was established. Significant current and recent reviews include the:

* Australian Energy Market Commission (AEMC) Review of Distribution Reliability Outcomes and Standards — New South Wales Workstream (current)
* AEMC Review of Distribution Reliability Outcomes and Standards — National Workstream (current)
* AEMC Transmission Frameworks Review (current)
* AEMC Transmission Reliability Standards Review (updated 2010)
* AEMC Review of National Frameworks for Electricity Distribution Network Planning and Expansion (2009).

These reviews examine some of the major questions relating to reliability in the NEM, such as whether:

* in a national market for electricity, there is merit in developing nationally consistent frameworks for expressing, delivering and reporting on reliability in transmission and distribution networks
* current approaches to setting reliability standards in different jurisdictions are appropriate and whether customer preferences should play a bigger role in determining the nature of those standards
* the range of parties involved in setting standards in different jurisdictions is appropriate and, if not, what alternatives exist?

These reviews also provide valuable insight into the many levels of complexity of reliability in electricity networks including:

* physical constraints of a network, especially a network that is part of an interconnected market as large as the NEM
* the special characteristics of a reliable network, including that some aspects of its reliability are not easily observable and some important variables are outside the control of the businesses (for example, storms and faults in adjoining networks)
* the degree to which it is possible to identify the future risks of unreliability posed by underinvestment, network design problems, poor maintenance, or inadequate planning.

Several inquiry participants have emphasised the important effects of reliability standards on costs, and the obstacles to effective benchmarking posed by different standards.[[1]](#footnote-1)

Three themes emerge from the discussion above, which inform this and the following two chapters:

* reliability standards are a significant driver of costs for network businesses and lie largely outside their direct control
* the stringency of reliability standards affects customers through, on the one hand, its impact on electricity bills and, on the other, its influence on power interruptions. Cost–benefit analysis of levels of standards should take proper account of this trade-off
* regulatory settings within which reliability standards sit affect whether and how businesses deliver reliability, and have implications for efficiency in the NEM. As an example, the degree of jurisdictional intervention in specifying different reliability standards across the NEM can have implications for the overall level of efficiency.

## 14.2 Reliability under incentive regulation

Revenue (and pricing) caps employed in economic incentive regulations (chapter 5) aim to encourage profit-motivated businesses to lower their costs below those used to set the regulatory caps, and to take the residual as profit.

Absent quality standards, one way to lower costs would be to reduce service quality, especially as the quality of networks is only partially observable. For instance, it can take some time before degradation of the physical infrastructure or insufficient investment in new capacity shows up as poorer reliability. Moreover, because network businesses do not operate in a competitive market, they do not face the usual commercial pressures to meet consumers’ preferences for the trade-off between price and quality.

The consequence is that, under standard economic incentive regulations alone, network businesses would most likely underinvest in reliability. For example, by reducing maintenance, a network business could cut its operating costs, and at first glance, might appear to be more efficient. Possible consequences such as trees growing up against lines or the failure to replace ageing poles would not be apparent to most customers until they caused power interruptions (box 14.2). Overseas experiences (discussed in chapter 15) show this is more than a theoretical notion. Indeed, deteriorating reliability will eventually result in more and longer interruptions, thereby escalating costs for customers and the wider economy.

It is important to recognise, that notwithstanding the natural monopoly characteristics of network businesses, there will be some ‘market’ constraints on the scope for degradation in reliability under incentive based price regulation (box 14.2). There is also a range of instruments that can be used to encourage higher reliability, involving different degrees of balance between prescription on how reliability outcomes are to be achieved and penalties for failing to meet reliability outcomes.

Suffice to say that the incentive regulation framework for the NEM is complemented by a range of reliability standards governing the planning, operation and performance of transmission and distribution networks (chapters 15 and 16 respectively). Standards also apply to other aspects of quality including the consistency and level of voltage and frequency, and safety. As noted in the following two chapters, these standards currently differ from one jurisdiction to the next and, in the case of distribution, even from one business to the next within a jurisdiction.

## 14.3 The costs of reliability for network businesses

It is costly to build, operate and maintain very reliable networks. There are various dimensions and trade-offs involved in this task.

* Network businesses build redundancy into their networks so that in the case of a wide range of contingencies, customers will not experience an interruption to supply. For example, most transmission lines in the NEM can continue to supply the load demanded even when an element of the network, a line or transformer for example, fails. Failures, especially for transmission lines, are rare — according to AEMO (2010d, p. 14) single lines are effectively available 99.98 per cent of the time. This implies that there must be backup (redundancy) for only around one hour and 45 minutes a year.

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| Box 14.2 How do changes in reliability affect efficiency? |
| The figures below show the relationship between the level of network reliability and the costs of network supply. The figure on the left depicts a cost/reliability curve where decreasing reliability leads to lower costs per unit of supply. The figure on the right is a standard demand (D) and supply (S) curve depiction for electricity.  The effects of the incentive to reduce reliability under incentive regulation (and without reliability standards) can be depicted as a downwards shift in the supply curve of a business (S to S’ in the figure to the right below). The shift arises from the network business moving down the cost/reliability curve (as shown in the figure to the left below).  Under this scenario, the price remains unchanged because it is regulated (PM) and as customers cannot immediately observe the deterioration in quality and adjust their demand. Consumer surplus (CS) also does not change.  This figure is comprised of two charts. The chart on the left shows how the costs of electricity networks rise with increasing levels of reliability. The chart on the right shows that decreasing reliability allows the same quantity of electricity to be supplied for a lower cost.  However, the business makes more profits (or increased ‘producer surplus’ (PS)), equivalent to the shaded area between the two supply curves. Even in the absence of regulated standards, there is a limit to how far businesses could let reliability decrease. Consumers would eventually experience interruptions, and alter their demand accordingly. For example, they might purchase a supplementary source of energy (such as gas for heating and cooking, or generators). Even so, the imposition of regulatory standards may be a more efficient solution. These could take several forms, including prescriptive technological standards; economic incentives to set efficient levels of reliability by introducing rewards (penalties) for exceeding (falling short of) reliability targets; or allowing an independent body to monitor and enforce quality outcomes. |
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* As the operator that dispatches electricity around the NEM, the Australian Energy Market Operator (AEMO) is constrained in the load that it can dispatch down a line by the equipment ratings on the line.[[2]](#footnote-2) For a network business, although lower ratings lessen the likelihood of faults from overheating on lines, and thereby increase reliability, lower than necessary ratings artificially constrain the way that generators can be dispatched, potentially leading to higher than necessary costs for generated power.
* Consistent maintenance of network infrastructure reduces the probability of faults occurring. Maintenance can include removing the dust that gathers in insulators and can cause fires, and cutting trees that are too close to lines.
* Actions to increase reliability can also be taken after a fault has occurred, both to limit the spread of the outage to other customers and to fix the problem quickly to restore the power. To respond quickly to faults, network businesses use sophisticated monitoring and relay equipment to alert operators when and where a fault occurs, and they ensure maintenance crews are ready to be dispatched as soon as they are needed.

All of these measures are intended to avoid outages and, where they do occur, to minimise their effects on customers. In a well-managed network, the likelihood of a serious interruption to supply should get smaller (reliability gets better) the more a network business invests in physical, operational and maintenance capacity.

Businesses can address some causes of outages easily and cheaply. For example, one business indicated that a large number of its faults had previously been due to animals climbing into equipment. Subsequent installation of inexpensive animal guards on the equipment had reduced such faults considerably. Other causes of outages cost more to address, for example, maintaining easements and clearing vegetation from under overhead lines.

More generally, at a broad level, the higher the level of reliability, the more costly it is likely to be to achieve further improvements. For example, it is nearly impossible to build a network that retains reliability following extreme weather events. Undergrounding lines might largely avoid faults from weather events but only at a very high cost and, even then, the lines would be vulnerable to being accidently dug up. Also, the incremental costs for businesses of improving reliability are likely to differ across large networks such as the NEM due to weather, terrain, network length and network density (Jamasb et al. 2010).

While network operators will have a detailed knowledge of the costs and means to increase reliability, governments and regulators are typically less well informed. Without good information or sufficient resources to access expertise, governments and regulators will not be in a good position to make judgements about the costs of maintaining or improving reliability (let alone to set those costs against the benefits delivered for customers) This information asymmetry is one justification for benchmarking (and associated information collection), since it makes the cost differences and their sources — including variations in reliability standards — more transparent. (It may also be another justification for the use of the Regulatory Investment Test for Transmission (RIT-T) as a transparency tool, and the involvement of an independent expert body — AEMO — in planning (an issue discussed in chapter 15).)

More specifically, benchmarking network businesses may shed light on instances where a business has used innovative strategies to meet reliability standards. Any benchmarking with a reliability focus would of course need to take account of the divergences in reliability standards that apply across the NEM. Even so, with the potential benefits from even modest efficiency gains in meeting expensive reliability standards being large, a well-constructed benchmarking regime could be highly worthwhile.

Expressing reliability standards in a consistent way under NEM-wide frameworks for transmission and distribution networks has the potential to make any benchmarking task easier. The AEMC (2010a, 2012i) has recommended national frameworks for reliability for transmission and distribution. A national framework for the expression and application of, and reporting on reliability standards in transmission has progressed further, with the AEMC considering the implementation of such a framework (MCE 2011). A national framework for reliability standards for distribution is also currently under review (AEMC 2012i).

Notwithstanding the benefits that consistency in the expression of standards to facilitate benchmarking might have, it will not address the concern that the standards themselves might not be optimal. Because the cost of an increase in reliability will ultimately be included in customers’ bills and the costs of low reliability will also be borne by customers suffering interrupted electricity supply, regulators should carefully consider the incentives network businesses have to meet standards efficiently, as well as the settings of the standards themselves.

## 14.4 What level of reliability is efficient?

Just as customers value the quality of physical products differently, so too will they place different values on ‘reliable’ electricity supply. In competitive markets, the determination of the efficient level of quality is often left solely to the interactions between many suppliers and many consumers. If the market for network reliability were competitive, customers who had a strong preference for reliability could choose a more reliable service with a correspondingly higher price and vice versa. And if the service, including its reliability, was not good value for money then a customer could switch to an alternative provider.

However, electricity networks in Australia do not operate in a competitive market; customers cannot change their network service provider without physically moving to an area operated by a different network business. The natural monopoly characteristics of electricity networks mean that, without regulation, businesses would face relatively few of the usual market disciplines in setting prices and levels of quality. As noted earlier, this is why both price and quality/reliability regulation is required.

From an efficiency perspective, the level of reliability pursued through regulation must have regard to both the rising incremental costs and the diminishing value of greater reliability (box 14.3). These costs and benefits vary, depending on the type of customer, time of interruption, geographical location, and climate. Hence, to set appropriate standards, regulators need detailed and accurate information about the cost functions of businesses and the value of reliability for customers.

## 14.5 Measuring the value of reliability

Estimating the value to customers of the reliability of electricity supply is challenging. As customers cannot choose between network businesses offering different levels of reliability at different prices (or indeed between services of different quality offered by the same business), they cannot reveal directly how they value reliability. This problem is not isolated to electricity. Governments often set or require standards where consumers cannot directly observe quality (such as qualification standards for surgeons). Where markets cannot be relied upon to determine trade-offs between reliability and costs, regulators must use indirect methods to set an efficient standard.

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| Box 14.3 Identifying the efficient level of reliability |
| The figure below depicts the efficient level of reliability for a network. The upwards sloping curve represents the rising marginal costs of providing a more reliable network. The downward sloping curve represents the benefits to customers of improvements in reliability. The optimal outcome is where the marginal cost of providing an extra ‘unit’ of reliability is equal to its marginal customer benefit.  This figure shows that the efficient level of reliability for a network is the downward sloping marginal benefit curve to consumers from increasing reliability intersects the upward sloping marginal cost curve for network businesses. Supplying a higher or lower level of reliability results in welfare losses. |
| *Sources*: Jamasb et al. (2010); Ajodhia and Hakvoort (2005). |
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On the customer side, the usual approach is to try to estimate the benefits of greater reliability as the avoided costs of power interruption. These costs depend on the characteristics of the customer:

* Costs for commercial customers might include lost production and sales, reduced reputation for reliable product delivery, the costs of re-starting equipment, food spoilage, off-specification production, and equipment damage. Even brief outages can be costly, if machines take a long time to restart (MEU 2011b, p. 19).
* Costs for residential consumers are more difficult to quantify since they include nuisance and subjective costs that are not priced in markets, such as resetting clocks, lost work on computers, changing plans, fear, anxiety and coping with inconvenience.

Costs can also differ within customer groups across locations. For example, residential customers in rural settings, who are more accustomed to experiencing interruptions, may incur lower costs since they are better prepared to cope (for instance, by having an emergency generator). And the same customer can incur different costs depending on the time of the interruption; how hot or cold the day is; and the duration of the interruption.

There are also broader social costs of power interruptions, such as an increase in road accidents, or disruptions to telecommunications or public transport. A widespread and long lasting power outage in Sydney, for example, might also damage its international reputation.

### How precisely is the value of reliability to customers estimated?

The costs to customers of interruptions can be estimated in several ways, such as the value of unserved energy (in dollars per kilowatt).[[3]](#footnote-3) Other measures seek to map the costs incurred by customers according to interruption duration, recognising that these costs might not be linearly related to the amount of energy unserved. A large commercial customer, for example, might incur the majority of costs during the first five minutes of a fault, after which costs increase only slowly.

Such changing cost patterns can be captured in Customer Damage Functions (CDF), calibrating the cost of being without power as a function of the duration of the interruption. CDFs for individual customers can then be aggregated to the sectoral level to form a ‘sector customer damage function’ (box 14.4). By way of illustration, sector CDFs suggest that customers in agricultural industries experience costs of around one dollar per kilowatt for an interruption lasting one minute.

#### Estimates of values of customer reliability in Australia

Most Australian estimates of the customer value of reliability are based on surveys conducted in Victoria. Monash University conducted the first survey in 1997 using direct survey methods and Charles River Associates (CRA) updated these results in 2001 and 2007 (AEMO 2010e, p. 14). Termed the Value of Customer Reliability (VCR), AEMO uses these estimates when setting and advising on reliability standards in Victoria and South Australia respectively. AEMO updates the measures annually, indexing them to Victorian income measures (AEMO 2010e, p. 10).

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| Box 14.4 Estimating ‘customer damage functions’ |
| A customer damage function (CDF) describes the relationship between the costs incurred by electricity consumers and the characteristics of faults. Interruption costs reflect:   * interruption attributes: duration, season, time of day, day of the week, time of the year * customer characteristics: customer type, customer size, business hours, household family structure, presence of interruption sensitive equipment, presence of back-up equipment * environmental attributes: temperature, humidity, storm frequency and other climatic conditions (Sullivan and Keane 1995).   CDFs require various information on the costs that consumers bear when faults occur. There are two main approaches for collecting this information — models and survey evidence. Model based approaches include gross national product per kWh of electricity consumed; wage income per kWh consumed; and the cost of a stand-by generator (Ajodhia and Hakvoort 2005 p. 219; Oakley Greenwood 2011, p. 4).  Survey based approaches include:   * estimates of the direct costs of an interruption (for example, lost sales of businesses, or wages paid to staff unable to work) and also sometimes the costs that customers take to avoid, or to prepare for, interruptions (Oakley Greenwood 2011, p 5) * estimates based on the economic cost of substitution, which ask customers to choose from a given list, the actions (and their costs) they would be most willing to undertake * contingent valuation surveys, which assesses customers’ willingness to pay to avoid interruptions or willingness to accept more or longer interruptions * ‘conjoint’ analysis, which asks customers to pick or rank service/price bundle options, and sometimes to indicate the extent to which they prefer one option over another (CIE 2001; Oakley Greenwood 2011).   In general, model based approaches are cheaper and easier to undertake because the data usually already exist. Survey approaches take longer and are more complex.  CDFs can be more than two dimensional if they map the costs of different types of user to interruptions of varying durations at different times of the day and days of the week. CDFs will be more accurate the more information they embody about variations in customers, and the costs incurred from variations in interruptions. |
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AEMO has also used data on the energy usage of different industries to estimate values in the other jurisdictions in the NEM (table 14.1).

Table 14.1 AEMO estimates of the value of customer reliability in the National Electricity Market

$AUS/kWh

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Year | NSW | Vic | QLD | SA | Tas |
| 2007 | 35.08 | 50.26 | 37.20 | 38.04 | 42.02 |
| 2008 | 37.53 | 52.94 | 40.13 | 40.06 | 45.69 |
| 2009 | 40.07 | 56.18 | 42.00 | 43.12 | 48.44 |
| 2010 | 41.53 | 57.29 | 44.31 | 44.30 | 50.97 |

*Source*: AEMO (2012c).

ACTEW Corporation and ActewAGL commissioned NERA and ACNielsen to measure customers’ willingness to pay for increased reliability in the ACT. The results are not directly comparable to those presented in the table above but are on average lower (NERA and ACNielsen 2003). In South Australia, survey evidence found that customers were generally unwilling to pay for higher levels of reliability except in areas where service was considered relatively poor (ESC 2005, p. 33 and KPMG 2003). The AEMC reports a VCR in New South Wales of around $95 per kWh from a survey conducted by Oakley Greenwood (2012) using the same basic approach used for AEMO’s estimates. This survey also reported VCRs for each of the state’s distribution businesses. These were $87, $111 and $91 for Ausgrid, Endeavour Energy and Essential Energy, respectively (AEMC 2012i, p. iv).

##### How good are the available measures?

The estimated VCRs for Victoria and New South Wales unsurprisingly reveal higher burdens of interruptions for commercial customers compared with those for households. Both report similar values for households of around $20 per kWh (table 14.2). However, there are large differences in the estimated values for commercial entities which are the source of the sizeable difference between the overall weighted average cost for these two jurisdictions.

The differences may reflect methodological variations, different customer categories (and the sample weights associated with them), and increased reliance of smaller service businesses on computerised ordering, accounting and management systems, electronic payment processing and the use of the internet. However, it is unlikely that small business expectations of reliability have changed substantially over the short period concerned (and certainly, this does not appear to be true for households).

Table 14.2 Sectoral values of customer reliability for Victoria and New South Wales, 2012**a**

$/kWh

|  |  |  |  |
| --- | --- | --- | --- |
| Sector | Vic VCR (AEMO) | Sector | NSW VCR (AEMC) |
| Residential | 23.80 | Residential | 20.71 |
| Agricultural | 130.26 | Small business | 413.12 |
| Commercial | 103.77 | Medium-large business | 53.30 |
| Industrial | 41.24 |  |  |
| Weighted average | 57.88 | Weighted average | 94.99 |

a The weighted average Victorian VCR is higher than the figures in table 14.2 because it has been indexed to 2012.

*Source*: AEMC (2012i, p. 42).

VCRs in Australia are generally high by international standards (tables 14.3). In representations to AEMO’s Review of National Value of Customer Reliability (2012c), Visy (2011, p. 2) and the Major Energy Users (2011b, p. 4) have also questioned whether the Victorian VCRs are excessive. PIAC (2012) made similar observations about the estimates of the VCRs in New South Wales.

The US results (table 14.4) show that the cost per unserved kWh falls the longer the interruption lasts for all types of customer — a pattern likely to apply to most, though not all, customers in Australia.

Table 14.3 International measures of value of customer reliability for comparison

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Region | Sectors | Origin value | Year | $AUS (2009)/kWh |
| Sweden | Residential | Kr 61.16 | 2004 | 13.00 |
| Chile | Industrial | $US 0.22 | 1989 | 0.49 |
| Indian States | Industrial | Rs 24.71 | 2001 | 1.35 |
| Thailand | All | 60 Baht | 2000 | 3.22 |
| France | All | $US 3.60 | 1988 | 7.96 |
| NE USA | All | $US 4.11 | 1977 | 15.84 |
| Netherlands | All | € 8.56 | 2001 | 17.98 |
| Great Britain | All | £ 10.00 | 2006 | 26.09 |
| Ontario | All | $US 10.00 | 1980 | 33.00 |
| NW USA | All | $US 16.93 | 1990 | 36.57 |
| Ontario | All | $US 17.00 | 1989 | 37.58 |
| USA | All | $US 33.01 | 2008 | 37.63 |
| Ireland | All | € 40.00 | 2005 | 76.39 |
| New Zealand | All | $NZ 20.00 | 2011 | 16.00 |

*Sources*: Hickling (2010, p. 11); New Zealand Electricity Industry Participation Code, Schedule 12.2.

Table 14.4 Estimated values of customer reliability in the US by customer type and duration (for a summer weekday afternoon)**a**

$US (2008)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Interruption Cost | Interruption Duration | | | | |
| Momentary | 30 minutes | 1 hour | 4 hours | 8 hours |
| **Medium and large commercial** |  |  |  |  |  |
| Cost per event | 11 756 | 15 709 | 20 360 | 59 188 | 93 890 |
| Cost per unserved kWh | 173 | 39 | 25 | 18 | 14 |
| **Small commercial** |  |  |  |  |  |
| Cost per event | 439 | 610 | 818 | 20 696 | 40 768 |
| Cost per unserved kWh | 2401 | 556 | 373 | 307 | 218 |
| **Residential** |  |  |  |  |  |
| Cost per event | 3 | 3 | 4 | 8 | 11 |
| Cost per unserved kWh | 22 | 4 | 3 | 1 | 1 |

a These data are from a meta-analysis of VCRs for different regions in the United States. An average residential household in New South Wales uses about 0.83 of a kWh in one hour of energy usage. The most comparable results in this table to the NSW results are in the column representing an interruption of one hour.

*Source*: Sullivan et. al. (2009, p. xxi).

From a methodological perspective, the existing Australian data seem to have several major flaws. The surveys ask customers to estimate the cost of interruptions were they to occur at the worst possible time (Visy 2011, p. 2; AEMC 2012c, p. 41). This will produce an upwardly biased estimate given that outages may occur at any time. An appropriate model would consider the costs of events of all kinds, taking into account risk aversion. A second major flaw — which produces an opposite bias — is the lack of a measure of the costs of momentary interruptions (AER 2011d, p. 2).

A third critical limitation is that the studies only provide a point estimate of the VCR, when the value will vary for different levels of reliability and across many more customer categories than the few identified in the current studies. Indeed, this is the intention behind estimating CDFs described above. It would therefore be desirable if, unlike its current practice, AEMO were to use different VCRs to assess whether investments should be made in places where interruptions are common and long-lasting, and/or in places where interruptions are rare and short-lived. If the downward sloping curve, representing this relationship in box 14.3 were very flat meaning that the per unit costs of interruptions did not decline much as the duration or frequency of outages increased, a point estimate of the VCR might be a reasonable approximation. However, the characteristics of the relationship are an empirical question requiring more frequent and extensive research.

Theoretically, a single VCR also fails to account for differences in the mix of customers affected by an investment for reliability. For example, a line servicing an area in which there are large industrial or mining customers is likely to be valued differently to a line to an area that is largely agricultural. AEMO uses the same weighted customer costs in areas with different customer profiles.

And there are also issues with the methodologies that underlie the sort of measures referred to above. A common finding in the extensive literature on contingent valuation is that respondents’ willingness to accept is around three times their willingness to pay.[[4]](#footnote-4) Theoretically, they should be the same (Hartman et al. 1991, p. 142). However, Coursey et al. (1987) find that such disparities typically present for goods unfamiliar to consumers and that the willingness to accept measures converge to the willingness to pay results after repeated experiments.

This suggests that if the customers surveyed for the Victorian and New South Wales VCRs were largely unfamiliar with valuing reliability, the current measures might not be accurate, but that repeated surveys should improve the accuracy of the results.

Contingent valuation studies, including studies of electricity reliability, have also found a preference for the status quo (Hausman 1979; Hartman and Doane 1986). Hartman et al. (1991) found that in two groups of generally similar customers with very different historic levels of reliability, the majority in both groups preferred the levels of reliability that corresponded closely to their current level (p. 153). An important implication of this result, and an observation made by Energy Australia (2007), is that the number of complaints about quality of service is not a good indicator of whether an existing level of reliability is appropriate.

### **What are the implications?**

In light of the above, some might question whether attempting to compute customer reliability values is worth the effort.

But the same dilemmas and complexities have been present in similar contingent valuation exercises for measuring natural resource damage (Diamond and Hausman 1994) and cost-benefit analyses of a wide range of public policies (Whitehead and Blomquist 2006). The general, but tentative, view is that a number is better than no number (Whitehead and Blomquist 2006, p. 112).

The key point is that, estimated or not, for any given level of reliability, there is a corresponding value that customers place on it. At the very least, the valuation implicit in any mandated standard should be made explicit, and assessed for its reasonableness using empirical evidence. A claim that it is not possible to collect *any* evidence of the costs and benefits, would imply that reliability standards can be selected by throwing a dice —not a compelling approach.

Once the available evidence, explicit or otherwise, is assembled, it should first be tested for reasonableness, and then used to limit the range of possible reliability levels set by a government or regulator. If this is not done, there is the strong potential for reliability standards to be anchored to engineering, political or commercial preferences or prejudices, rather than customer preferences.

### A role for the Australian Bureau of Statistics

Given the complexities of compiling robust estimates of VCRs, and the costs of basing reliability decisions on sub-standard estimates, the most appropriate body to carry out the ongoing research necessary to improve VCR measures for the NEM would most likely be the Australian Bureau of Statistics (ABS).

The ABS has the technical capabilities to recognise and deal with the methodological challenges of undertaking surveys to measure non-market goods. They also have the organisational capacity to collect and synthesise large datasets.

Their independence ensures that external concerns such as political or commercial considerations would not influence their estimates of VCR. Comparisons between VCRs and other ABS data covering income, education, occupation and household characteristics would lead to a better understanding of the drivers of VCRs (and therefore feed into better surveys) in the future.

It is appropriate, however, that the industry (and therefore electricity customers) fund the research undertaken by the ABS. AEMO should commission and pay the ABS to undertake regular and detailed surveys, disaggregated by customer type, throughout the NEM. It is likely that the ABS could combine these surveys with others that they are conducting periodically and in that way reduce the costs of the research. Having such survey evidence available would provide greater surety that the benefits to customers of investments to enhance network reliability exceeded the costs.

### Other costs to be considered — the difficulty with transmission

The framework for determining an appropriate level of reliability is the same for transmission and distribution networks. However, given the different nature and consequences of faults, the methods used to discover customer valuations and the values themselves are likely to be different. Some transmission specific considerations include that:

* distribution businesses are also ‘customers’ for transmission businesses, and distribution networks can be damaged from voltage surges or other equipment failure in connected transmission lines
* interruptions in transmission networks can include wide-spread cascading interruptions that take a long time to resolve. The costs of these faults could be larger than the costs found in a distribution-focussed survey. For example, the options for customers facing an outage might be more limited and costly if the whole region is without power (for example, making it harder to rely on friends or family)
* transmission businesses have to consider high-cost, low-probability events, and how these might be valued by customers who may have never experienced such extensive outages before. Some costs might include having to truck in fuel for generators and fresh water from long distances, or the costs to society of being without everyday services such as street lighting and some public transport
* transmission networks in one part of the NEM are connected to transmission networks in other parts. Failures in one part of the network can have network-wide impacts. Any such costs would also need to be included.

### Setting standards in a dynamic environment

Customer preferences for reliability do not remain constant. Nor do the technologies for, and costs of, improving reliability. For example, as electrical appliances become cheaper, and people become more reliant on them, the premium on reliability is likely to rise (chapter 10). Similarly, increasing peak demand, more extreme weather events or changing costs of key inputs such as labour are likely to increase the costs of improving reliability. Such changes will in turn have implications for the appropriate level of reliability, highlighting the need for regular re-assessments of VCRs and in intermediate periods, empirically justified extrapolation.

#### The problem with averages

Networks cannot supply electricity with different levels of reliability to houses that are next door to each other. Accordingly, efficient levels of reliability do not mean that every person or business will get their desired trade-off between reliability and price. There will be customers who have a much higher (lower) willingness to pay and who will want a higher (lower) level of reliability. People with higher values may be able, if there are cost-effective options, to achieve greater reliability through other means, such as backup generators. But people with lower than average values of reliability have little capacity to adjust down.

#### Equity considerations

Efficient reliability may not always mean equitable reliability. The degree to which equity concerns should affect regulatory reliability standards is complex and context dependent. In some cases, people may value reliability very highly, but be unable to pay for it given income constraints. For instance, someone on an oxygen machine for emphysema will require reliable power to survive. However, circumstances where the value is as high as this usually require 100 per cent reliability, best met through ancillary (transparently subsidised) measures, such as a battery backup, rather than by increasing the reliability of the entire network.

Extreme cases like this aside, the most likely source of tension between efficiency and equity would arise if people on lower income placed a low value on reliability, but had to pay a higher network contribution due to the weight of more affluent households assigning a higher value to reliability. There is some evidence of this, albeit mainly from the US. In a large-scale meta-study, lower income was associated with smaller values of lost load (Sullivan et al. 2009, p. 67). Moreover, the uptake of electrical goods is lower among lower-income people (for example, air conditioning, multiple refrigerators and pool pumps), which would tend to reduce their VCR.

Addressing such tensions might be possible through different pricing menus. For instance, people on lower incomes spending smaller amounts on power could be offered a reduced fixed charge (which would be the main funding source for the fixed costs associated with meeting reliability standards) and a higher usage charge. Alternatively, some sort of subsidy might be provided, though any such subsidies should be transparent, and funded efficiently (chapter 3). (Given that current levels of reliability appear to be in excess of people’s average value of reliability — chapters 15 and 16 — were this to be corrected, electricity network charges should not rise as fast in the future, which would also assist lower income households.)

Of course, not all lower-income people will have relatively low VCRs. One example may be elderly people requiring reliable heating or cooling — with people aged above 65 years appearing to have (other things equal) higher VCRs than younger household customers (Sullivan et al. 2009, p. 67). However, it is unlikely that these older customers would be penalised by the sort of valuation approaches outlined above, given that there are many other non-vulnerable people who also value highly reliable systems.

#### The difficulty with the Back o’ Bourke

A correctly estimated VCR will indicate the costs that customers experience due to power interruptions in different locations. But the costs to increase (or even maintain) levels of reliability to some places, especially in rural or remote locations, are likely to far outweigh the willingness (or ability) to pay of the customers who reside there.

Through an economic lens, prices should be cost reflective, and it can be difficult to justify maintaining network infrastructure to deliver relatively reliable supply to some locations at a price at reasonable parity with urban areas. VCRs for these areas then lose their explanatory power.

However, governments in the NEM have expressed a clear desire to ensure service delivery at reasonable reliability continues for all customers. As described by the MCE:

Energy supply is considered to be an essential service and vital to the maintenance of the standard of living of individuals and households. Governments are concerned to avoid the outcomes a loss of supply due to inability to pay [for] (or a refusal to supply) electricity … can have on residential users (MCE n.d., p. 6).

The typical response has been some form of subsidy, sometimes effectively funded by other customers (and hidden) and sometimes by government. The latter is to be preferred, and any such Community Service Obligations should be transparent. Other responses to ensure that customers in rural and remote locations receive electricity supplied through networks connected into the NEM have included specific reliability standards (including Guaranteed Service Levels) and requirements to connect new customers.

The level of reliability that customers receive in these locations is therefore largely a question determined by governments. However, as well as being transparent and preferably funded directly by governments, the configuration of subsidies used to meet reliability objectives should create incentives for cost effective approaches. Energy supply to rural and remote areas can be provided in a number of ways, and the options available will increase into the future. If cheaper options exist to supply reliable electricity to an area than maintaining network infrastructure, service obligations should encourage, not hinder, network businesses to uncover them.

## 14.6 Concluding comments

Overall, decisions about the reliability of electricity networks should be empirically based, drawing on survey evidence about the value that people and businesses place on the various dimensions of reliability. This would ensure better outcomes for consumers as a whole, and most likely generate larger relative benefits for poorer households. If governments wish to provide subsidies to particular groups, then they should indicate the rationale for doing so, the basis for eligibility, indicate the costs transparently, and use the most efficient funding sources.

Revealing the value that customers place on reliability is only one prerequisite for efficiency and needs to be weighed against the costs of achieving different reliability levels.

The aim of benchmarking reliability standards is to discover the optimal trade-off and to identify what aspects of the regulatory regime are allowing (if not encouraging) inefficient expenditure to occur.

The next two chapters explore reliability in transmission and distribution networks, and the regulation affecting reliability in each.

Draft finding 14.1

Efficient levels of reliability are based on balancing the benefits to customers of fewer interruptions with the costs to network businesses of building, maintaining and operating reliable networks. Identifying the point at which the costs to network businesses of further increments in reliability exceed the additional benefits for customers should be the first step in regulating reliability.

draft finding 14.2

Current estimates of the value that customers place on reliability are based on inadequate sampling, data and methodology and need to be updated regularly.

DRAFT RECOMMENDATION 14.1

The Australian Energy Market Operator should commission and pay the Australian Bureau of Statistics to undertake regular, detailed, disaggregated surveys based on best practice methodologies to reveal the value of reliability for different categories of customers, with the methodologies and results made public.

The Australian Energy Market Operator should commission suitably qualified experts to consider and measure the costs of interruptions not likely to be captured in the Australian Bureau of Statistics surveys. This should include the costs associated with citywide disruptions, including to telecommunications, water services and public transport, and the resulting loss of international reputation from lower reliability. The Australian Energy Market Operator should use these measures to supplement the results of the surveys.

1. These include ETSA Utilities, CitiPower and PowerCor Australia (sub. 6, pp. 43–4), Ergon Energy (sub. 8, p. 10–11) and the Energy Networks Association (sub. 17, p. 30). [↑](#footnote-ref-1)
2. Line ratings limit the proportion of the maximum capacity of a line that can be used under different ambient conditions. For example, when the weather is cooler and there is more wind lines have higher ratings (more capacity) because they do not heat up (and then sag) as much. [↑](#footnote-ref-2)
3. Unserved energy is the amount of electricity demanded by customers that is not delivered due to interruptions over a given period. [↑](#footnote-ref-3)
4. Willingness to pay in this circumstance is the maximum that an individual would be willing to pay to reduce the number or frequency of power interruptions by a given amount. Willingness to accept is the minimum an individual would be willing to receive to accept an increase in duration or frequency of outages of the same amount. [↑](#footnote-ref-4)