REPORT

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Economic value of reducing the risk of a gas supply outage

A threshold benefit-cost analysis

Prepared for ActewAGL

Centre for International Economics
Canberra & Sydney

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Summary

- **Estimates of the probability of a supply failure that results in a cut in gas supply to customers are quite low. This probability is estimated to start at around 0.0059 per year, increasing to 0.0123 by 2029.**
- **If an outage does occur, it is expected to involve a cut in gas supply to 50 000 customers. The customer exposure increases over time to 84 000 by 2029.**
- **The average time that affected customers are without gas is estimated to start at 130 hours, increasing to around 200 hours by 2029.**
- **Estimates of customer willingness to pay (WTP) to avoid an outage suggest that, for the length of time involved, WTP starts at around $1 300 per residential customer, increasing to around $2 000 per residential customer by 2029 (as the length of outage increases). For commercial customers, these range from $11 500 to $18 000 per customer. These WTP estimates are not precise, but are probably at the upper bound of what is likely.**
- **An outage will also involve reconnection costs (around $35 per customer) and other 'communication' costs incurred by ActewAGL (set at $25 per customer).**
- **Combining these estimates suggests that the present value of the expected outage costs is $11.8 million if all customers affected are residential, or $14.1 million for a mix of residential and commercial customers. This range is equivalent to the maximum benefit that could be obtained from investments to increase system security. Based on the factors quantified in this report, it is the maximum amount that can be justified on a benefit cost basis to increase security.**

1 Introduction

This note provides an estimate of the expected cost of a supply system failure that results in the disconnection of customers. This expected cost is equivalent to the maximum value of improvements to security (that reduce the probability of an outage) or, alternatively, the maximum amount that should be spent on increasing security.

The underlying evaluation framework is typical of risk analysis. The expected cost (or risk in dollar terms) of an outage is calculated as the probability of an outage multiplied by its consequence.

The probability of an outage (for a particular number of customers) is built up in a number of stages, as considered in section 2.

This note considers three measured consequences:

- the willingness of customers to pay to avoid an outage;
- the costs of reconnection; and
- the 'publicity' and administrative costs to ActewAGL of an outage.

The value of these consequences is built up from:

- the willingness to pay per customer (for a particular length of outage);
- the projected number of customers affected;
- the projected length of outage per customer;
- the reconnection cost per customer affected; and
- the 'publicity' cost per customer affected;

There are two main sources of information for the estimates presented here:

- the willingness to pay study conducted by NERA for ActewAGL;
- estimates of system demands and probabilities of failure provided by Jemena[1].

Neither of these two sources of information has been independently validated by the CIE. Rather, we have used them as inputs into the threshold benefit-cost analysis.

[1] Jemena 2009, *Engineering Assessment: ACT and Queanbeyan Network Security of Supply*, Revision C, 24 December 2009.

2 Security analysis

Building up the probability of an outage

The reliability of gas supply to the ACT is determined by a sequence of factors. The first of these is the security of the gas supply trains that deliver to the ACT — the MSP and EGP pipelines. Determining the probability of failure in these is the fundamental starting point to the analysis.

The probability of failure in each supply train is itself built up from the likelihood of failure at key supply points within the train. These are shown in tables 2.1 (for MSP) and 2.2 (for EGP). In each case, the probability of failure of the full train is the sum of the probabilities of failure at each point along the train.

2.1 **Probability of failure in MSP**

	Gas field		*Moomba-Dalton*		*Dalton-Watson*		*Total gas supply train*
Mean time to failure (MTF)	5214.29	→	8.77	→	100.63	⟶	8.056
Probability of failure (1/MTF)	0.000192	OR (+)	0.114	OR (+)	0.009937	EQUALS	0.1241

Source: Jemena

2.2 **Probability of failure in EGP**

	Gas field		*EGP Main*		*Hoskintown-Fyshwick*		*Fyshwick TRS*		*Total gas supply train*
Mean time to failure (MTF)	5214.29	→	25.97	→	201.29	→	26280	⟶	22.884
Probability of failure (1/MTF)	0.000192	OR (+)	0.0385	OR (+)	0.00497	OR (+)	0.000038	EQUALS	0.0437

Source: Jemena

In the case of MSP, the weakest component is in the Moomba to Dalton pipeline, with a probability of failure of around 0.114. This probability dominates that of the full train, which has a probability of failure of 0.1241, or 1 in 8 years.

In the case of EGP, the weakest point is the EGP main, with a probability of failure of 0.0385. This dominates the probability of failure of the full train, which is 0.0437, or once every 23 years.

How these two probabilities translate into the probability of actually cutting supply to ACT customers depends essentially on the underlying redundancy within the ACT network — whether supply sources can be switched, so that the failure in one supply can be controlled for, or whether both supply sources need to be running to satisfy demand. This in turn depends on the level of demand.

There are two possible outcomes. In the first, the ACT system contains a redundancy so that if either of the MSP or EGP fails, the other can still provide gas to the ACT. In this outcome, the probability of an outage is related to the probability of *both* the supply sources failing — an AND probability, involving the multiplication of two underlying probabilities.

In the other outcome, there will be times when both MSP and EGP are required to satisfy demand. This occurs at peak times within the year — and will become increasingly likely over time as demand increases. In this outcome, the probability of an outage is related to the probability that either MSP or EGP fails — an OR probability, involving the addition of two underlying probabilities.

Table 2.3 shows how the probabilities of these two outcomes are built up.

2.3 Two possible outcomes

Outcome 1: Demand less than capacity at Watson, redundancy in the system	***Outcome 2: Demand greater than capacity at Watson, systems requires both EGP and MSP***
Probability of failure = p(MSP fails) **AND** p(EGP fails)	Probability of failure = p(MSP fails) **OR** p(EGP fails)
(assume 14 days downtime to fix failure in either)	
Probability of failure = 2*[p(EGP fails)^2]*14/365	Probability of failure = p(EGP fails) + p(MSP fails)
Which = 0.000146	Which = 0.168
Weighting of this outcome = 8457 out of 8760 hours, decreasing to 8121 out of 8760 hours by 2029	Weighting of this outcome = 303 out of 8760 hours, increasing to 639 out of 8760 hours by 2029
Weighted total probability equals 0.0059 increasing to 0.0124 by 2029	

Source: Jemena, CIE calculations

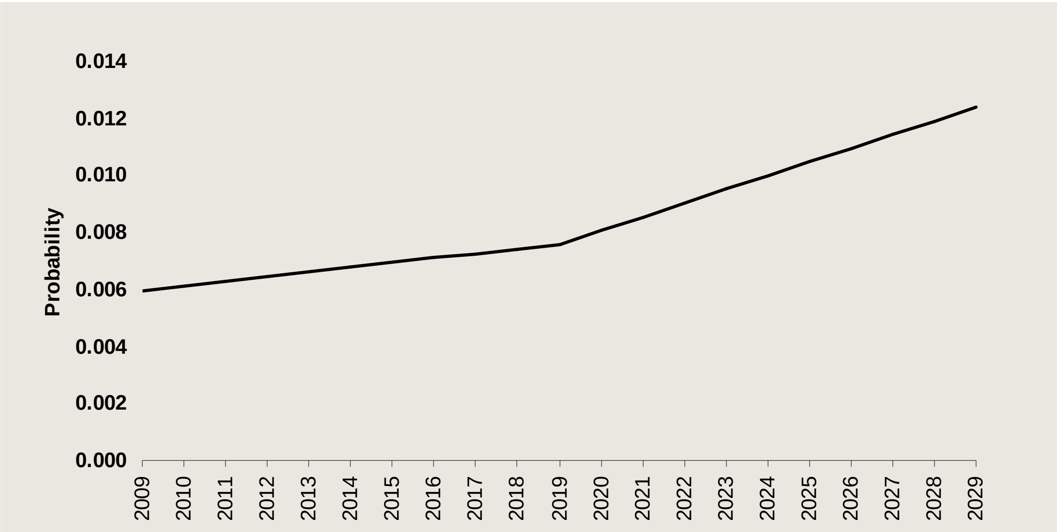
Table 2.3 shows that the probability of failure in outcome 1 (probability of failure when demand is less than capacity at Watson) is very low. Moreover, this will be the most frequent outcome, accounting for the majority of hours in a year.

Table 2.3 also shows that the probability of failure in outcome 2 (probability of failure when demand is greater than capacity at Watson) is relatively high (around 0.17). However, this will not be a frequent outcome, occurring in between 303 and 639 hours (depending on demand) out of the full year.

The combined probability (the weighted average of the two) is quite low, as it is dominated by the fact that for most of the time, the ACT system has built in redundancy.

The overall probability of failure over time is shown in chart 2.4. This probability increases over time, as demand increases mean that over time, it is more likely that both EGP and MSP will be needed to satisfy demand.

2.4 **Probability of system supply failure**



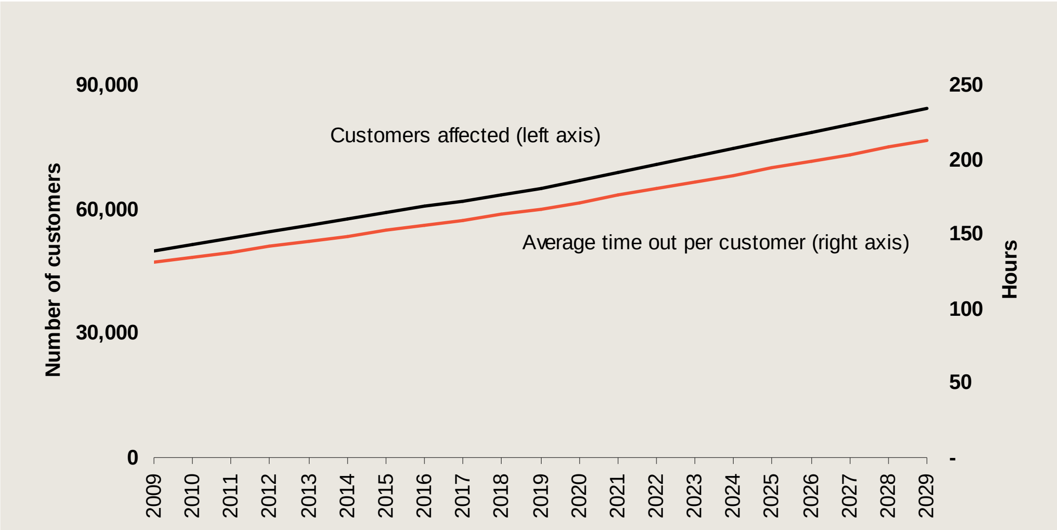
Data source: Jemena

Number of customers and expected time of outage

Chart 2.5 summarises Jemena's projections of the number of customers affected by an outage, and the expected time (in hours) that each customer will be without gas. This is determined by the estimated time it takes to reconnect supply. The number of customers affected by an outage starts at 50 000 and increases over time as more customers are added to the system.

The expected time of an outage is a function of the number of customers affected. For 50 000 customers, the duration of the event is estimated to be 260 hours. This increases as the number of customers increases. The amount of time that the average customer is without gas is assumed to be half the duration of the event.

2.5 **Customers affected and average outage time per customer**



Data source: Jemena, CIE

The consequence of an outage

Willingness to pay (WTP) to avoid an outage

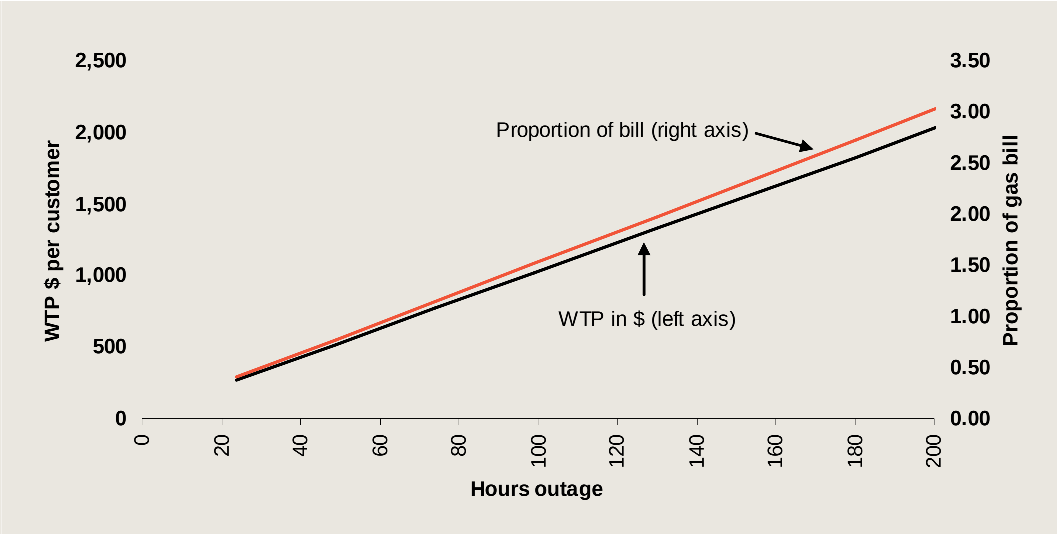
In 2003, NERA undertook a WTP analysis on behalf of ActewAGL. Part of their analysis included considering the willingness of both residential and commercial customers to pay to avoid a gas outage. In this analysis, WTP is — amongst other variables — a function of the length of the outage.

Residential customers

Broadly, residential WTP to avoid a 24 hour outage was estimated to be around $270 dollars per customer (or around 40 percent of their average gas bill). As noted above, the likely length of an outage is much greater than this (between 130 and 200 hours). This length of time is outside of the original range considered by NERA, which raises the question of the appropriate way to estimate WTP to avoid long outages.

One possibility is to assume a continual relationship between length of outage and WTP. Chart 2.6 illustrates this for a range of outage lengths. Thus, for example, WTP to avoid an outage of 130 hours would be around $1 300 per customer. This is around 2 times the average bill. This amounts to assuming that the costs to customers of an outage continue to accumulate as the time of the outage increases. This could reflect, for example, ongoing costs of using other means of providing the services originally provided by gas — the cost of alternate heating and cooking arrangements, for example.

2.6 **WTP per residential customer and outage length**



Data source: CIE estimates based on NERA data

Another possibility is that the WTP does not increase as time of the outage goes beyond 24 hours. This could be, for example, because once customers have experienced the initial cost of an outage (through, for example, purchase of electric heaters, or a new microwave) the costs no longer increase as the time of outage continues.

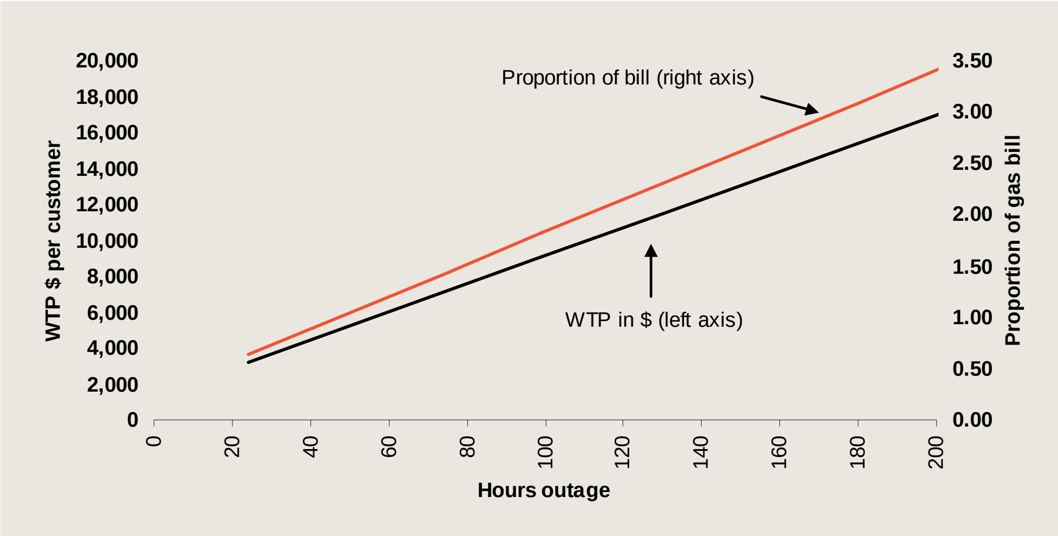
The correct outcome is likely to be somewhere between these two extremes. For the purposes of the initial analysis presented here, we assume that WTP continues to increase as the time of outage gets longer.

Commercial customers

Commercial customers (which are around 3 per cent of the total number of customers) are generally prepared to pay more to avoid a gas outage — simply because they purchase more gas, and have more at stake from an outage.

Chart 2.7 shows the relationship between commercial WTP and the length of outage. Thus, for example, WTP to avoid an outage of 130 hours would be around $11 000 per customer. This is around 2.3 times the average bill.

2.7 **WTP per commercial customer and average outage length**

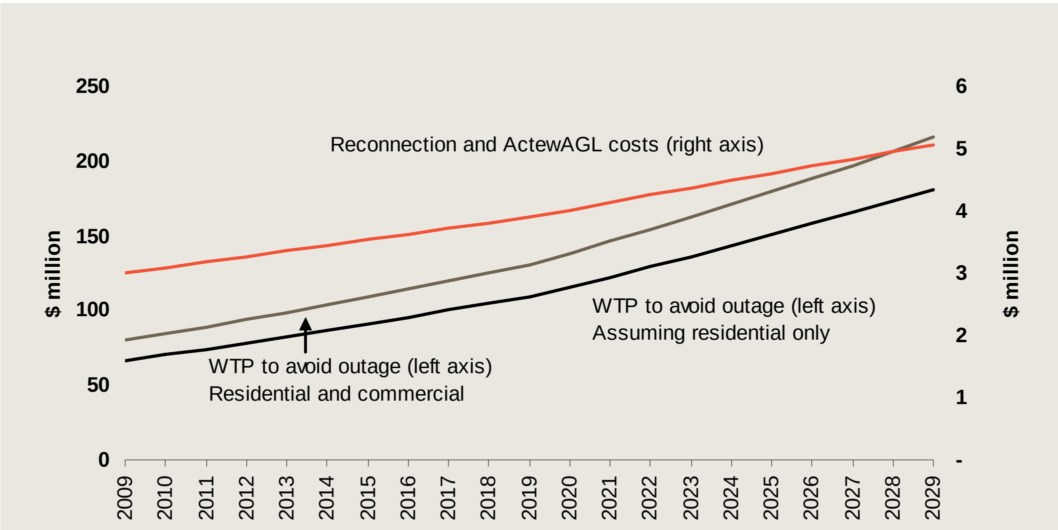


Data source: CIE estimates based on NERA data

Aggregate willingness to pay

Chart 2.8 shows the resulting estimate aggregate WTP for the number of customers (as shown in chart 2.5) and the time of outage (also shown in chart 2.5). The resulting aggregate WTP starts from $66 million and increases to $180 million by 2029 if all customers affected are assumed to be residential. If a mix of residential and commercial is assumed, then aggregate WTO starts from $80 million and increases to $216 million by 2029.

2.8 **Willingness to pay to avoid outage, and reconnection and administrative costs of an outage**



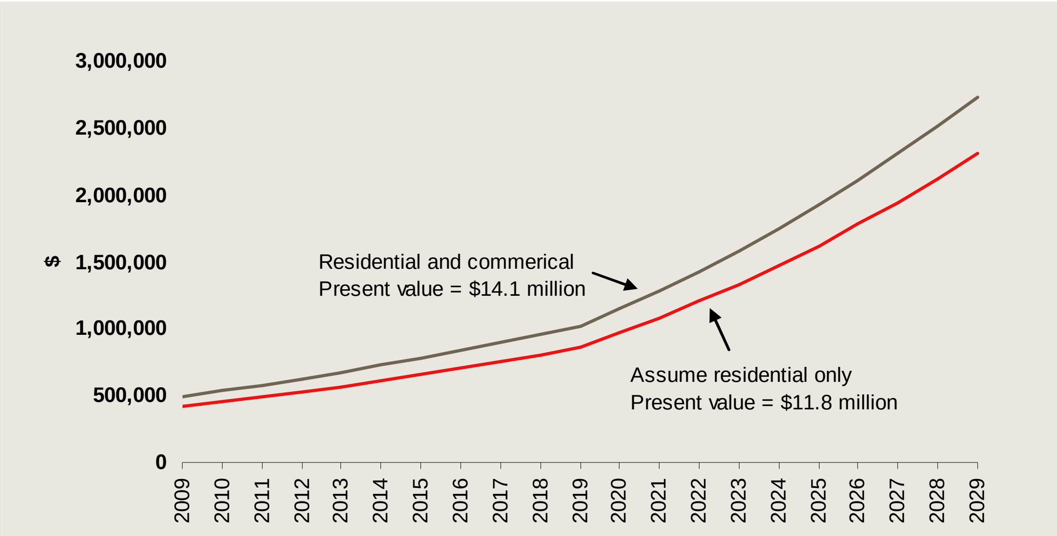
Data source: CIE estimates based on Jemena and NERA data

Also shown on chart 2.8 are the estimates of reconnection and ActewAGL costs. Reconnection costs are estimated by Jemena to be around $35 per customer, while other ActewAGL costs (dealing directly with affected customers) are assumed by the CIE to be $25 per customer[2]. The magnitudes of these costs are considerably smaller than the WTP estimates.

The expected cost of an outage

Chart 2.9 shows the result of multiplying the total cost of an outage by the probability of an outage.

2.9 **Expected cost of an outage (probability of outage times cost)**



Data source: CIE estimates

Considering the case where only residential customers are affected, the expected cost of an outage starts at around $400 000 in 2009. This is equal to a WTP of $1 330 per customer (for an expected 130 hour outage) times 50 000 customers, plus $35 per customer reconnection costs plus $25 per customer other costs, all multiplied by the probability of an outage of 0.005946.

By 2029, the expected cost of an outage is around $2.3 million. This is equal to a WTP of $2 146 per customer (for an expected 212 hour outage) times 84 000 customers, plus $35 per customer reconnection costs plus $25 per customer other costs, all multiplied by the probability of an outage of 0.012378.

The present value (at 5 per cent discount rate) of this stream of expected costs is $11.8 million. This is equivalent to the value of reducing the existing risk of an outage to zero. Equivalently, it is the maximum amount that should be paid on the basis of the factors quantified to reduce the probability of an outage.

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[2] This is broadly equivalent, for example, to the cost of phoning each customer individually to explain and deal with the outage.

The calculations are similar for the where a mix of residential and commercial customers are considered. In this case, around 3 per cent of customers are assumed to be commercial (reflecting the current mix), and the higher commercial WTP is included in the calculation. The present value (at 5 per cent discount rate) of this stream of expected costs including commercial customers is $14.1 million. This is equivalent to the value of reducing the existing risk of an outage to zero. Equivalently, it is the maximum amount that should be paid on the basis of the factors quantified to reduce the probability of an outage.

Sensitivity analysis

The results presented here are clearly sensitive to a variety of assumptions. Table 2.10 explores some of the key sensitivities.

2.10 **Sensitivity analysis**

Sensitivity considered	***Variation***	
Reconnection costs and ActewAGL costs	*Half* $13.9m	*Double* $14.5m
Underlying risk	*Half* $7m	*Double* $28m
Proportion of the year without redundancy	*Base* $14.1m	*Plus 2 weeks* $24.8m
Time of outage	*Base* $14.1	*Plus 2 weeks* $27.1m
Discount rate	*1 per cent* $23.4m	*10 per cent* $8.2m

Source: CIE estimates

It shows, for example, that doubling or halving the reconnection and administrative costs has a relatively small effect, with the outcomes ranging from $13.9 million to $14.5 million. Note that increasing the reconnection costs may mean that the time of outage is reduced (through, for example, employing more personnel). Given that outage costs are greater than reconnection costs, it is possible that spending more on reconnection could reduce the overall costs of an outage.

Halving or doubling the underlying risk has the direct effect of halving or doubling the overall cost of the outage. Note that doubling the underlying risk implies a mean time to failure in the MSP supply train of 4 years. This is more frequent than observed. Similarly, it implies a mean time to failure of the EGP train of 11 years, again a very high frequency of failure.

It is possible that an outage in the MSP supply train that lasts for 2 weeks has the effect of increasing the proportion of time that the ACT network has no redundancy. The effect of this is to increase the cost from $14.1 million to $24.8 million.

Similarly, an increase in the effective time of the outage will increase WTP, so the NPV increases from $14.1 to $27.1 million.

Finally, the discount rate has an important influence on the overall result. A lower discount rate (1 per cent) increases the NPV to $23.4 million (or by 66 per cent). Increasing the discount rate to 10 per cent lowers the NPV to $8.3 million, (or by 41 per cent). This asymmetry simply reflects the fact that many of the costs are in the future.

Other uncertainties

The above analysis refers to the physical infrastructure that delivers gas to the ACT. There are other factors that may generate security issues even in cases where the physical infrastructure has no failure.

Shipper under-nominations (not ordering enough gas to satisfy demand) have been suggested as a potential future risk to security in the ACT. While mis-nomination relative to demand is almost guaranteed, in the past this has only led to security issues where some other external factor has been involved. In general, under-nomination has been dealt with through intra-day renominations.

Under-nomination could become an issue if there is an increasing likelihood of some other external reason why additional gas cannot be sourced in the short term to correct the under-nomination. This may be, for example, because of very high demand (as would be expected in a sudden cold snap) or perhaps because of changing pattern of demands and nature of gas supply to the ACT following the introduction of the short term trading market (STTM).

In this case, the risk posed by under-nomination depends on whether it exceeds the threshold that can be managed within the ACT network. Analysis by Jemena suggests that this threshold would be 22 per cent (of demand) in 2009, 6 per cent in 2019 and 1.5 per cent in 2029. That is, if the under-nomination is greater than 22 per cent of demand (in 2009), then there is a risk of disconnecting customers. By 2029 this threshold is reduced considerably because of demand growth — an under-nomination of greater than 1.5 per cent of demand leads to the risk of disconnecting customers.

A quantitative measure of the risk posed by under-nomination in these circumstances is not currently available. Indeed, because under-nomination is in many ways a behavioural issue, the risk probably depends on currently unknown choices that may be made in the future — particularly surrounding the STTM. At this stage we are therefore unable to quantify the risks associated with under-nomination.

3 Conclusion

The underlying low probability of a supply failure to the ACT puts a limit on the amount of mitigation spending that could be justified.

It is important to note, however, that as the risk is expected increase over time (as demand on the system increases), the willingness to pay for increases in security will also increase over time. Mitigation projects that are not easily justified today may become so in the near future.

In addition, this report has not been able to quantify all risks to gas supply in the ACT — particularly risks or unintended consequences that may be associated with the operation of the STTM. It is expected that these risks will be better understood over time. It may, therefore, be worthwhile updating the risk evaluation on a regular basis.