Report to

National Generators Forum

Reliability Panel's Comprehensive Reliability Review-Technical Matters

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EXECUTIVE SUMMARY

McLennan Magasanik Associates (MMA) has reviewed some of the technical questions concerning the reliability standard that have been raised by the National Generators Forum (NGF) and the Reliability Panel (RP).

MMA supports the current definition of the reliability standard and considers that the methods for its estimation represent good industry practice. The methods are being progressively improved by NEMMCO with support from a number of consultants such as KEMA, ROAM and MMA in recent years.

Objective

The objective of a reliability standard is to manage the risk of the market failure concerning adequate provision of generating capacity. Market failure may arise either through insufficient reliability, or through excess reliability in that capital resources were not being applied where their value exceeded their cost. If the excess reliability occurs through market intervention, customers bear the cost of the intervention. If reliability is insufficient, customers are adversely affected by supply interruptions that disrupt their activities which cause them additional cost through loss of production or costs for emergency power supplies and loss mitigation.

In order for the reliability standard to achieve this objective, some further developments are recommended by MMA. This requires the formulation of a reliability standard on an economic basis.

Optimal Reliability

A process for assessing an optimal reliability level for the NEM on an economic basis is recommended to reduce the risk of inefficient intervention in the market by NEMMCO and to provide better incentives for demand side participation. This level can be determined by balancing the cost of unserved energy and the cost of reserve capacity for different levels of reliability, to determine the level of reliability which minimises the total cost.

MMA has performed such an analysis based on available data and determined the optimal level of reliability for each region of the NEM for each year to 2009/10. The analysis could be improved by using data held by the jurisdictions but not available to MMA. The savings from moving to such standards were estimated at up to $40M pa relative to achieving the current standard.

MMA has outlined a strategy to achieve the above objective and realise these savings in the longer term outlook. This strategy requires a review and optimisation of the load shedding arrangements and the determination of the corresponding optimal reliability level having regard to the value of customer reliability to the customers most exposed to supply interruptions and high energy prices.

NEMMCO's Interpretation of the Standard

MMA believes that in general, NEMMCO is applying the current standard using the best available methods. MMA supports the continuation of the ongoing improvements to the implementation of the reliability standard as recommended by MMA in 2002, KEMA in 2004 and ROAM Consulting in 2005.

However as outlined by MMA in 2002, there remain some uncertainties in determining the capacity level needed to achieve a given level of reliability. Given the longer term consequences of frequent intervention, a margin should be applied to the optimal level prior to intervening to reflect the uncertainty in measurement and outcome. That is, intervention should not occur unless the projected capacity shortfall exceeds the margin which represents the uncertainties. NEMMCO's current conservative implementation has the opposite effect, creating the risk of frequent intervention even if the reliability standard is being met over time. The uncertainty margin would reduce the reserve margin for intervention by about 50 MW in South Australia, 80 MW in NSW and 100 MW for Victoria and Queensland.

MMA believes that while it does not matter what peak demand basis is used to determine long-term reserve margins, stating them on a 50% POE basis for publication purposes might give more comfort to the general public that they are adequate and in accordance with international practice. We do not believe this change would alter the economic analysis of potential well informed investors.

The estimation of capacity requirements for the planning horizon should take into account the uncertainty of economic growth and the associated electricity demand. A composite measurement of capacity requirements would indicate how much capacity needs to be in the planning approval pipeline in each region to manage the risk of higher demand growth. This would be useful for monitoring the health of the new capacity investment process.

The modelling of load diversity between constrained NEM regions can be improved by further analysis of the relationship between peak demand and weather and the longer-term trends in this sensitivity and the weather itself.

If these improvements are adopted, MMA sees no merit in changing from NEMMCO's continuing to implement the standard.

System Security

The classification of unserved energy events in measuring and modelling exposure of customer load to disconnection should relate to the most economic mitigation measure. If the risk of unserved energy can be economically mitigated by building reserve generating plant, contracting demand side withdrawal or augmenting transmission capacity with a neighbouring region, then the unserved energy for that class of events can be related to bulk system reliability and should be included in the reliability standard. All other matters including those arising from industrial action, control and protection failures in the transmission system, local restrictions in network capacity, and widespread events arising from cascade failures should be regarded as separate considerations from the bulk system reliability measures.

MMA supports collecting data on near-misses to assist in modelling these low-probability events more accurately.

Distribution Reliability

MMA believes that distribution reliability should not be linked to the assessment of bulk system reliability because efficient levels of reliability in these two areas of the supply chain are achieved by entirely different types of investment. It would lead to sub-economic outcomes if these two aspects of reliability were linked in some arbitrary way.

Process for Analysis

MMA has recommended a process for quantification of a reliability standard which includes:

- Developing optimised load shedding policies in each jurisdiction to minimise the cost of exposure to unserved energy
- Quantifying the costs and benefits of alternative schemes for setting independent reliability targets and caps for each region and year based upon expected supply/demand conditions and their uncertainty or averaging them over regions and years.
- Choosing a new methodology from among the schemes to set standards by regio and time
- Setting appropriate targets for monitoring purposes and critical cap levels for regional capacity as the basis for intervention to contract additional reserve capacity and for identifying deficits in the planning and approvals pipeline
- Establishing a basis for adjustment to the target and cap levels between reviews as a function of reserve capacity costs, customer value of reliability, forced outage rates and patterns of economic growth
- Publishing an Intervention Frontier which defines combinations of minimum capacity levels below which NEMMCO would intervene on the basis of demonstrated market failure.

1 INTRODUCTION

The National Generators Forum (NGF) has engaged McLennan Magasanik Associates to assist its understanding of and submission to the Reliability Panel's (RP) Comprehensive Reliability Review (CRR). The Australian Energy Market Commission (AEMC) supports the Reliability Panel, and a Terms of Reference and Statement of Process may be found at www.aemc.gov.au.

An Issues Paper has been released on 11 May 2006, with comments due by 30 June 2006.

The Issues Paper raises 47 questions covering a wide range of issues pertaining to NEM generation/transmission system reliability. The issues upon which the RP is seeking comment include:

- the acceptable level of reliability in the NEM, its measurement and application;
- whether or not there is a problem with reliability levels in the NEM and if so is it material and how should it be fixed;
- how the review of reliability should be structured and what issues are a matter of priority;
- what should be allowed as the value of customer reliability;
- what this means for price caps and the cumulative price threshold in the NEM and the consequential economic drivers for generator investment;
- the triggers and basis for reviewing the reliability standard in the future;
- the use of contract trading instruments to improve reliability outcomes
- the role of demand side response in achieving reliability outcomes; and
- the changes in the power generation mix and how that could affect reliability outcomes.

MMA has been invited to provide expert assistance to the NGF's Reliability Sub Group (RSG) regarding the acceptable level of reliability in the NEM, its measurement and application. The questions relating to the economic drivers for new investment need not be considered.

1.1 NGF Views and Activities

The NGF has advised MMA that its members have varied views on the ability of the current market design to deliver a sustainable economic return for existing and new plant required to meet a reasonable level of reliability. Nevertheless the NGF agrees that the energy-only market may fail if there are excessive reliability expectations, or, if reliability portrayals are unreasonably alarmist.

The NGF has had a long-standing concern that NEM reliability is unreasonably portrayed as poor, and during 2004 sponsored a detailed modelling consultancy that concluded that the method of setting intervention trigger levels at that time was conservative in comparison to the RP's 0.002% average Unserved Energy Limit. It further recommended greater use of probabilistic planning approaches and different means of publishing reliability assessments.

That study has been provided to a number of stakeholders, and whilst not all its recommendations have been taken up, NGF notes that the intervention trigger levels have since moved closer to the levels expected by the study. The study will be provided to interested parties.

The RSG formed a preliminary view that an outcome-based average annual unserved energy target of 0.002%, implemented accurately, is not unreasonable in the context of an efficient first-world power system and the levels of distribution interruption.

However NGF believes that other stakeholders favour a more conservative target, or a deterministic reserve measure only.

1.2 Matters to be Considered

MMA has been requested to assist the NGF's interpretation and response to the following matters :

1. The use of the outcome based standard, i.e. an average Unserved Served Energy (USE) as a reliability target measure in the NEM.
2. Whether 0.002% USE, is a reasonable level, considering economic impacts and community expectations?
3. Is NEMMCO interpreting the standard in a reasonable manner?
4. Are the benefits of the national diversity of demand peaks being appropriately recognized?
5. Should "Security" incidents (i.e. transient disturbances), be incorporated into reliability forecasting?
6. Where relevant to the above, take into account the characteristics of distribution reliability.

NGF requested comment on these issues by MMA expertise regardless of their coverage in the Issues Paper.

1.3 Cross-reference to the Issues Paper

After the Issues Paper was released, the NGF requested that MMA focus on Chapter 3 and sections 5.3 and 5.4 of the Issues Paper. An analysis of the issues as structured in the Issues Paper with the questions posed above is presented in Table 1-1. In this report, the questions are posed by the Reliability Panel will be addressed directly so as to facilitate consideration of the NGF's submission. The questions raised by the NGF move from the more important and general to more specific and this report retains that structure.

Table 1-1 Issues proposed by NGF and as presented in the Issues Paper

Key Issues in Scope	Corresponding Issues Paper Questions
The use of an outcome based standard	10. Is a measure based on unserved energy the most appropriate form of standard? 11. If not, what would be a more appropriate form of standard for use in the NEM and why? 12. Is it desirable, and are there ways, to broaden the form of the standard to incorporate a range of reliability-related considerations? If so, which considerations and why? 19. Should there be greater clarity in terms of the definition of bulk transmission? If yes, how should it be defined? 24. Should specific 'exogenous' matters such as industrial action be included or excluded? If so, what factors and why?
Is 0.002% a reasonable level?	13. Should the standard be determined on a NEM-wide basis or separately for each region?
Economic basis for the reliability standard	14. Is the level of the current NEM reliability standard appropriate? If not, what level would be appropriate and why? 15. What level of VCR is appropriate and how, and on what basis, should it be measured? Provide reasons or analysis to support your views.

Key Issues in Scope	Corresponding Issues Paper Questions
Is NEMMCO interpreting it in a reasonable manner?	16. Should the reliability standard be treated as a cap or as a target? If the latter, should the standard be expressed as a range for NEMMCO to target? 42. Is the current approach to NEMMCO's operationalisation of the standard through the reserve margin thresholds appropriate? If no, what improvements are suggested to the framework and/or the methodologies and why? 43. Should the Panel explicitly approve NEMMCO's reserve margin calculations or should the Panel undertake the calculations itself? What POE or POEs should they be expressed in relation to (for example, a 10 per cent, 50 per cent or weighted average? 44. Should the fuel issues and changing generation mix described above be factored into the reserve margin calculations? If *yes*, explain why and how? 45. Would the effectiveness of the reliability settings be improved by explicitly defining contingency, short term and/or medium term capacity reserve standards? If *yes*, how should they be determined?
Are the benefits of regional load diversity being correctly modelled?	No specific Issues Paper questions. This was a question of concern to NGF.
Should security incidents be included into reliability forecasting and reporting?	22. Should the scope of the standard be extended to encompass matters currently treated as system security issues such as multiple contingency events? Should near misses be reported? 23. If *yes*, how should such matters be defined to ensure that supply adequacy is appropriately monitored in the context of power system security?

Key Issues in Scope	Corresponding Issues Paper Questions
How should the standards relate to distribution reliability?	20. Are there additional considerations which should be included in the standard to reflect regional concerns, for example, stricter standards for high-load areas such as CBDs? 21. Should there be a role for the NEM reliability settings in compensating for potentially lower reliability outcomes further down the supply chain?

A summary of responses to the issues raised by the RP is provided in the Conclusions in Chapter 10 to facilitate analysis by the Reliability Panel in the context of reviewing submissions concerning the Issues Paper.

1.4 Matters not considered by MMA

The Issues Paper also covered the following matters:

- The levels of VoLL and Cumulative Price Threshold;
- Whether the energy-only market will drive investment to an acceptably reliable level
- The extension, replacement or cancellation of the reliability safety net.

MMA was not required to provide views on these matters except where they have a direct bearing on the matters described in section 1.2.

1.5 References

A number of documents were referred to as part of this project which are summarised in APPENDIX A

2 PROJECT APPROACH

2.1 MMA Perspectives on the Reliability Standard

MMA's currents views on the generation reliability standard in the NEM have been published previously in a report to the Reliability Panel in September 2002 (Ref 1). More recently in March 2006, MMA has completed an additional analysis of the economics of the NEM's reliability standard (Ref 3). As a result of this work, MMA is of the view that:

- the current reliability standard is not necessarily economically optimal, although the essential data necessary to prove this proposition are not made public;
- substantial changes may be needed to the standard to make it economic;
- the information needed to determine an economic level is protected by jurisdictions as confidential and that this inhibits proper planning and risk management in the NEM, especially involving the role of the demand side and the risk to customer loads;
- The load shedding arrangements need to be reviewed and optimised to minimise the customers' expected cost of unserved energy;
- the uneconomic standard being delivered through generating capacity is uneconomic and squeezing out demand side participation that would make the NEM more effective as an energy market as it was intended to be;
- the initial impact of a change to an economic reliability standard would be negligible in the next two years because the NEM has surplus generating capacity;
- the long-term benefits of an optimal reliability standard could be as much as $40 M per annum relative to achieving the current standard of 0.002% in each region;
- using the expected unserved energy as a standard for intervention by NEMMCO is inappropriate because there is some uncertainty in the measurement of unserved energy and some margin from the expected value should allowed before intervention. Markets should not be subject to frequent intervention if they are achieving the standard considered acceptable; and
- NEMMCO's intervention if any should be based upon a risk margin away from the target requirement depending on the prevailing uncertainties affecting the measurement of expected unserved energy or alternative reliability criterion. This would allow the market to work without the risk of uneconomic and counter-productive interference.

> The current reliability standard is not necessarily economically optimal.

> Load shedding arrangements need to be reviewed and optimised.

These perspectives form the basis of the review reported here.

MMA's approach to this project was to summarise the available literature including the Issues Paper on these matters and, drawing on its own analysis and experience, highlight the critical issues and propose changes that would be helpful in making the NEM a more efficient market. In the following chapters we discuss each item in the context of the work that has gone before, the current issues and the prospects for the future based upon MMA's view of the likely development of the NEM. The corresponding questions in the Issues Paper are then considered and a summary response is provided based upon this analysis. Each of the following chapters addresses the NGF questions in turn.

2.2 Are there any completely new ways of looking at this?

Reliability management practices relying on measures of unserved energy have been in use for decades in electricity markets. Both probabilistic and simulation models of electricity markets provide this measure as an output in energy terms. It is challenging from an academic and professional perspective to seek better and different ways of approaching the problem which may reflect paradigm shifts in the market or the use of new technologies. For example, high powered computers now make reliability forecasts possible with a higher level of sophistication than ever before. This means we can analyse aspects of the problem that were not worth bothering about previously because the previous analytical tools were not able to deal with the market complexity in any practical time frame. We could not operate the NEM as it is today without the internet and broadband communications.

MMA does not perceive that a radical change in direction with respect to reliability management would markedly improve the performance of the NEM. MMA recommends that the focus on setting reliability standards not get too concerned with technical detail such as how the measure should be specified until it has chosen a course through the major conceptual pathways of increasing complexity which are:

We are ultimately trying to manage the risk of market failure by monitoring trends in and forecasts of reliability and acting on it accordingly through the market regulations.

- Accept what we have without question (not what this Reliability Panel review is about)
- Update the current unserved energy reliability standard in accordance with previous methods and fix it for a period until the next review (the Issues Paper has already gone beyond this stage as well)
- Design a new process to manage reliability with new criteria and management processes (a possible outcome of the current review); or
- Accept that reliability is an outcome of a market process rather than an input and that we are ultimately trying to manage the risk of market failure by monitoring trends in and forecasts of reliability and acting on it accordingly through the market regulations.

If we pursue the last pathway then we need to consider what constitutes the market failure related to reliability. An efficient market will deliver services that have a marginal cost equal to the marginal value of those services. If there is a substantial gap between the marginal cost and the marginal value within the lead times of delivery and consumption then we would say that the market has failed to work efficiently, hence the use of the term "market failure". The evidence would show a need that was not being met by current of planned resources that were available in principle but were not being delivered, or that the market over-delivered on the need and resources were wasted without benefits to market participants commensurate with their costs.

> The potential market failure is that the marginal cost of reserve capacity is not equal to the marginal value of supply interruptions to customers.

In the context of reliability the potential market failure is that the marginal cost of reserve capacity or demand side withdrawal to meet the failures of supply elements in the market is less than the marginal value of supply interruptions to customers (the Value of Customer Reliability VCR). In economic terms excess reliability is also a market failure in that capital resources were not being applied where their value exceeded their cost. If the excess reliability is achieved by market intervention, customers bear the cost of the intervention, and potential investors are effectively put on notice that intervention may occur again. This will reduce their propensity to invest, creating a longer term threat to reliability, and a greater market failure than an equivalent under-supply of capacity because the development pipeline would dry up. On this basis, we approach this task with the objective of achieving an efficient electricity market with a reliability level that equates the marginal cost of reserve capacity (including the savings that could be achieved from mothballing surplus plant) to the marginal value of capacity in terms of its value to customers in avoiding unintentional load shedding. MMA recommends that this be the objective and focus of this reliability review.

2.3 Usefulness of International Practice

MMA does not think that the focus should be on other electricity markets. The focus should be on getting the best outcome for Australian customers in the NEM, not following any particular new international developments of how to specify reliability standards. International practice can provide guidance to avoid pitfalls but it isn't necessarily the best answer for local market conditions.

2.4 Treatment of Demand Side Response

One important issue not adequately addressed in the Issues Paper is the treatment of demand side response that is priced into in the market operation. How does such demand reduction be related to the unserved energy criterion? Are such load reductions to be treated as part of the unserved energy or to be excluded from the measure?

In MMA's analysis we include such load reductions as part of the unserved energy because the high prices at which such load reduction occur normally signal an impending shortage of capacity or low utilisation of generation assets. In an economic analysis of unserved energy we treat all load as firm and explicitly value the load that is disconnected on price or involuntarily disconnected on the same basis. This best represents the economic impact of the load shedding if we assume that:

> Demand side response whether bid into the market or imposed involuntarily in response to capacity shortages should be costed when assessing the optimal level of reliability.

- The bid price based demand side response is offered at its marginal value which reflects its economic value to the customer
- The involuntary load shedding is valued at the value of customer reliability indicated from market surveys for those customers who are at risk and not the market on average.

Using this method avoids potential confusion from trying to discriminate between the two types of load reduction and inadvertently overlooking the economic value of the demand side response that is bid into the market.

In terms of market monitoring this may be difficult if load reductions occur without being explicitly bid to NEMMCO. This would be interpreted as a change in the peak load shape and would not be valued explicitly. However, if the remaining bid and involuntarily shed load resources were evaluated then a robust economic analysis should still be feasible because the analysis would be based on marginal values and we could deem the embedded demand side response as not marginal.

> The applicable value of customer reliability should be that for the actual load at risk and not the market on average.

3 UNSERVED ENERGY AS AN OUTCOME BASED STANDARD

3.1 The Issue

The first area to be considered is the use of the outcome based standard, i.e. an average Unserved Served Energy (USE) as a reliability target measure in the NEM. The alternative approach is to use an input based measure such as capacity reserve, or a capacity level by time. The decision as to whether the reliability measure should be input or output based is addressed in the Issues Paper and the request for analysis has been provided by means of questions 10 to 11 as shown in Table 1-1 on page 10.

3.2 Analysis of Sources

A summary of views from published sources is provided in Table 3-1 as a basis for this discussion.

The argument for an output based measure is strongly based upon the proposition that it provides a more relevant measure of the impact on customers than does an input measure that may have only a tenuous relationship to customer impacts. This is well argued in ROAM Consulting's Paper (Ref 2). For example, reserve capacity once defined as a MW quantity does not by itself take into account most of the factors that influence bulk supply reliability such as the pattern of loading, the variability of load in response to weather, or the forced outage performance of generators.

Input measures can serve a limited purpose of providing a measurable quantity that is benchmarked to a reliability measure for a limited period and a defined set of market conditions. For example, NEMMCO can say for a period of a month what set of capacity levels would be sufficient in each NEM region to ensure that a reliability standard defined over a period of a year can be satisfied with a specific level of confidence. In this example an output based reliability measure can be converted into an observable input measure that can be used for monitoring and intervention on a real time basis.

3.3 Analysis of Options

MMA supports the principle of using an outcome based standard as an appropriate measure of reliability providing its benchmarking and application is based upon economic principles. A reliability measure is regarded by MMA as well suited to its purpose if meets the following criteria:

- It is easy to understand as a concept
- It reflects in some meaningful way how customers are affected by the level of reliability either in a proportional or inverse way
- It is economically optimal over time, stable and does not require frequent and costly reviews

Table 3-1 Summary of Published Views on the use of an unserved energy standard

<table>
<tr><th>Source</th><th>Context</th><th>Conclusion</th><th>Rationale</th></tr>
<tr><td>Determination on Reserve Trader and Direction Guidelines June 1998</td><td>Original basis for reliability standard and basis for intervention</td><td>Unserved energy standard 0.002%

Intervention on the basis of 10% POE peak demand plus largest unit except 830 MW in NSW allowing imports from Snowy as capacity.</td><td rowspan="2">Consistent with good industry practice. Reserve margin requirement was based upon security considerations in meeting 10% POE peak demand. Based on recommendation by NEMMCO which was accepted by the Reliability Panel.

It was consistent with practice prior to the NEM.</td></tr>
<tr><td>Reliability Panel – Re-evaluation of Minimum Reserves June 1999</td><td>Analysis of original basis for reliability standard</td><td>Documents reserve required to meet the largest single contingency at 10% POE peak demand or capacity so that expected unserved energy is no greater than 0.002% of energy demand.</td></tr>
<tr><td>MMA Report September 2002</td><td>Review of NEMMCO's determination of a reserve margin in 2001</td><td>The use of an outcome based standard was not challenged.</td><td>The scope of the project was concerning the application of the unserved energy standard rather than its suitability for quantifying a reliability standard. The level of the standard was not reviewed.</td></tr>
<tr><td>ROAM Report June 2004</td><td>Review of reliability analysis for NGF</td><td>The use of a probabilistic rather than a deterministic measure of reliability was endorsed. The largest contingency method of defining a reliability measure was shown to be too conservative relative to the unserved energy measure.</td><td>Reliability depends on six different aspects of the power market. The use of a simple reserve margin does not adequately capture the impact of these factors on customers.</td></tr>
<tr><td>MMA Report March 2006</td><td>Analysis of economic reliability Standard</td><td>The use of an outcome based standard was not challenged.</td><td>The scope of the project was to determine an economic level of reliability for the mainland regions of the NEM.</td></tr>
</table>

- It can be used to estimate the costs of unreliability upon customers
- It can be used to determine how much generating capacity must be provided and where it can be situated to deliver the optimal level of reliability
- It can be used to derive a basis for managing reliability risk either by individual market participants or by the market operator.

Table 3-2 shows how the expected unserved energy as a measure of reliability meets these criteria as well as some common alternatives. The table does not provide a comprehensive analysis of all options because MMA considers that there is no better alternative worth pursuing at this time. Table 3-2 also shows where each measure has its contribution to make:

- The measure of unserved energy is suitable as the primary index because it includes the impact of duration and the amount of power at risk as measured by energy.
- The measure of loss of load hours gives a measure of the duration of exposure to load shedding and may be useful as a secondary measure of impact.
- The measure of reserve capacity is useful as a real time measure that can be used to indicate when intervention would be beneficial and how much additional capacity would be needed to manage the risk of load shedding.

The application of unserved energy as a descriptive basis for reliability standards between review periods is appropriate provided it is based upon a proper assessment of the risks to customers and the economic benefit to the market as a whole. Ideally, the analysis should include the risk of adverse outcomes and the marginal cost of improving reliability with more or less reserve capacity on the supply or demand side.

The application of unserved energy as a descriptive basis for reliability standards between review periods is appropriate provided it is based upon a proper assessment of the risks to customers and the economic benefit to the market as a whole.

If the standard is to be reviewed infrequently then the choice of the standard should reflect customer impacts as closely as possible and be able to be recalibrated to the prevailing costs of reserve and supply interruption. An unserved energy criterion meets that requirement because it is a volume measure even if not a direct measure of economic value. This approach is satisfactory providing loading patterns are stable and the cost of unserved energy is escalating at the same rate as reserve generation or demand side withdrawal costs. Such a standard can be applied reasonably accurately under stable market conditions and readily adjusted to reflect unusual or substantial cost changes as follows:

1. The unserved energy criterion should be multiplied by a ratio of changes in the costs of reserve generating plant. For example if the cost of reserve plant were to increase by 20% due to a marked fall in the foreign currency exchange rate then the

standard should be increased by 1.2 (1 + 20%). In the NEM this would mean moving from 0.002% to 0.0024%.

Table 3-2 Analysis of Input and Output Measures

	Alternative Reliability Measures		
Measure ► Criteria ▼	**Expected unserved energy**	**Expected loss of load hours**	**Reserve Capacity**
Explanation	The ratio of energy not supplied divided by the energy demanded averaged over a range of uncertain market conditions. Usually measured or analysed on an annual basis.	The average period of time in a year during which customer load cannot be fully supplied averaged over a rage of uncertain market conditions.	Installed capacity less a forecast peak demand defined for a specific set of weather conditions. Weather conditions refer to an extreme hot or cold day in the peak demand season with a probability of being exceeded on an annual basis.
Understandable	Is a very low number which many may find difficult to appreciate in quantitative terms.	Quite easy to understand because it is measured in hours or minutes.	Simple to understand but confusion arises over the basis for the corresponding peak demand.
Meaningful	Directly related to customer impacts but not necessarily directly related to their costs. Expected customer unreliability costs increase monotonically with unserved energy. Unrelated to reserve capacity costs.	Outage duration is meaningful to customers but is not related to the magnitude of supply interruption in power or energy terms.	Related to reserve capacity costs. Unrelated to direct customer impacts and may inadvertently exclude demand side response if not included in "capacity".

	Alternative Reliability Measures		
Measure ► **Criteria ▼**	**Expected unserved energy**	**Expected loss of load hours**	**Reserve Capacity**
Stable and economic	Optimal value would vary with changes in the customer mix, patterns of usage and generator plant performance. Stable for changes in load growth. Proportional to capacity reserve costs and inversely proportional to customer value of electricity.	Optimal value would vary with changes in the customer mix, patterns of usage and generator plant performance. Stable for changes in load growth. No clear relationship to economic costs.	Has a complex relationship to all dependent factors and would need to be recalculated often based on output based reliability measures and market costs. Optimal reserve margin can be reasonably stable if market conditions are stable.
Related to Customer Costs	For small changes in unserved energy, customer's costs would vary directly with unserved energy. Over a wide range customer costs vary non-linearly with unserved energy.	Unrelated to customer costs because it does not measure the volume of energy at risk or maximum power at risk.	Unrelated to customer costs.
Determine capacity	It can be used to determine capacity costs by means of supply reliability simulations. It cannot be used directly to determine reserve capacity costs. Capacity varies approximately as the negative of the logarithm of unserved energy.	It can be used to determine capacity costs by means of supply reliability simulations. It cannot be used directly to determine reserve capacity costs.	Directly related to reserve capacity costs

	Alternative Reliability Measures		
Measure ► **Criteria ▼**	**Expected unserved energy**	**Expected loss of load hours**	**Reserve Capacity**
Managing Risk	Market simulations can determine the uncertainty in unserved energy outcomes and their associated costs providing that customer survey data are available and current. Such analysis can form the basis for risk management and intervention.	Because it does not directly measure customer impacts, other measures are better suited for this purpose.	Because it does not directly measure customer impacts, other measures are better suited for this purpose.
Preferred role	The basic measure of reliability performance because it is related to customer impacts.	A measure of the duration of exposure to load shedding as a supporting measure.	A real time measure of what is needed to deliver the target reliability over the longer term. It is used as an indicator of when intervention would be beneficial and how much additional capacity would be needed to manage the risk of load shedding.

2. The unserved energy criterion should be divided by a ratio of changes in the value of electricity to customers who are most exposed to load shedding for changes in the reliability standard. For example if residential customers were the only significant segment at risk with a previously assessed value of customer reliability of $1.00/kWh and a subsequent assessment shows this to be inaccurate and that the new value was $1.50/kWh then the unserved energy criterion would be divided by 1.5 ($1.50/$1.00) to reflect the higher impact. In the NEM this would mean moving from 0.002% to 0.0013% if these were the customers most affected by the standard (unlikely except for a very stringent standard that avoided exposure to commercial and industrial customers).

> The optimal expected unserved energy level is proportional to reserve capacity fixed costs and inversely related to the value of customer reliability.

If reserve costs and customer impacts costs were changing at the same rate then the two price based adjustments would cancel out. This is the implied assumption behind the current stable level of 0.002%.

3.4 Issues Paper Questions

Taking this analysis and considering the Issues Paper questions we make the following arguments as detailed in Table 3-3. There is scope to broaden the application of reliability related parameters in managing supply risk in the NEM. This is highlighted in the answer to Q12 and is discussed further in Chapter 5 in relation to the application of the standard.

Table 3-3 Analysis of Issues Paper Questions on the use and Basis of an Output Standard

Question	Analysis	Qualifications
10. Is a measure based on unserved energy the most appropriate form of standard?	**YES** because it is related to customer costs for interruption to supply and it can be readily recalibrated between market review periods if costs change. It combines both the duration and power level at risk in one convenient measure. Simple sensitivities to cost factors and capacity can be derived for use between reviews.	Using only the **expected** unserved energy may not adequately quantify the risks faced by customers. Refer chapter 5. It effectiveness depends on realistic modelling of the future power system including all major supply and demand side risks affecting reliability.

Continued on the next page…

Question	Analysis	Qualifications
11. If not, what would be a more appropriate form of standard for use in the NEM and why?	The fundamental principle would be characterising feasible values for the level and type of capacity in each NEM region that would equalise the marginal cost of reserve capacity with the marginal cost of supply interruption. From such an analysis we would derive the parameters we need to measure the deviation from the optimal outcome and manage accordingly.	It might be argued that excess capacity does not need to be managed because those bearing the costs (the suppliers) are able to manage those excess costs by mothballing surplus capacity. However it would be helpful if market monitoring and information would highlight that surplus position and give a time horizon for plant mothballing given the published demand outlook.
12. Is it desirable, and are there ways, to broaden the form of the standard to incorporate a range of reliability-related considerations? If so, which considerations and why?	**YES**. It would be desirable to quantify the risk of high levels of unserved energy affecting the higher value customers such as small industrial and commercial customers. This would be more important if reliability is to be based upon economic analysis and be more finely tuned to market conditions.	Little effort can be justified in broadening the form of the standard if the NEM is going to continue policies that over-estimate the requirements for generating capacity and over-deliver on reliability.

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Question	Analysis	Qualifications
19. Should there be greater clarity in terms of the definition of bulk transmission? If yes, how should it be defined?	The critical question is not the definition of the bulk transmission system but rather the types of disturbances in the market that can be managed through regionally sited reserve generating capacity or upgraded interconnection capacity. There is no need to define a fixed boundary if this approach is taken. A boundary could be misleading if power transfers could be effected at subsidiary voltage levels between regions.	There may be a need to define whether a particular project constitutes an upgrade to interconnection capacity which affects regional supply reliability. If the reliability benefit would become part of the market benefit test for regulatory purposes and after commissioning the capacity levels to meet the standard would need to be re-evaluated.
24. Should specific 'exogenous' matters such as industrial action be included or excluded? If so, what factors and why?	Matters should only be included if they can be most economically managed by adding reserve generating capacity or upgrading interconnection capacity. Industrial action does not usually fall into this category unless the union has no market power and cannot escalate the action to achieve its objective. Similarly multiple outages of transmission lines with cascade failure of control and protection facilities does not qualify either because improved design and operational standards and practices are by far the most effective way to minimise exposure to such events. Surplus generating plant could assist recovery but not until the transmission system is re-energised, so it's not the most effective mitigation method.	All unserved energy events should be recorded and classified according to their type and the best method for their avoidance or management in the future. This will assist understanding of the processes which affect the continuity of supply and support the mitigation of supply risks in the future.

4 THE 0.002% STANDARD

4.1 The Issue

4.1.1 Historical Basis

An intriguing question is the basis for the setting of the 0.002% expected unserved energy level by the Reliability Panel in 1998. The stated basis for this level was "at approximately the same level as the existing planning standard in each jurisdiction." (Ref 4). It appears to have been selected as consistent with preceding practice in Australian jurisdictions without any specific analysis of its economic viability in the Australian context at the time. This may have been a matter of convenience as the effort in establishing the NEM was considerable at that time and all industry and government resources were stretched.

Under Government ownership of electricity systems, reliability standards have become established through political and technical processes that determine an acceptable balance of risk and cost. Such standards then became the basis for investment timing with the focus of risk analysis relating to short-term uncertainty of demand and performance of existing resources. In the experience of MMA's staff, the reliability standard itself was not usually called into question at the point of investment timing.

4.1.2 Current Purpose

> Rather than being a target to be met, the primary use of the reliability standard should be as a basis for responding to market failure.

However, in the NEM, the reliability standard only affects new investment if NEMMCO intervenes in the market to contract additional peak resources. Otherwise, investors are expected to use spot prices, forward market prices and technical analyses of supply/demand balance as the basis for investment in new capacity. Since this intervention by NEMMCO is conducted on a time scale shorter than the lead time for new generating plant, it can only affect mothballed plant and demand side response with some minor exceptions[1]. Therefore the purpose of the reliability standard under a competitive market with market regulation is different from that under the previous public sector ownership regime with Government oversight.

Rather than being a target to be met, the primary use of the reliability target should be as a basis for responding to market failure. However, MMA is not convinced that this change in practice is fully appreciated by governments and many market participants. The fact that the 0.002% unserved energy measure has been accepted as a minimum level and is also now applied as the basis of intervention implies that either:

[1] Apart from installation of diesel powered generators at industrial sites

- There is a confusion between the acceptable level of reliability and the basis for intervention which would be expected to be at a lower level of reliability (higher unserved energy) than the minimum target of 0.002%; or
- If the target level of reliability really is 0.002% but it has been erroneously adopted as the basis for intervention.

Ironically the previous basis for intervention, capacity falling below the 10% POE peak demand plus the largest unit was MORE stringent than the reliability standard as shown by the NEMMCO analysis in 2002 (Ref 1) and by ROAM Consulting in 2004 (Ref 2). This ensured that the minimum level of reliability could not have been achieved by the market without intervention because NEMMCO would have intervened as Reserve Trader before the market had achieved the minimum acceptable reliability level.

4.1.3 NEM Outcomes

Certainly, previous analysis recorded in the Reliability Panel annual reports show that the NEM has delivered sufficient reliable generating capacity to ensure that the maximum of 0.002% unserved energy has not been violated due to failures in the generation and transmission system arising from independent causes[2]. Therefore, in recent times we have been unable to observe the consequence of poor reliability in the NEM arising from generation capacity shortages or to confirm that the target level is about right for prevailing circumstances. We have seen government influence maintaining a high level of reliability in the form of:

- The Queensland Government owned generators not being prevented from building surplus base load capacity despite adequate resources being available in NSW to support Queensland's forecast demand growth. This would appear to be a parochial response contra to the concept of a "national" market.
- The Victorian Government encouraging VENCorp to proceed with the Snowy to Melbourne 400 MW upgrade in 2002 ("SnoVic") even though surplus capacity was already committed in Victoria and South Australia at Hallett, Somerton and Valley Power.
- The South Australian Government securing a contract with International Power for Pelican Point to facilitate financial commitment. The plant was constructed at twice the size needed to meet medium term market requirements.

In the remainder of this chapter we assume that 0.002% is intended as the minimum acceptable level of reliability as previously stated by the Reliability Panel and was not intended as the basis for intervention by NEMMCO. The basis for intervention is addressed in Chapter 5.

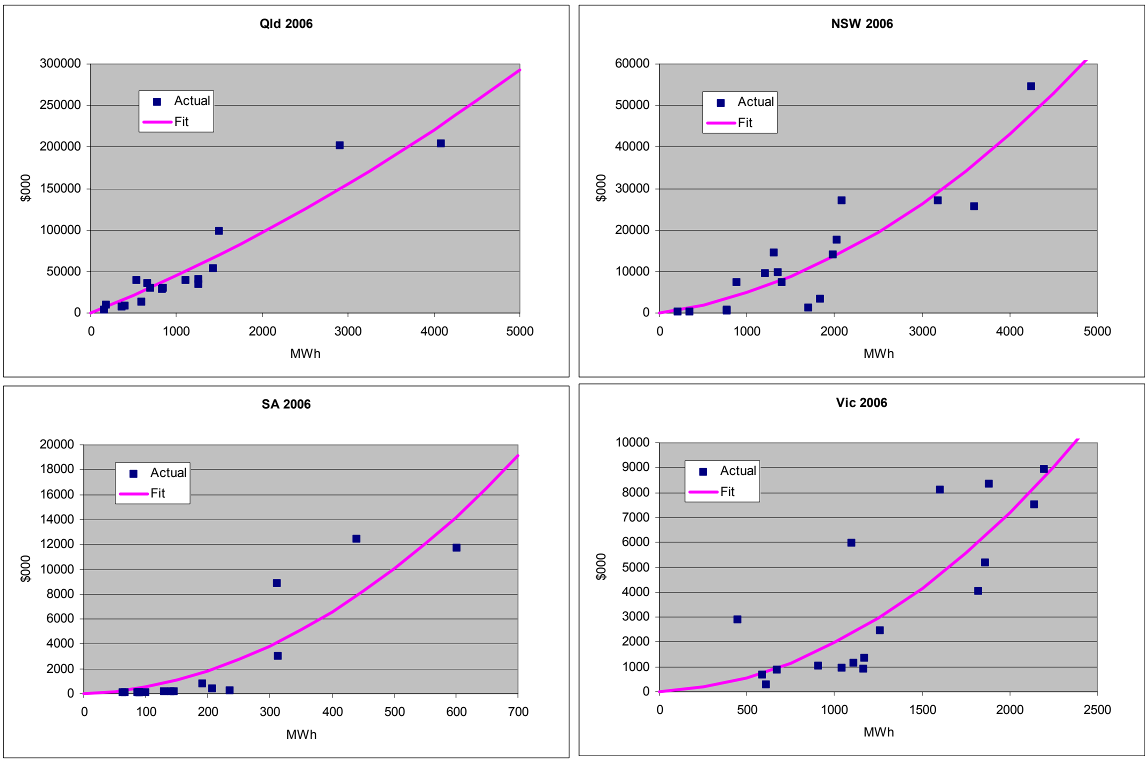
[2] In chapter 7 we explore the issue of what kinds of events should be included in the bulk system reliability unserved energy measure.

4.1.4 Determining the Appropriate Level

To determine whether or not it is appropriate is indeed a difficult task for the following reasons:

- The reliability of the NEM has been very good in recent years and therefore practical experience with major disruptions to electricity supply that can provided data for economic and customer impact analysis is scarce. The consequences of this became painfully apparent when Victoria experienced supply disruption during an industrial dispute at a Latrobe Valley power station and the processes for rationing demand were found to be inadequate. Victoria had substantial power restrictions whilst it was exporting power to NSW during a week day. This baffled many observers. It was inevitable that relatively course levels of restrictions could not achieve the required level of power restrictions over the daily load cycle to match supply and demand.
- The amount of unserved energy is interpreted on an average annual basis and if achieved it could be realised in many different ways with some large unserved energy events occurring once in ten years or many smaller events within one peak season or indeed at any time of year if the window for plant maintenance was fully utilised. It is not possible to characterise a single level of customer cost with a single level of unserved energy as shown in Figure 4-1. Each blue dot represents a simulated year of unserved energy cost versus its corresponding unserved energy level in MWh from the Plexos simulations in Reference 3. The pink line shows a quadratic regression function used for assessing the average relationship between annual unserved energy level and the corresponding customer cost. The regression lines were used to derive an optimal reliability level. It should be noted that the scales in the individual charts differ markedly as the reflect the differing sizes of the NEM regions and the cost structure of load shedding as estimated by MMA's assumptions and cost models.
- It is difficult to determine the costs associated with particular unserved energy events or average outcomes because so many customers would be affected. To accomplish this task requires a detailed analysis of load shedding procedures, the nature of customers affected and the costs that are imposed or perceived to be imposed on those customers.
- Given that unexpected disruptions to electricity supply can cause high levels of angst for customers, it is not plausible that economic costs as measured by loss of production, loss of profit or additional expenditure for emergency power tell the full story. A more encompassing approach is to survey customers' willingness to pay for reliability but it is difficult to get a real answer to this question unless there has been recent experience of poor reliability. In the context of bulk system reliability such surveys may be confused by the fact that customers may respond concerning outages resulting in the distribution system which have a different duration profile than events at the bulk supply level.

Figure 4-1 Expected Unserved Energy Cost Versus Expected Unserved Energy for 2006



- The reliability in one region of the NEM is affected by plant capacity, its performance and patterns of load diversity in neighbouring regions. Hence the analytical problem of quantifying reliability versus installed capacity is quite complex and time consuming.
- The economy is becoming more and more computerised, even in the home, and the distribution of high value uses for electricity in computerisation and broad band communication have become very widespread. It could be expected that the customer value of reliability may well have increased markedly in recent times and the volume of readily accessible low value electricity available for load shedding (such as in domestic premises) may have decreased. This may have increased the value of reliability without it yet becoming apparent through day to day market operations.

However, during 2005 MMA became aware that there had been no public analysis of the optimal level of reliability in the NEM. MMA has since performed such a study which is reported in Reference 3 (refer APPENDIX A). Some results reported in this report are based on the subsequent 2006 MMA Report and some further analysis of those results.

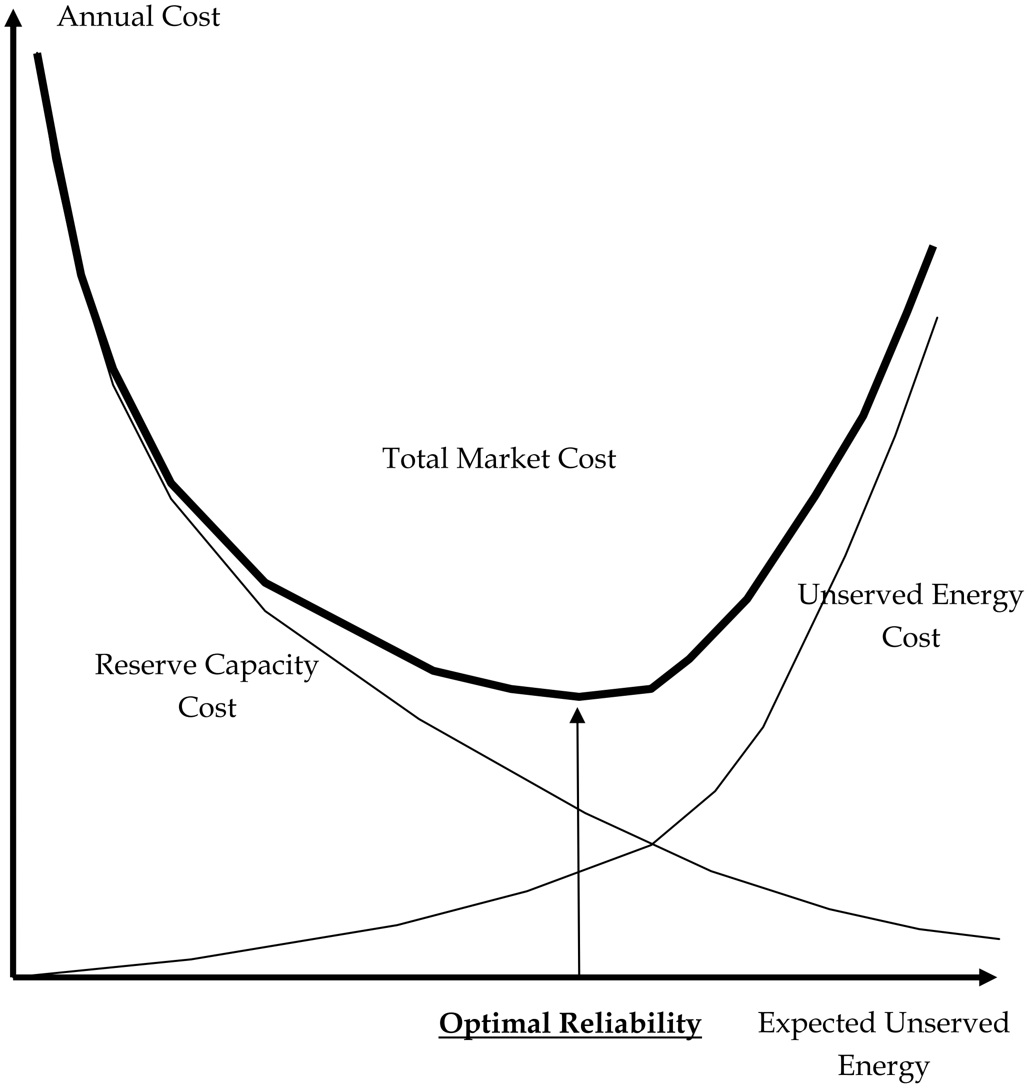
4.2 Optimal Reliability Level

This MMA study provided some useful insights into the likely range of optimal reliability in the NEM. One of the objectives of the study was to see what economic basis could be found for defining a level of expected unserved energy in each region or commonly across all NEM regions. The optimal principle was that the reliability level should be set where the marginal value of reserve capacity was equal to the average marginal value of customer load shedding for variations in the target unserved energy level.

The concept representing the trade-off between capacity cost and supply interruption cost is illustrated in Figure 4-2. As you move towards zero expected unserved energy, the amount of required system capacity becomes extremely large[3]. This occurs because generating resources are not perfectly reliable and therefore system costs tend to infinity as more and more capacity is added to gain a small improvement in reducing unserved energy. Thus the capacity curve progressively becomes more vertical and approaches the cost axis in the chart. At zero unserved energy, the customers' costs of unserved energy are also zero and they rise approximately linearly with unserved energy at first. As the amount of unserved energy increases, higher and higher value services would be interrupted within the practicalities of managing supply shortages on a contingency basis and therefore the cost of interruptions progressively rises more rapidly as the total expected volume increases. Eventually the interruptions would become so severe that

[3] Tends to infinity in mathematical terms

Figure 4-2 Concept for Optimal Reliability Standard



Government would introduce restrictions on consumption and a much greater amount of energy would be unserved. If we consider the horizontal axis as the amount of unserved energy that would occur without restrictions applied (as modelled in a standard market simulation) but apply the costs of imposed restrictions for severe events, then the exposure to these events increases as the expected unserved energy increases and the costs to customers increases exponentially. The required amount of reserve capacity reduces and therefore the generation costs decline as the amount of unserved energy increases.

Evidently there must be a point at which the total cost of generation and unserved energy is at a minimum and this represents the idealised optimal reliability level that would minimise the service costs and maximise the benefits to market participants over a long period of time. This is also the point where the slope of the reserve cost versus unserved energy is the negative of the slope of unserved energy cost versus unserved energy[4].

4.3 Modelling Methodology

The modelling concept was to simulate the NEM using the Monte Carlo market model Plexos with 17[5] different levels of capacity in each mainland NEM region. From these cases we determined the corresponding expected unserved energy level as an exponential function of a linear combination of the capacity levels. The parameters of this function were determined for each year by regression of the unserved energy[6] versus the capacity levels in each region.

Tasmania was not included in the study because the necessary hydrological information for accurately modelling the reliability of supply in Tasmania was not available to MMA prior to the study and it was anticipated that it would be difficult to acquire it and use effectively in Plexos. The impact of reliability in Tasmania on the mainland would be negligible because it would normally have capacity surplus to support the mainland over the study period to 2009/10. Reliability in hydro systems is affected by water yield, storage management and the risk of long dry sequences. It is necessary to model hydrological sequences to obtain a realistic measure of reliability in Tasmania. This requires specialised models and much historical data to quantify such risks.

The actual modelled events of supply disruption in Plexos were evaluated based on an Excel spreadsheet model which described what kinds of customers would be disconnected for various load shedding events and what their particular value of customer reliability was expected to be based on the Monash University and CRA surveys.

The main reason why the study could not be definitive was that the jurisdictional co-ordinators were unwilling to divulge even on a confidential basis the quantitative nature of load shedding arrangements in each region sufficient to be able to value the load at risk for various levels of expected unserved energy according to the types of customer affected. That these data could be made available on a timely basis was a false premise in formulating the project. However, not to be deterred, and with the encouragement of the jurisdictional co-ordinators, MMA developed its own formulation which is described in detail in the report. The model of load at risk was formulated based upon verbal descriptions of the types of policies followed in each jurisdiction.

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[4] In econmic terms the marginal rate at which capacity reserve costs decreases with expected unserved energy equals magnitude of the marginal rate at which customer costs increase with unserved energy.

[5] The studies indicated that more than 17 capacity states would be needed to properly characterise the relationship between regional capacity and USE. Further work is needed to identify how many capacity states are needed.

[6] The logarithm of the unserved energy was the independent variable and the installed capacity in each region were the dependent variables in the regression. It may be noted that the NEMMCO of June 2004 also showed that USE was an exponential function of capacity transferred between Queensland and NSW. MMA's approach was developed independently of the NEMMCO work.

4.4 Analysis of Options

In the MMA report, a number of different policies were evaluated, starting with the assumption that the major descriptive reliability variable remains the expected unserved energy as a target to be achieved on an annul basis that would minimise the total costs of the electricity market from fuel purchase to end-use value. Given the absence of good information on the customer impacts we did not think it material to consider fuel costs in the analysis. Only capacity costs were considered to be material. This was reasonable because the value of customer reliability far exceeds marginal fuel costs for most customers affected by unreliable supply.

The alternative policies were:

1. Continue with 0.002% as the expected unserved energy level as the only reliability criterion without any specific reference to minimum reserve margins based on the largest contingency. This is the deemed base case most similar to current practice.
2. Modify the expected unserved energy level so that it is the same in all NEM regions over a five year period and minimises the sum of reserve and customer load interruption costs in the market as a whole. This method provides averaging over time and region.
3. Modify the expected unserved energy level so that it is the same in all NEM regions in each year and minimises the sum of reserve and customer load interruption costs. This method provides averaging over regions but allows flexibility over time.
4. Modify the expected unserved energy level so that it may differ in each mainland NEM region according to the local characteristics of supply and demand in each year and minimise the cost of reserve and customer load interruption costs in the NEM. This method provides only averaging within the year and region allowing for random plant outages and weather variations.

The optimal values were determined using either $30/kWh as the value of customer reliability or detailed modelling of supply outages and their associated customer costs. In all cases the cost of capacity reserve was assumed to be $100/kW/year.

4.5 Potential for Adaptation of the Reliability Standard

It is beyond the scope of this report to fully explain the analysis in the MMA Report. Indeed it is likely that the report will be made public in due course. However, in responding to the questions posed it is helpful to draw upon the results from that work and a summary of the key results is included in this report. Table 4-2 shows the summary of results including:

- The optimal unserved energy levels for each measure, its average over space and time and ranges where applicable based on the two methods of valuing customer reliability.

- The potential savings relative to adopting the 0.002% standard and achieving it simultaneously in all mainland NEM regions.

Table 4-2 shows that there are potentially higher economic benefits from differentiating reliability standards among the regions. There remains some statistical error in the analysis, but the assessment is that relative to the present standard if applied rigorously:

- Optimising reliability standard over five years without differentiation by state would save about $4 M pa relative to the current standard if the market had delivered the current standard exactly;
- Optimising each region over a five year period instead of a constant standard across the NEM would yield benefits of $6 M pa on the same basis; and
- Optimising the reliability standard by year and region would save between $30 M and $40 M pa versus the current.

These results assume that smelter load in Victoria and NSW participates fully in the NEM with some limitations on annual contribution and a maximum of 1.5 hours for each potline interrupted. The actual contractual constraints were not able to be included in the analysis as they were not available.

A likely optimal profile would have a standard of about 0.0010% to 0.0012% in Queensland and between 0.003% and 0.006% in the southern regions excluding Tasmania which was not evaluated. The optimal profile obtained in the 2006 MMA study based upon the estimated value of customer reliability was as shown in Table 4-1. This

Table 4-1 Estimated optimal Regional and Annual Reliability Standard

	2006	2007	2008	2009	2010	Average
SA	0.0033%	0.0041%	0.0071%	0.0044%	0.0024%	0.0043%
Vic	0.0059%	0.0049%	0.0054%	0.0086%	0.0056%	0.0061%
NSW	0.0028%	0.0043%	0.0041%	0.0042%	0.0020%	0.0035%
Qld	0.0012%	0.0015%	0.0010%	0.0011%	0.0008%	0.0011%
Average	0.0033%	0.0037%	0.0044%	0.0046%	0.0027%	0.0037%

Table 4-2 Alternative Reliability Standards 2005/06 to 2009/10

Type of Standard	Unserved Energy Measure Range	Key Assumptions	Annual Levelised Cost Saving
0.002% in all regions	0.002%		$0 M pa Base Case
Common standard in all regions and years to 2009/10	0.0016%	$100/kW/year reserve cost and $30/kWh USE cost based upon 9%	$3.5 M pa

		discount rate	
Common standard in all years but different by region	0.0019% average Range 0.0013% to 0.0026%	As above	$5.8 M pa
Variable standard by region and year	0.0028% average Region Range of 0.0007% (Qld) to 0.0102% (SA) Annual Range of 0.0022% to 0.0037%	As above	$32.7 M pa
Common standard in all regions and years to 2009/10	0.0015%	$100/kW/year reserve cost and estimated USE cost	$6.5 M pa
Common standard in all regions but differ by year	0.0016% average Range 0.0009% to 0.0019%	As above	$5.7 M pa
Variable standard by region and year	0.0037% average Regional average 0.0011% (Qld) to 0.0061% (Vic) Annual Range of regional average USE 0.0027% to 0.0046%	As above	$39.5 M pa

estimation assumed $100/kW/year as the capacity reserve fixed cost. The variability from year to year within the same region reflects statistical sampling error and the difficulty in filtering out the statistical noise to track the underlying trends. It is recommended that more simulations be conducted if this method is accepted as a basis for setting new standards. MMA considers that the annual average for each region gives a robust estimate of the optimal level of reliability for the assumed parameters of the model.

The corresponding average marginal value of customer reliability resulting from the outage modelling is shown in Table 4-3. The high marginal values in Queensland and South Australia reflect the absence of smelter loads made available for load shedding. The high values suggest considerable opportunity for demand side response from industrial customers. The lower values in Victoria and NSW assume effective use of smelter load to manage short-term capacity constraints.

Table 4-3 Marginal Value of Customer Reliability ($/kWh) for Optimal Reliability

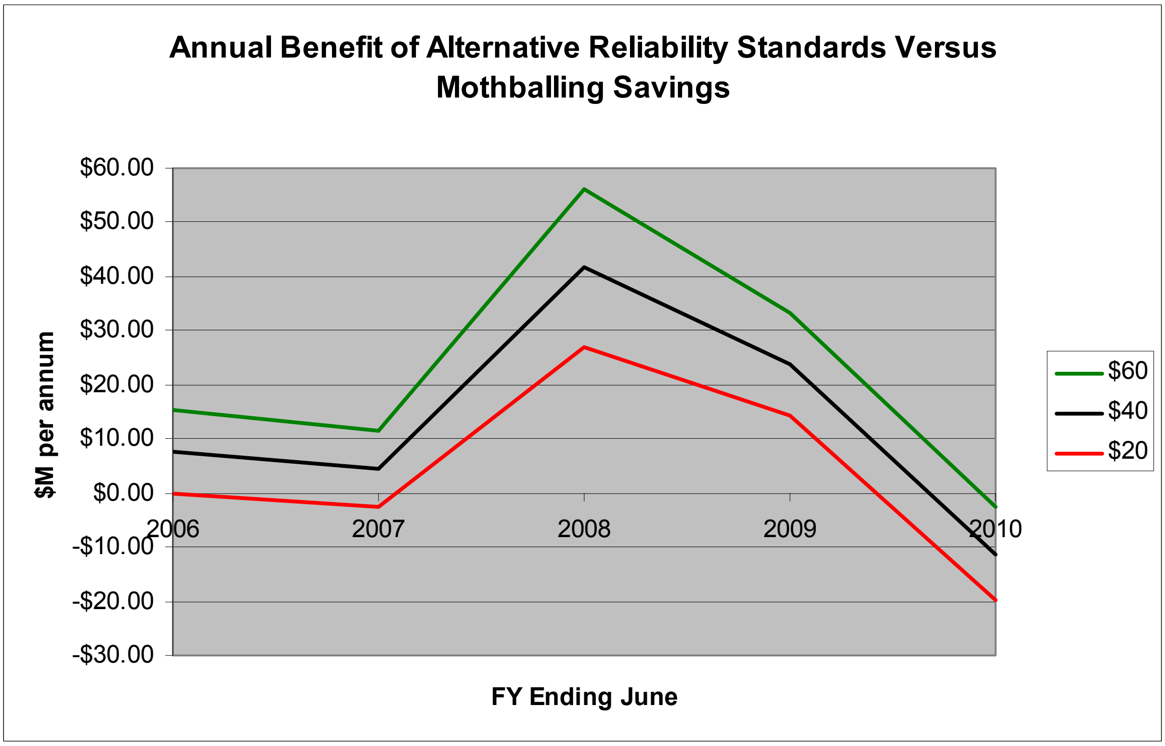
	2006	**2007**	**2008**	**2009**	**2010**	Average
SA	$32.61	$34.10	$43.48	$54.04	$56.27	$44.10
Vic	$9.86	$15.63	$6.25	$17.85	$18.85	$13.69
NSW	$11.13	$11.57	$7.20	$9.26	$9.81	$9.79
Qld	$45.47	$39.15	$43.95	$38.91	$42.05	$41.91
Average	$24.77	$25.12	$25.22	$30.01	$31.75	$27.37

Analysis of the current committed capacity shows that the benefit of moving from the currently committed capacity position to the optimal reliability profile by 2010 would be much less than $40 M pa. The savings would depend on the available savings from mothballing surplus capacity. The benefit would be about $4.0 M pa levelised over the period to 2009/10 assuming that $20/kW/year could be saved by mothballing surplus capacity. This rises to $8.7 M pa at $30/kW/year. The dependency of the annual benefit on time and mothballing cost is shown in Figure 4-3. By 2010 the cost of mothballing has no effect because the committed plant would be delivering close to the target reliability.

These results suggest that:

- There is long-term potential for a more efficient electricity market if the reliability standard were optimised from time to time taking into account trends in reserve capacity costs, the load shedding arrangements and the value of customer reliability.
- There is scope to refine the load shedding arrangements and stimulate demand side response together with implementation of lower reliability standards.
- The immediate benefit of a revised standard is minimal until 2007/08 because of the capacity surplus.
- There is time available to refine these arrangements and to adjust the reliability standard without undue penalty to market participants as a whole.

Figure 4-3 Benefit of target reliability over standard, for different mothballing values



- There is scope to make some savings in 2007/08 and 2008/09 even with some low value mothballing.

4.6 Issues Paper Questions

The Reliability Panel has asked whether the 0.002% USE, is a reasonable level, considering economic impacts and community expectations.

As discussed above, the MMA study (Reference 3) has provided evidence that the current standard is not optimal for the market as a whole based on information made available to MMA and the published reports on the cost of unserved energy to customers. The report shows that different unserved energy standards are appropriate in different regions because of different consumption patterns and different load shedding policies in each jurisdiction. As expected, the report shows that the flatter the peak load profile and the more inefficient the demand side management response to supply shortages, the more reserve capacity is needed. Queensland is the definitive example of this conclusion.

The focus of this MMA report is mainly about methodology for estimating an economic reliability standard. The quantification of optimal reliability is examined within the context of the current standard but suggests a better approach. The results may not be accurate because the jurisdictions refused to provide the necessary data to MMA on load shedding policies. Such data are necessary to quantify the optimal standard properly having regard to the load shedding policies and the

> The unserved energy reliability standard needs refinement in the range of 0.001% for Queensland to 0.004% for the southern regions.

value of the actual customer loads. Using an average value of customer reliability is not an appropriate economic basis for assessing the required level of capacity reserve.

Chapter 9 outlines a process for AEMC to conduct a full economic analysis of NEM reliability and to ascertain a more suitable target for each region over time that can be adapted to prevailing market conditions and be used as the basis for intervention by NEMMCO and monitoring of the market by jurisdictions and participants.

4.6.1 Q14. Is the level of the current NEM reliability standard appropriate? If not, what level would be appropriate and why?

The indicative answer to this question based on the MMA analysis to date is that unserved energy reliability standard needs refinement in the range of 0.001% for Queensland to 0.004% for the southern regions. These estimates need to be validated with a proper assessment of load shedding policies, voluntary demand side response and involuntary customer impacts for large and small unserved energy events. The objective would be to confirm the customer cost versus expected annual unserved energy level and use it to validate an economic reliability standard and an intervention level for capacity management on various time scales. The optimal standard itself would vary according to input costs and the nature of installed capacity by sensitivity functions developed during each review phase and applied between reviews.

4.6.2 Q15. What level of VCR is appropriate and how, and on what basis, should it be measured? Provide reasons or analysis to support your views.

The Value of Customer Reliability (VCR) which is used to justify the reliability standard should be based on the costs estimated to be incurred by customers directly affected by load shedding policies at the level applicable to the reliability standard. This is discussed section 4.5 above and the levels of marginal VCR were as shown in Table 4-3 in the recent MMA analysis. It is not relevant to apply the market wide average VCR unless all customers are equally at risk of being shed. Such is clearly not the case except for a total system black condition which is not applicable to the formulation of the reliability standard.

> The relevant level of the Value of Customer Reliability should be based on the costs estimated to be incurred by customers directly affected by load shedding policies at the level applicable to the reliability standard.

APPENDIX B provides a review of approaches to surveying the value of Customer Reliability that could be considered as an element of a review of the reliability standard. This review is provided by the MMA market survey group who could be engaged to conduct this work.

5 NEMMCO INTERPRETATION

5.1 The Issue

The issue discussed in this chapter is whether NEMMCO is interpreting the unserved energy standard in a reasonable manner. This question covers a range of issues including:

- Is the standard being treated as a target to be achieved or a level where market intervention is justified to protect customers?
- Is the unserved energy level being evaluated properly when market modelling is applied to assess the capacity levels that correspond to this level of reliability?
- If the unserved energy level is regarded as a minimum target level, is the uncertainty in its measure being adequately considered when intervening as Reserve Trader or when indicating how much capacity is needed in the planning and development pipeline?
- When NEMMCO determines the required capacity levels in the short term consistent with the reliability target in the long-term, is the methodology consistent with the long-term target?

5.2 Analysis of Sources

NEMMCO has been progressively improving its analysis of required capacity levels since 1998 to bring them into line with the reliability standard and to reduce reliance on the largest unit reserve margin principle as a basis for intervention. Processes to monitor forced outage rates of generators have been implemented through the Forced Outage data Working Group following reviews from KEMA Consulting in 2004 (Ref 5) and ROAM Consulting in 2005 (Ref 6).

The KEMA review showed that most of NEMMCO's practices were as good if not better than international practice. KEMA highlighted some aspects of the modelling that needed further attention such as:

- Better data gathering and model representation of partial forced outages;
- Assessing why forced outage rates are much lower than international experience to validate the data available to NEMMCO;
- Aggregating forced outages of large versus small units within each region to better track the impact of the large units separately from the smaller units;
- A suggestion that using historical load diversity of the last five years was different from best practice which involved using a moving five year average; and
- That NEMMCO should evaluate the use of the 16 ANTS zones to identify those intra-region transmission limits that should be analysed as part of their reliability review.

Generally the KEMA review identified that further improvements are possible in relation to treatment of forced outages and load diversity. The ROAM Report for NGF in 2005 suggested that inter-regional load diversity at the summer peak could be declining over time based on the last five years of observations. This would have the effect of requiring more capacity overall to maintain the reliability standard. However, ROAM admitted that the size of the sample was not large enough to obtain a robust indication of trends.

It is MMA's view that the overall process for assessing the capacity required to meet a given reliability level is excellent and being progressively improved. If anything the methodology is conservative and unlikely to under-estimate reliability. The major weakness that is not being addressed is in the application of the reliability standard rather than its calculation in relation to capacity.

5.3 Treatment of Intermittent Generation

The treatment of intermittent generation is becoming a more important issue affecting reliability especially in South Australia where the wind potential is large compared to the regional demand. The refusal of the Federal Government to expand the renewable energy scheme and to commit to Kyoto targets has meant that most of the commercially viable wind power is already committed and large new developments are not immediately foreseeable. However the amount of wind capacity in South Australia could have a material affect on South Australian reliability if the Heywood interconnection and Murraylink became constrained frequently in the future. In such a case the modelling of intermittent generation sources in the reliability modelling would need to be enhanced.

The treatment of intermittent generation can be accomplished by adding the contribution from embedded generation back into the historical regional load profile and then modelling the embedded sources explicitly. The wind farms can then be modelled by various methods including:

- **Simple thermal equivalent** - where detailed wind data are not available, model a group of wind farms in a region as an equivalent thermal plant model using equivalent capacity and partial and full outages to match the probability curve of the resource. This method has been used by MMA for modelling the NEM and the South-west interconnected system of WA. It does not represent the diurnal pattern of wind but it can be adjusted to represent seasonal energy patterns.
- **Historical for incumbents** – use the aggregate output from the existing wind resources for the same year as used to capture the hourly load pattern of the regional demand profile so that diversity of wind power and system load is captured. This method is suitable for modelling existing wind farms if data are available.
- **Detailed derivation for new resources** – use weather and topographic modelling to forecast the output of new wind farms where physical data is available from developers for the weather corresponding to the historical year used for the

regional load pattern. Outputs from new and existing wind farms within a region could be aggregated to obtain the diversified generation pattern matching the loading pattern. This modelling work is specialised and may only be needed where there is a large new development that would have material reliability impacts within a constrained region. If not it may be adequate to use historical data from existing wind farms to derive a profile.

5.4 Basis for Intervention

The implication of all this uncertainty in the analysis of the unserved energy level and its cost as discussed in Chapter 4 is that it is inappropriate to be basing intervention on capacity reserve levels derived from the expected level of unserved energy. As argued in the 2002 MMA paper (Ref 1), an uncertainty margin should be applied to the expected level before intervening to recognise the uncertainty in the measure and economic outcomes. If it is deemed that there is a substantial threat to reliable supply, the quantum of intervention should reflect that uncertainty on the other side of the mean so that there is confidence that the intervention will be effective.

> It is inappropriate to be basing intervention on capacity reserve levels derived from the expected level of unserved energy. An uncertainty margin should be applied.

The uncertainty in the measure of unserved energy is a consequence of modelling and assumption uncertainty. The key assumption uncertainties are:

- Forced outage rates
- Demand forecast
- Diversity of weather patterns and regional electricity demand
- Hydro yield energy, especially in Tasmania and to a lesser extent for Wivenhoe in Queensland
- Plant mix in the longer term.

The key modelling uncertainty arises from the process of statistical sampling and the choice of capacity states by trial and error to achieve a given reliability level or the discovery of a stable relationship between capacity and expected unserved energy.

Based on the data collected in Table 5-1 and assuming that the reference case includes uncertainty in demand patterns (such as 10%, 50% and 90% POE peak demand patterns), we would expected the USE to be estimated to within about 33% to 50% of its true value for a given capacity state allowing a standard deviation of 1% for the forced outage rate uncertainty and sampling error of about 20% for the underlying

> The uncertainty margin would reduce the reserve margin for intervention by about 50 MW in South Australia, 80 MW in NSW and 100 MW for Victoria and Queensland.

USE after estimating capacity relationships based upon 100 simulations. If we want to limit the risk of intervention to 1 year in 5, we would take 84% of the standard deviation

Table 5-1 Indication of Impact of Data Uncertainty on USE Estimate

Source of Uncertainty	Estimate of Impact for a Given capacity	Source	Method of Determining Impact
Increase forced outage rates by 1% for 10% POE peak demand	0.0005% increase for Qld and SA 0.0001% increase for NSW and Vic Increased the USE by between 60% (NSW) and 330% (Qld) of base value. Average 150% increase over the four regions	2001 NEMMCO Review for 2002/03	Calculation of sensitivity based on changes in forced outage rate for each region.
Halving the energy available in storage at Wivenhoe.	Doubled the USE in Queensland from 0.0003% to 0.0006% and from 0.0007% to 0.0017% with internal transmission constraints in Queensland	As above	As above. Changes in Wivenhoe stored energy only affected USE in Queensland to any significant degree.
Sampling error over 17 scenarios allowing for capacity dependence	Between 50% and 90% of the USE estimated at 0.002%. This error should be able to be reduced to 25% to 40% by refining the pattern of capacity states and increasing the number of simulations to 100 per case over the demand profiles.	2005/06 MMA study	USE as an exponential function of a linear function of the capacity in each region. Derived from the residual error in the regression representing unexplained variation in the USE.

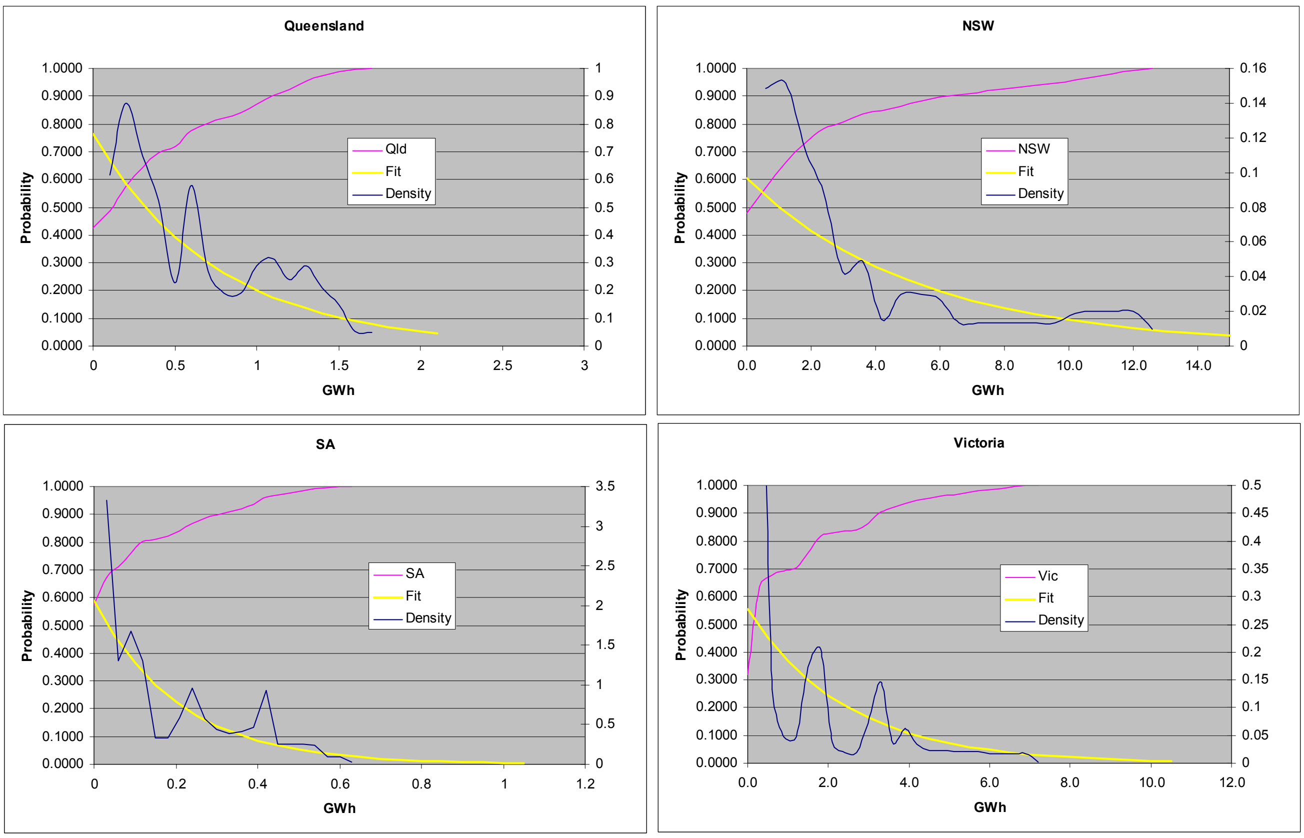
Source of Uncertainty	Estimate of Impact for a Given capacity	Source	Method of Determining Impact
Sampling 100 simulations of one capacity case with variations in peak demand including 10%, 50% and 90% POE peak demand.	Standard error of USE of 15% to 20%. The asymmetry of the USE distribution makes it difficult to obtain an accurate estimate without a large number of samples.	New analysis	A distribution of the expected USE to be obtained from one simulation was estimated and then sampled 100 times. The probability density distribution of USE was formulated as a probability (P) of obtaining no unserved energy plus (1 – P) probability of drawing from an exponential distribution fitted to the remaining observations. Refer Figure 5-1.
Demand forecast	No sensitivity study has been identified. Simple approximation based on change in capacity might be a useful estimate. Based on the 2001 NEMMCO study, a change of 100 MW in capacity provided an increase in USE of between 67% and 125% except NSW where there was no noticeable impact because the USE was so low.	2001 NEMMCO Review for 2002/03	Change in USE for a 100 MW change in capacity might be expected to be similar for a 100 MW change in peak demand.
Composite USE sampling error with 100 simulations and characterisation of dependence on capacity with 1% uncertainty in forced outage rates	Standard error of USE about 33% to 50%. To avoid intervention more than once in 5 years, this corresponds to an extra capacity margin of about 50 MW in SA, 80 MW in NSW and 100 MW in Victoria and Queensland assuming no changes in the other states.	New analysis	Scale the observed modelling uncertainty by the square root of the inverse ratio of increased samples and increased capacity states.

which at best is 84% * 33% = 28% of the USE[1]. Such an approach would subtract an uncertainty margin from the reserve capacity level of about 50 MW in South Australia, 80 MW in NSW and 100 MW in Victoria and Queensland based upon the sensitivity of USE to capacity. These are preliminary estimates taking results for 2005/06 from the recent MMA modelling. These values would be refined whenever the uncertainty of input parameters changes materially.

In practice the margin for USE uncertainty would depend on the prevailing uncertainties and the relevant time scale as discussed in the 2002 MMA report.

Figure 5-1 shows the cumulative and probability density functions for unserved energy in 2005/06 for a particular sample case. The blue line shows the observed density function and the yellow line shows an exponential fit to this curve after allowing a probability for the zero value samples. The probability distribution made up of probability P for a zero result and probability (1-P) for a sample from the exponential distribution was sampled 100 times to estimate the uncertainty of the expected unserved energy. A standard error of 15% to 20% was obtained for the four regions. Such an analysis would be applied to estimate how much error remains in an estimate of the expected unserved energy from a number of market simulations.

Figure 5-1 Example of Exponential Distribution of USE



[1] 84% of one standard deviation from the mean is exceeded with 20% probabaility in a Normal distribution. This corresponds to a 1 in 5 event. The 33% value is taken s the best case from the 33% to 50% range mentionned above.

5.5 Issues Paper Questions

We now specifically address the relevant questions in the Issues Paper.

5.5.1 Q16 - Is NEMMCO interpreting the standard in a reasonable manner?

MMA believes that NEMMCO is applying the current standard using the best available methods for estimating the relationship between installed capacity and expected unserved energy. In 2004 and 2005 there have been further improvements to the methods related to treatment of forced outages and load diversity.

However, MMA does not consider that the uncertainty of the measurement is properly taken into account when setting intervention levels. Some preliminary analysis by MMA suggests that an additional deficit of between 50 MW and 100 MW below the economic reserve margin standards should be applied in each region before NEMMCO seeks to act as Reserve Trader. By reducing the probability of intervention, the role of the Reserve Trader would become less contentious with the generation side of the market and the market generally would be allowed to experience the risks associated with capacity shortages and thereby develop the strategies within the market framework rather than relying on regulatory action. This would have the longer term benefit of stimulating demand side.

5.5.2 Q42 - Is the current approach to NEMMCO's operationalisation of the standard through the reserve margin thresholds appropriate? If no, what improvements are suggested to the framework and/or the methodologies and why?

The above analysis indicates that with the exception of Queensland the risk of NEMMCO's intervention is too high when the market is achieving an economic level of reliability. A risk assessment is needed to set a reduced reserve margin for the purposes of defining the basis for intervention as Reserve Trader. This would reduce minimum reserve margins by between 50 MW and 100 MW in each NEM region as discussed above in section 5.3 and Table 5-1.

5.5.3 Q43 - Should the Panel explicitly approve NEMMCO's reserve margin calculations or should the Panel undertake the calculations itself? What POE or POEs should they be expressed in relation to (for example, a 10 per cent, 50 per cent or weighted average?

MMA has no objections to NEMMCO conducting the studies. It has access to the market information needed and is unlikely to have a conflict of interest in conducting the studies. If NEMMCO's resources are limited there are several Australian consulting firms including MMA which have well developed reliability models of the NEM and which could be contracted from time to time to perform the analysis. The process to trade-off the cost of the analysis with the modelling assumptions is no easy task given the features that are now available in the software products available for the purpose. It might be more effective for NEMMCO to oversee that process rather than the Reliability Panel itself which would not be expected to have the required expertise.

It does not matter what peak demand basis should be used to determine long-term reserve margins. In the end a capacity level must be determined as the basis for monitoring and intervention. Stating the capacity level on a 50% POE basis for publication purposes might give more comfort to the general public that they are adequate and in accordance with international practice. We do not believe this change would alter the economic analysis of potential well informed investors.

5.5.4 Q44 - Should the fuel issues and changing generation mix (described in the Issues Paper) be factored into the reserve margin calculations? If *yes*, explain why and how?

The optimal reliability would depend on fuel supply reliability and plant mix in principle. These issues would need to be tested from time to time to quantify their relative magnitude and determine whether they should be included as material sources of unreliability. In conducting analysis for future periods the assumptions about the plant mix and the availability of new resources during the commissioning period and early years of operation would be a major component of the optimal reliability and its uncertainty.

Increasing penetration of wind farms will be a significant component that would affect the calculation of installed capacity to match an economic standard. Methods for modelling wind farm contributions on regional aggregate basis are needed to properly model the required capacity reserves to manage the risk of low wind contribution at times of high demand. This requires modelling the correlation of peak demand and wind farm contribution as discussed in section 5.3.

5.5.5 Q45 - Would the effectiveness of the reliability settings be improved by explicitly defining contingency, short term and/or medium term capacity reserve standards? If *yes*, how should they be determined?

5.5.5.1 Seasonal Assessment

The determination of sufficient capacity during the non-peak seasons to ensure that the reliability target is satisfied is needed to manage the planned maintenance window through the publication of the MTPASA. If we accept that there may be pre-contingent load shedding to maintain operating reserves on infrequent occasions, then it will be necessary to manage the "reliability budget" over the measurement period which we take to be a financial or calendar year.

There are two aspects to this:

i) providing an indication of what capacity is needed to deliver the optimal reliability. This would correspond to the target reliability level.

ii) providing an indication of the capacity level at which NEMMCO would intervene to seek additional demand side resources or to defer some scheduled maintenance to reduce the risk of unserved energy. This would represent the intervention level. Since the uncertainties on a week ahead or month ahead are much less than a year ahead, the gap between the target level and the intervention level may be quite small and negligible in the short-term.

The intervention management could be accomplished in three possible ways:

A) Assume that the annual exposure to unserved energy is allocated equally on a weekly or monthly basis over the year to each region and define the equivalent capacity level each week that corresponds to that exposure irrespective of what has gone before;

B) From the capacity reserve required in the peak months, determine the unserved energy exposure in those months and allocate the remaining annual budget equally to the non-peak months; or

C) Assume that the annual limit can be managed as an aggregate outcome, set up a monthly profile as per (B) and then manage the residual balance as a progressively revised target. For example, if the year has had several outages early in the year above the budgeted reliability budget on a year to date basis then more stringent limits would be set to keep within the remaining annual budget. Conversely, if the year has had a good start then less stringent measures would be adopted and more risks accepted later in the review period.

Method (A) could create additional intervention risks if the seasonal maintenance window was more than adequate and most of the risk normally falls in the peak season. If the annual risk is then allocated uniformly that would result in a lower acceptable risk of unserved energy assessed for the peak season and potentially an inconsistency between an annual assessment and the seasonal assessment. For this reason Method (B) is more appropriate under normal conditions than Method (A).

> The annual unserved energy not occurring in the peak months should be distributed equally in the non-peak months to provide a short-term reliability target for monitoring maintenance scheduling.

MMA considers the Method (B) to be most realistic and simpler to operate and likely to produce the same outcome as Method (C) in most years. Intervention Method (C) would have an advantage in reducing the risk of intervention if the market was generally going well but may not signal the opportunity for cost-effective action later in the year if supply conditions deteriorated. From an economic viewpoint, historical unreliability is a sunk cost and has no bearing on future costs and benefits apart from arising from socio-political consequences. If the simple economic principle is accepted and we don't think it is important to bank risk to meet other objectives, then Method (B) is preferred.

5.5.5.2 Medium Term Outlook

When multi-year capacity assessments are needed to guide medium term intervention or to assess whether sufficient new capacity is being committed or active in the development pipeline, then the range of risks to be included in an intervention methodology may differ. Currently NEMMCO is not required to intervene as Reserve Trader any sooner than 6 months before the impending capacity shortfall. If the market development risks in the longer term are to be better understood and managed then it is necessary to ensure that the uncertainties are properly reflected in the analysis.

For such a purpose, the reserve requirements would also include the impact of uncertainty in:

- economic growth (the impact of the high growth forecast would be given some notional weighting in the analysis of unserved energy)
- trends in forced outage rates (with increasing rates associated with high reserves as generators skimp on maintenance to reflect lower market risks of non-performance and lower forced outage rates if reserves are tightening)
- any rapid changes in loading patterns (such as the decline of electric hot water load in summer time as solar hot water services replace them)
- the timing of plant retirements nearing the end of their economic life (this could be represented as an increased forced outage rate beyond that expected on purely technical grounds for smaller plants but may need to be treated explicitly as a separate case for larger units)

This is a much preferred approach than separately showing required capacity for the high, medium and low growth separately at 10% POE peak demand. As we have seen every year the SOO is published there is panic in the media when someone discovers that the high growth forecast at 10% POE peak demand cannot be supplied next year or the year after. If the high growth has only a 20% probability of being exceeded then we are describing a non-credible requirement: that we should have sufficient capacity to cover a 36 second in one year event (taking a 30 minute peak load with a 1/50 probability of occurrence (1/10 * 1/5)). It would be far better to combine the unserved energy over the range of uncertainties and determine a capacity target than would match it. Such a method would create a higher new capacity target if there were assessed to be:

- a higher probability of high or higher economic growth
- a higher risk of plant being retired early
- greater uncertainty about the performance and timing of new plant using a technology new to Australia (such as LMS100 gas turbines, ultra-critical coal with carbon sequestration, large nuclear units, solar towers etc)

This is as it should be. There is no guarantee that current methods would recognise these factors in the medium term when they become important because the analysis is conducted in the short-term (one or two years ahead), a capacity reserve level is fixed and then held constant indefinitely into the future as we have seen in the SOO. This is not helpful for policy development and correctly defining market opportunities. It provides incentive for the intervention strategies to be unnecessarily constrained (limited to six month lead time instead of longer term).

With regard to the difficulty of assigning probability to economic growth forecasts, it may be feasible to examine the historical performance of deviations of actual growth from previous forecasts to obtain a measure of forecast uncertainty. The forecasters should be requested to provide a statistical basis for the uncertainty of their forecast on this or similar basis.

6 LOAD DIVERSITY

6.1 The Issue

A high level of load diversity means that regions do not have their peak demand at the same time and that neighbouring regions have low or moderate loads at the time of an annual peak elsewhere. Diversity is measured as the coincident peak demand across one or more regions divided by the sum of their individual non-coincident peak demands. The issue is that load diversity is a material determinant of regional reliability because it enables spare capacity in one region to support peak demand in a neighbouring region. If the peaks in neighbouring interconnected regions are coincident then each region must provide all of its own reserves. If the peak in one region is 90% of its own peak when a neighbouring region peaks, then that corresponding portion of capacity (10% of peak demand) can be applied to meeting the neighbouring peak if transmission capacity is sufficient. Load diversity determines the viability of augmenting the interconnecting transmission system to allow reserves in one region to support the importing region.

6.2 Analysis of Sources

The ROAM report to NGF in 2005 (Ref 2) showed that load diversity may be changing over time. The analysis indicated that diversity is decreasing over time but it was not definitive because only five years of data were analysed. Diversity is quite dependent on the extremity of the peak season weather. For example, recent experience shows that Victoria and South Australia have low summer peak diversity under 10% POE conditions. The diversity is higher at lower levels of peak demand such as 50% POE. The extreme conditions arise during a long sequence of hot summer days by which time both Victoria and South Australian buildings have reached thermal equilibrium and all cooling equipment is running at peak utilisation in both regions. The highest combined regional load would occur on the last hot day in the sequence in South Australia and the penultimate day in Victoria. Since Victoria's summer load would have levelled out, its peak would coincide with an extreme demand in South Australia. Under normal conditions such as 50% POE conditions, the hot day may only be a two day sequence and there would be a cooler day in South Australia when Victoria reaches its peak. This is illustrated from 2001 (24% POE) and 2005 (94% POE) in Figure 6-1. The 2001 data represented 24% POE peak in SA and 57% POE in Victoria after a long hot day sequence[2]. The combined peak demand was 96% of the composite 24% POE total. In 2006 summer the peak demand was at about 94% POE and the peak demands were coincident but of course not at a level that was critical for reliability considerations. In the 2001 summer the combined peak load in Victoria and South Australia was about 96.1% of the combined

[2] This was estimated by linearly interpolating the observed peak between the 90%, 50% and 10% POE peak demand forecasts published by NEMMCO for medium growth in the latest forecast prior to that summer period.

Figure 6-1 Diversity of Victorian and South Australian Summer Peak Demand

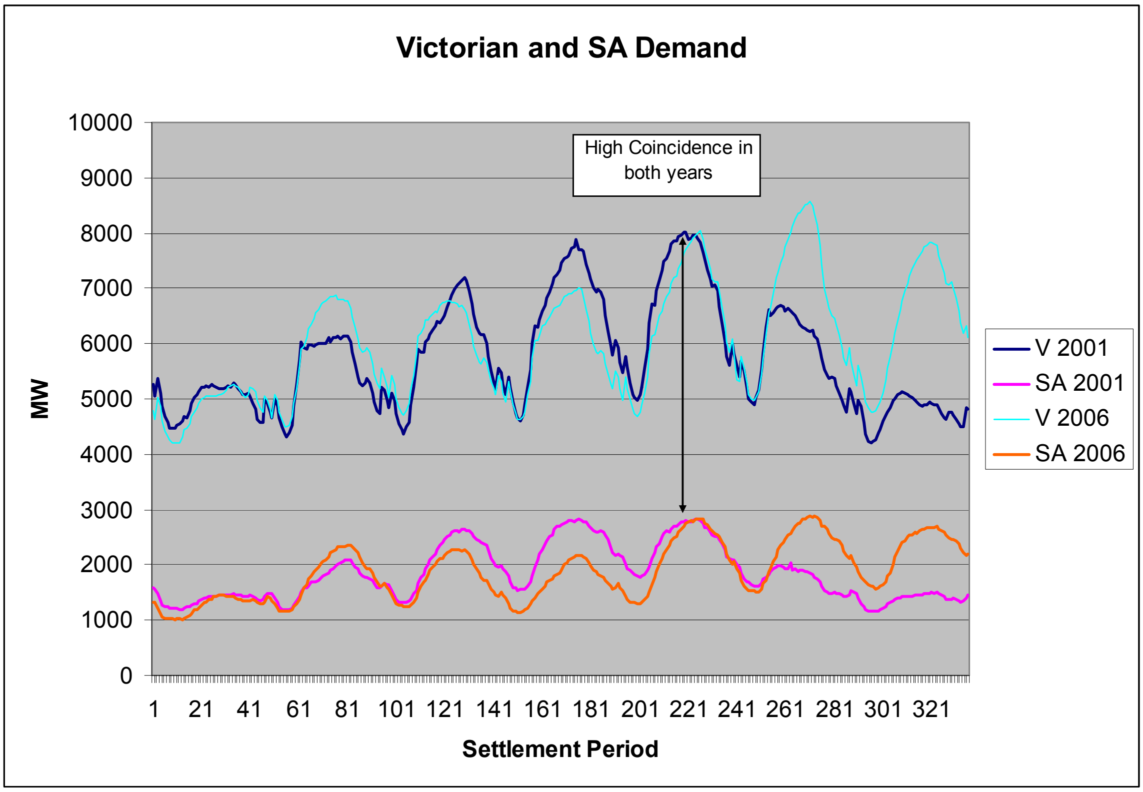


Table 6-1 Analysis of Coincidence in 2001 and 2006 for Victoria and South Australia

		2001				2006		
	POE	Vic	SA	Total	POE	Vic	SA	Total
Summer Peak		8019	2833	10811		8545	2873	11417
Coincident Peak Week		8019	2833	10811		8545	2872	11417
Annual Coincidence		99.6%				99.99%		
Week Coincidence		99.6%				100.00%		
Vic Equivalent Load	57%	8019	2678		100%	8560	2842	
Coincidence		100.0%				100.0%		
SA Equivalent Load	24%	8414	2833		94%	8647	2873	
Coincidence		96.1%				99.1%		

forecast peak load at 24% POE which was the estimated intensity of the SA peak. When referred to the 57% POE level as occurred in Victoria the diversity was 100% at that level.

What this means is that we need to be careful how we define the co-incidence of peak loads. We expect high coincidence if both regions have 90% POE peak loads or lower because that is typical of average summer days that occur often. At the 50% POE level we would expect more diversity typical of what occurred in 2001. For extreme conditions in both regions, we would expect greater co-incidence of peak loading. MMA considers that characterising and modelling these loading coincidence patterns is quite difficult. Until we have a satisfactory general method that describes the full range of peak load dependence in all NEM regions, we need to use historical patterns typical of the loading conditions we are trying to model so that we represent load diversity in a meaningful way. It is too conservative to assume that peaks are simultaneous in Victoria and South Australia except for the 10% POE condition which is expected to occur in both regions at the same time due to a long sequence of hot days. We do not expect coincident 10% POE days in Victoria and South Australia once in 100 years because the events are highly correlated.

The diversity of peak loading between Victoria and NSW is quite substantial and will remain so because the conditions to cause summer peak demand in these regions are incompatible. When a north-westerly wind heats up Melbourne, a south easterly wind moderates Sydney temperature. Similarly, when hot westerly wind afflicts Sydney, Melbourne experiences easterly breezes which can be humid but are not hot enough to cause more than 90% POE peak demands.

MMA is not as familiar with the patterns that would affect NSW and Queensland. From the NEMMCO Report of June 2004, the diversity between NSW and Queensland summer peak is about 95% historically. This enables about 600 MW to be traded between the states at the summer peak which is generally within the QNI capacity given that QNI normally exports 600 MW south.

6.3 Analysis of Options

It is therefore important the pattern of loading related to weather be modelled as accurately as is feasible given the availability of data and the functionality of market models. It would be useful to track the long-term trends in weather patterns and the relationship between weather and peak demand to determine if the load patterns are likely to experience decreasing diversity. This would involve developing a functional relationship between peak demand in each region and the peak and average temperatures of the current and previous days for each day of the week in each calendar month of the summer season except for Tasmania where winter is critical. The day of the week is important because hot days over the weekend do not produce extreme peaks. Then one would take 50 years of weather data and calculate the corresponding daily loading patterns. We could then assess relativity of peak demand across the regions at various levels of extremity in each region corresponding to the 90%, 50% and 10% POE peak demands. The corresponding average diversity and variation in diversity could then be applied in formulating the load shapes for the reliability analysis. MMA has not had the opportunity to test this approach. We offer it as a suggestion which might be helpful for future work.

6.4 Issues Paper Questions

6.4.1 Q42 - Is the current approach to NEMMCO's operationalisation of the standard through the reserve margin thresholds appropriate? If no, what improvements are suggested to the framework and/or the methodologies and why?

This question is answered here only with respect to load diversity.

The simplification of allocating reserves across regions at times of peak demand based upon a static analysis of reserve sharing is not of itself a basis for assessing inter-regional reliability. It is only a short-hand way of defining reserve margins by notionally allocating required capacity among the regions at times of peak demand. The critical issue is the modelling of reliability and loss of customer load having regard to interconnection constraints as affected by loading and credible generation states.

The impact of regional load diversity can be modelled in a market simulation by ensuring that historical chronological loading patterns are used in the modelling having regard to variations in weather patterns. Providing that multi-area reliability models are applied with a set of historical load shapes that represent the impact of weather variations then the relationship between installed capacity, unserved energy and loading patterns should be able to be adequately quantified.

> The modelling of load diversity between constrained NEM regions can be improved by further analysis of the relationship between peak demand and weather and the longer-term trends in this sensitivity and the weather itself.

The methodology could be further improved by analysing the relationship between weather and daily demand patterns and using historical weather to generate patterns of loading across the NEM regions so that the variability and level of diversity can be better understood and quantified. It should then be possible to more accurately take account of the level and uncertainty in peak load diversity in the peak seasons in the reliability modelling. We would take historical profiles closest to the 90%, 50% and 10% POE shapes and adjust the daily patterns to match the average or extreme trends as appropriate rather than relying solely on the historical year. The recent ROAM report has shown the year to year variation and sampling from just three historical years is not ideal.

7 INCLUSION OF SECURITY EVENTS

7.1 The Issue

The issue discussed here concerns the scope of the bulk system reliability standard. What kinds of incidents should be counted when measuring and modelling the reliability standard? There are industrial relations incidents that can take out one or more power stations simultaneously. Should we include that risk in defining a bulk system reliability standard?

7.2 Analysis

The traditional practice is NOT to include the following types of events in the analysis of bulk system reliability:

- Multiple loss of generators arising from a single contingency due to control and protection failures
- Multiple loss of generators arising from a series of cascading failures arising from operator error in combination with control and protection problems
- Multiple loss of generating units as a result of industrial action
- Coincident loss of parallel transmission lines due to a common cause such as air crash or bush fires.

The reason is that the risk implied in these types of events cannot be economically mitigated by installing reserve generating plant. The appropriate measures are summarised in Table 7-1.

> The classification of unserved energy events in measuring and modelling exposure of customer load to disconnection should relate to the most economic mitigation measure.

The principle that should be adopted is that events of disruption to customer load should be modelled and measured according to the appropriate class of measures to mitigate that risk on an economic basis. If the risk of unserved energy can be economically mitigated by building reserve generating plant, contracting demand side withdrawal or augmenting transmission capacity with a neighbouring region with diversified load then the unserved energy for that class of events can be related to bulk system reliability and should be included in the Reliability Panel's scope of activity and associated standard. All other matters including those arising from industrial action, control and protection failures in the transmission system, local restrictions in network capacity, and widespread events such as cyclones taking out multiple transmission lines should be regarded as separate considerations from the bulk system reliability measures that are addressed by means of reserve capacity as above.

Table 7-1 Contingencies and Mitigation Measures

Types of event	Causes	Mitigation measure	Include in Bulk system reliability standard?
Loss of supply to a portion of the distribution system	A transformer failure at a terminal station or a disruption to a radial transmission line	Install a parallel transformer or a third transmission line or uprate the existing transmission lines	**No.** Such problems could be addressed by building embedded generating plant at a specific location. This is not a problem that can be addressed effectively or efficiently at the bulk meshed system level.
Multiple loss of generators	A single contingency due to control and protection failures	Improve maintenance and design of control and protection schemes and staff training.	**No**. Such problems cannot be economically remedied by building additional generating plant.
Multiple loss of generators	A series of cascading failures arising from operator error in combination with control and protection problems	Operator training and refinement of operating procedures and operator interface facilities	**No**. As above
Multiple loss of generating units	Industrial action	Improve labour management. Disaggregate businesses to reduce market power.	**No**. If unions have market power they will increase the intensity of their industrial action to make up for additional resources.

Types of event	Causes	Mitigation measure	Include in Bulk system reliability standard?
Coincident loss of parallel transmission lines	A common cause such as air crash, bush fires or cyclones	Where the risks to an easement or multiple easements are significant then additional transmission connections may be needed on a different route. This is a matter of transmission system design and asset recovery inventory and emergency response.	**No**. Transmission design practices provide a more economic way of mitigating this risk with separate easements.
Inability to maintain frequency control once in 20 years due to peak demand in excess of the 10% probability of exceedance.	Extreme hot or cold weather conditions that cannot be supported even with all generating capacity in service.	This is a very extreme event which is best managed with some short-term pre-contingent load shedding. The exposure to customer load shedding should be included in the analysis. It is not necessarily economic to be able to supply under these extreme conditions. Often the distribution and transmission system will overload and prevent these extreme loads being required to be met so there are in-built mitigating factors.	**Yes.** These events can be managed by acquiring additional demand side response for very infrequent usage. Under very extreme conditions they are self-managing because the grid will overload and disconnect some loads automatically.
Coincident loss of one or more generating units.	Coincidence of planned and forced outages due to independent events.	Provide additional reserve generating capacity or demand side withdrawal for infrequent extreme events. Augmentation of interconnection import capacity from a neighbouring system with diversified load may also be economic.	**Yes**. These risks can be best addressed with reserve generating capacity for up to 3 hours per year and with demand side resources for less than 3 hours per year on average.

Types of event	Causes	Mitigation measure	Include in Bulk system reliability standard?
Coincident loss of generation capacity and interconnection transmission capacity.	As above	As above.	**Yes.** As above. Transmission capacity could be economic for as little as 0.5 hour per year duty if the capital and operating cost is low enough.

One pertinent consideration is at what peak load exposure is considered "credible" and must be able to be carried with one generating unit out of service so that the system may be defined as "secure". For example the 10% probability of exceedance load only occurs for 0.5 hour once in ten years on average. This level of demand cannot be economically supplied by reserve generating capacity. Rather than assume that it should be able to be supplied with one or no units out of service, it would be best to treat these extreme events as part of the tail of the risk and examine the true customer impacts if reserve capacity is not provided for such events. Pre-contingent load shedding or demand side withdrawal would be viable to meet such duty and this should be included on an economic basis rather than arbitrarily assuming that such extreme loads should be secure with all generating and demand side resources available at the time of such a peak.

7.3 Issues Paper Questions

Table 7-2 summarise an analysis of the relevant questions raised in the Issues Paper.

System security should be taken into account in the modelling of reliability through:

- Defining the constraints for inter-regional power transfer so that the system operates in a secure state having regard to the response of the transmission system to credible disturbances which by definition have a significant frequency of occurrence.
- Defining the requirements for spinning reserve so that frequency control is stable for credible events. If pre-contingent load shedding were necessary to maintain a secure state then this should be included in the reliability modelling. This is not normally necessary in the NEM because the reliability standard is set high enough that pre-contingent load shedding would be a very infrequent event and neglecting such events does not affect the analysis materially. (This is an MMA expectation and qualitative assessment and has not been proven in any MMA analysis.)

However, MMA understands that the critical issue here is whether additional generating capacity should be provided to reduce the impact of some non-credible events such as where a three-phase short-circuit fault would cause multiple loss of transmission lines or generation plant. Sometimes protection and control failures cause loss of multiple generating units following a single contingency. MMA does not think that such problems should be addressed by building generating capacity. They are more economically addressed through appropriate design and operating standards and staff training. The reliability standard would take into account the magnitude of pre-contingent load shedding necessary to keep the system secure.

MMA's approach here would be to outline a methodology that examines the incidence of such events, the cost of minimising their impact with generating capacity versus the cost of improved design and operational practices. Only those events that can be best addressed with generating capacity or demand side response on a post-contingent or pre-contingent basis would be included in the bulk system reliability standard.

Table 7-2 Analysis of Issues Paper Questions on the Treatment of System Security Matters

Question	Analysis	Qualifications
22a. Should the scope of the standard be extended to encompass matters currently treated as system security issues such as multiple contingency events?	**Yes,** but only in so far as they have a direct impact on the risk to customer load due to pre-contingent load shedding to maintain system security. Rather than arbitrarily require reserves to be held to cover the largest contingency over an extreme peak load (say 20% POE or greater load) , it is best to include any load shedding necessary to maintain system security in the modelling and measurement of unserved energy events. If the system load must be shed to protect the system against a credible double contingency because there is inadequate generating capacity to reschedule, then such events should be included in monitoring and where feasible and significant in the modelling. An example is the occasional reduction in the capacity of the Heywood interconnection during lightning storms. Such events should be included in the reliability modelling and standard for South Australia because such risks can be managed with demand side or reserve capacity resources.	This approach should not be used to require reserves to be held other than on an economic basis. If the volume of pre-contingent load shedding would be large or frequent then the economic analysis would justify an alternative action rather than the large volume of load shedding. Normally the consequence of an insecure system is that if a credible contingency does occur then the amount of lost load would be enormous (most of the system's load) and therefore the protective mechanisms to constrain power flow or dispatch under such conditions are economic.

Question	Analysis	Qualifications
22b. Should near misses be reported?	Reporting near misses would help to validate the reliability models in terms of the frequency distribution of low levels of reserve. However these should not be reported as unserved energy events.	Such data collection would help to validate the modelling of uncertainty of the unserved energy levels relative to apparent exposure in the real world.
23. If *yes*, how should such matters be defined to ensure that supply adequacy is appropriately monitored in the context of power system security?	Whenever customer load is shed or demand side resources disconnected to secure the system in the absence of a new outage but rather to protect system security from the adverse consequences of a credible outage event, then such unserved energy should be recorded as pre-contingent for system security.	Such unserved energy should also be modelled in the reliability model if possible where there are load disconnections arising from needing to carry spinning reserves or spare transmission capacity to secure the system against a credible contingency related to bulk power system reliability.

An example is the occasional reduction in the capacity of the Heywood interconnection for transfer to South Australia during lightning activity. Such events should be included in the market modelling and the reliability standard for South Australia because such events are occasional and the risks can be managed with demand side or reserve capacity resources in South Australia at an economic cost relative to the load at risk.

8 DISTRIBUTION RELIABILITY

8.1 The Issue

One issue that has been raised is the relationship between reliability at the customer level as affected by distribution system performance and the reliability contributed by the bulk generation and transmission system. We presume the concern is whether high reliability at the bulk system level is justified if the economic level of reliability at the distribution level is much lower. If the customers don't notice it why bother?

8.2 Analysis

The appropriate approach to this question starts from the principle that if you can improve performance at a cost that is less than the benefits in customer terms then customers would benefit overall. As the distribution system is generally in series with the bulk transmission system in the chain of customer supply, the methods which improve the reliability of the distribution system have no effect on the reliability of bulk supply. This is not true where the sub-transmission and distribution system is meshed with the bulk system so as to permit transfer of power between terminal stations, as in North Queensland. Excluding this situation, we can completely decouple the economic cost/benefit analysis of distribution and bulk system reliability. Therefore the investments to improve reliability are unrelated and the economic standard in both regimes must logically be unrelated also.

High costs to achieve high transmission or generation reliability would be unlikely to be economic where customers have already accepted low distribution reliability as economically acceptable relative to the costs of improving performance. It is only through the relative economics of performance improvement in relation to the value to customers that these two aspects of supply reliability to customers might be indirectly coupled.

For example, distribution reliability may be improved by:

- increased distribution line and transformer capacity to minimise the risks of peak day overloads
- more frequent tree clearing to reduce exposure to short-circuit faults on power lines
- distribution system control and data acquisition to enable networks to be reconfigured remotely to isolate the faulted section and restore power to other sections by reconnection to an unaffected source
- installation of emergency generation at critical customer sites

Apart from the last item these measures would have no effect on bulk system reliability.

Bulk system reliability is improved by:

- installing additional large scale reserve generating plant

- upgrading interconnection capacity for import from regions with diversified peak demands
- establishing new interconnections, especially where this is disparity of marginal supply costs and seasonal peak loading patterns.
- improving the performance of power generation and transmission equipment.

None of these items would affect distribution system reliability.

Another consideration is that the requirements for distribution system reliability cover a wide range from rural areas where it is only economic to provide one HV supply at the distribution and sub-transmission level to central business districts where N-2 redundancy is required to support high rise buildings and associated high value commercial activities relative to the power consumed. The bulk transmission reliability must be adequate to support these high value activities as well and it would be inappropriate to let bulk system reliability fall to some lower level related to average distribution reliability.

Therefore distribution and bulk system reliability are separate issues and there is no benefit in arbitrarily linking their reliability standards. Reliability levels should be based upon cost/benefit analysis. The costs to provide higher reliability should be matched to the value as appreciated by customers on the basis of their willingness to pay for a given level of reliability or the demonstrated economic value of their activities as affected by the particular pattern of unreliability of the electricity supply. This approach requires a demonstrated link between the aspect of supply disruption that is of concern and the most economic means to reduce that exposure to disruption. This reinforces the earlier discussion in Chapter 7 about appropriate classification of supply interruption events based on the economic means for improvement (refer Table 7-2).

8.3 Issues Paper Questions

On the basis of the above analysis, specific answers are provided in this section to the Issues Paper questions 20 and 21.

8.3.1 Q20 - Are there additional considerations which should be included in the standard to reflect regional concerns, for example, stricter standards for high-load areas such as CBDs?

Based on MMA's recommendations the bulk system reliability standard would include the impact on supply reliability for high load areas if those area loads were at significant risk of involuntary disconnection. Normally this is not the case and those areas are the last to be shed. They are normally exposed to the risk of a total system shut-down (called "system black") which occurs about once in 40 to 50 years in modern power systems. Building additional generating capacity does not mitigate system black risk.

8.3.2 Q21 - Should there be a role for the NEM reliability settings in compensating for potentially lower reliability outcomes further down the supply chain?

The answer is "No" apart from exceptional circumstances. It is not economic to compensate one part of the grid for deficiencies in another part. Each part should optimised for its own performance irrespective of other unrelated aspects.

Distribution reliability is not normally affected by generation system reliability and vice versa. It would only be in exceptional circumstances where loads can be quickly and remotely transferred between transmission regions in response to generation or transmission contingencies that distribution and generation reliability would be jointly affected.

High costs to achieve high transmission or generation reliability would be unlikely to be economic where customers have already accepted low distribution reliability as economically acceptable relative to the costs of improving performance. It is only through the relative economics of performance improvement in relation to the value to customers that these two aspects of supply reliability to customers might be indirectly coupled.

Distribution and bulk system reliability are separate issues and there is no benefit in arbitrarily linking their reliability standards. Reliability levels should be based upon cost/benefit analysis. The costs to provide higher reliability should be matched to the value as appreciated by customers on the basis of their willingness to pay for a given level of reliability or the demonstrated economic value of their activities as affected by the particular pattern of unreliability of the electricity supply. This approach requires a demonstrated link between the aspect of supply disruption that is of concern and the most economic means to reduce that exposure to disruption. This reinforces the earlier discussion about appropriate classification of supply interruption events based on the economic means for improvement (refer Table 7-2).

9 PROPOSED RELIABILITY STRATEGY

The integrated management of reliability in a competitive electricity market is a complex task. Whilst MMA has not been commissioned to come up with a comprehensive strategy, we consider it would be helpful to outline an approach to these contentious issues that would provide benefits to all market participants. Customers would benefit through a less volatile market that would reduce the risk premium that retailers must pass on to customers. It would also provide enhanced opportunity for customers to earn revenue from demand side programs and thereby reduce their total net input costs for energy. Generators would benefit with higher plant utilisation and reduced market risk which affects their cost of capital. There would be a lower requirement for market intervention and less concern about market power abuse which creates administrative overhead for all market participants, either by trying to defend their own market power or to over-turn the market power of others.

Accordingly, MMA recommends the following steps be considered as a basis for reliability management in the NEM.

9.1 Review Load Shedding Policies

It is recommended that AEMC secure the support of the jurisdictions to review the quantification of the reliability standards on a market economic basis which would include reviewing the options for load shedding policies. This would require data for the current practices in a form that can be used to assess the types of customers whose supply is at risk. This would include current and continuing availability of aluminium smelting and other industrial loads under interruptibility arrangements. The objective would be to bear the political pain of revealing the real situation and establishing a public and transparent basis for market intervention in the event of market failure.

9.2 Market Economic Basis for Reliability Standard

In late 2006, AEMC should commission a study of the economic basis for supply reliability over the five year period 2007/08 to 2011/12 based upon committed resources and with economic generation investments to meet any remaining supply deficit. In all regions this would require open cycle gas fired generating plant as there is a surplus of base load plant throughout the NEM[1]. This study would include existing price based demand side withdrawal as part of the unserved energy so that an economic analysis can be conducted.

9.3 Trade-off Complexity for Economic Value

Review the economic benefits of moving optionally from the common standard of 0.002% to

[1] Pelican Point is under-utilised in SA, Bell Bay is under-utilised in Tasmania, Liddell and Munmorah are under-utilised in NSW and Gladstone, Swanbank B and Callide A are under-utilised in Queensland, thus the argument for the surplus of plant capable of base load operation throughout the NEM.

- a revised common standard across the NEM (about 0.0015%), to
- a separate standard for each region that is stable for a five year period (about 0.001% to 0.002%), to
- a standard that varies for each year and each region according to plant mix, the prevailing marginal reserve capacity cost, and customer value (0.001% to 0.004%).

9.4 Recognise Uncertainties in Measurement

The study would allow for the following factors and their uncertainties:

- Generator forced outage rates
- Generator scheduled maintenance requirements and long-term maintenance cycles where they are significant[2].
- Weather influenced demand patterns (using typical 10%, 50% and 90% POE load shapes)
- Diversity of loading between neighbouring regions based upon an analysis of historical weather and the impact of weather on peak demand
- Interconnection limits as affected by generation capacity and regional demand
- Interconnection reliability and maintenance requirements where material

9.5 A Target and an Intervention Level

The expected values of the forecast parameters would determine a target level of reliability which can be monitored and provide the basis for forecast generating capacity requirements. The uncertainties in the parameters would provide the basis for a risk margin to determine when intervention is required on the basis that market failure is clearly demonstrated.

9.6 Review Objectives

The study would examine:

- The relationship between installed capacity in each region, and expected unserved energy in each region by determining a regression function so that inter-regional benefits can be recognised and quantified. This function can be used between major reviews to indicate the impact of possible developments where the plant mix does not change markedly.
- The relationship between expected unserved energy and its cost in each region for current and prospective load shedding policies. A quadratic function has been found to be suitable in prior MMA work for expected values. Uncertainty

[2] For example if several large units have major maintenance every five years and some of these are expected to coincide in the three year period then the reliability standard for that year may need to be adjusted so that proper capacity targets are determined to provide a sufficient maintenance window.

assessment might require more sophisticated statistical analysis than has been attempted to date.

- The sensitivity of these factors to generator forced outage rates and scheduled maintenance requirements so that standards can be adjusted according to prevailing conditions by NEMMCO without revising the detailed studies every year.
- The sensitivity of the optimal reliability level to the costs of reserve capacity.
- The economic value of moving to a more complex standard given the costs and benefits resulting from that complexity.

9.7 Review Process

The review should:

- demonstrate the expanded role for the demand side response that would be required and the magnitude of load at risk and its annual cost by region under typical and extreme circumstances (1 in 2 years, 1 in 10 years, 1 in 30 years etc). The analysis would include the call upon existing price based resources and the burden that would be carried by demand side resources involuntarily.
- examine whether load shedding policies could be amended to reduce exposure to high value loads and thereby allow a reduced level of reliability to be accepted.
- examine the uncertainty of the estimated unserved energy and the appropriate probability that intervention would be accepted based on the forecast frequency and customer costs of events. For example, intervention one year in five might be an acceptable risk profile and this might correspond to expected unserved energy being about 30% higher than the economic level. The capacity levels as a function of the forecast peak demand, forced outage rates, and reserve capacity costs in each year would provide an *Intervention Frontier* for NEMMCO in the three year outlook period and a basis for market development in the longer term to ensure that sufficient projects were active in the planning pipeline for the subsequent period.
- prepare a consultation paper on the results of the study and the economic benefits of moving to a new standard including the timing of the change and the change in load shedding policies and basis for intervention.
- for the economic standard, review the value of VoLL that would be commensurate with the customers' loads that would be at risk for the revised policy. This may justify a different VoLL in each region. Higher VoLL would be justified where the marginal value of customer load at risk is higher. A higher VoLL may also be necessary to justify higher level of reserve plant where a region has high value load at risk[3].

[3] A theoretical example of this occurring might be where a city region forms with transmission easement constraints into that region. Because of the high value of services and the absence of low value loads, there would be need for a higher VoLL to support higher levels of reserve genenratng capacity or more expensive transmission solutions such as long underground cable networks. Such a case is not currently foreseeable in the NEM.

- develop a generation capacity *Intervention Frontier* for the five year planning period that defines combinations of capacity levels in each region that would result in an unacceptable risk of customer load shedding with a marginal value higher than the prospective cost of reserve capacity. The *Intervention Frontier* would calculate the expected unserved energy and its uncertainty for the prevailing market conditions as a function of installed capacity and price bid demand side withdrawal and thereby enable various capacity outcomes to be tested in each forecast year. The *Intervention Frontier* would vary with forecast forced outage rates, scheduled maintenance requirements, median peak demand forecasts and any other material sensitivities and their uncertainties that are confirmed in the study.
- publish the *Intervention Frontier* function so that market participants can view the relationship between prevailing and forecast market conditions and forecast reliability and make their own assessment about the value of reserve capacity and the risk of intervention.
- establish monitoring procedures for NEMMCO to track how much load is shed for contingencies included within the reliability standard and to estimate the types of customers disconnected and their resulting costs on the same basis as used in the market modelling. This information would be used to review the operation of the revised standard, to validate or otherwise the basis of the revised standard and to be used in refining the methodology for future revisions of the reliability standard.
- maintain record keeping for forced outage rates and the weather sensitivity of load so that plant performance and load diversity factors can be monitored and applied in future modelling.

NEMMCO would also keep records on forced and maintenance outage rates, load diversity, and interconnection transmission reliability as the basis for future reviews and the measurement of uncertainty in the analysis.

9.8 How will the Market benefit from these Measures?

In brief market benefits would arise because:

- The lower level of intervention in the market by NEMMCO would reduce costs and relieve the surplus capacity that exists in the NEM and hopefully reduce the tendency for governments to panic about the status of the NEM's performance and over-react by stimulating more unnecessary capacity.
- The more realistic assessment of the role of demand side response would provide more higher marginal value resources participating in the NEM which would make the market more stable and less prone to rushes of investment after a price spike such as occurred in 2000/01. This would lower the risk in the market and thereby lower the cost of capital to the market suppliers.
- The more detailed and better understanding of the relationship between regional capacity, demand patterns, load shedding policies and customer risk would enable

NEMMCO to minimise its intervention and lead to a less conservative approach to managing the risk of unreliability. This would reduce the risk of price collapse in the market from excessive intervention and excess generating capacity.

- Customising the reliability standard to each region and over time would also reduce the risk of uneconomic intervention and increase return on investment to the generation sector.
- Customers would benefit directly from the demand side participation and from reduced fixed costs that are reflected in contract premiums. The contract premiums would be lower because of more orderly new entry, less risk of uncontrollable price spikes and less built in costs in maximum retail tariffs.
- Since generators are exposed to less risk they would not need to recover their weakened position after a revenue drought and expose customers and retailers to large asymmetric risks of sustained high prices. Indeed, if they did behave in such a way in a less risky market it would be easier to demonstrate market abuse. In the current circumstances it is harder to prove market abuse when price support well above short-run marginal costs is necessary for long-term financial survival.

10 CONCLUSIONS

The major conclusions from this analysis which have significance for the current review of the Reliability standard are as follows:

10.1 Output Based Measures

1. The use of output based reliability measures that relate to the customer's exposure to unserved energy as a way of modelling, measuring and reporting reliability is strongly supported.

2. The application of unserved energy as a descriptive basis for reliability standards between review periods is appropriate provided it is based upon a proper assessment of the risks to customers and the economic benefit to the market as a whole.

3. Demand side response whether bid into the market or imposed involuntarily in response to capacity shortages should be costed when assessing the optimal level of reliability.

10.2 Defining the Reliability Standard

4. Rather than being a target to be met, the primary use of the reliability standard should be as a basis for responding to market failure.

5. It is difficult to determine the costs associated with particular unserved energy events or average outcomes because so many customers would be affected. To accomplish this task requires a detailed analysis of load shedding procedures, the nature of customers affected and the costs that are imposed or perceived to be imposed on those customers.

6. Based upon preliminary analysis by MMA, the unserved energy standard needs refinement in the range of 0.001% for Queensland to 0.004% for the southern regions. The proper valuation requires assessment of the effect of load shedding policies on customers and the optimisation of the load shedding arrangements.

7. The relevant level of the Value of Customer Reliability should be based on the costs estimated to be incurred by customers directly affected by load shedding policies at the level applicable to the reliability standard.

10.3 Plant Mix and Fuel Supply

8. Changes in plant mix including the development of wind farms ought to be recognised in calculating reliability versus installed capacity and thereby determining required capacity levels to match the reliability standard.

9. For the modelling it will be necessary to project capacity developments beyond the commitment period for the purposes of estimating how much capacity needs to be in the development and planning process for the five to ten year outlook. This would require some assumptions about efficient plant mix in the long term which can be estimated using standard least cost methods.

10. The modelling of reliability ought to recognise the pattern of generation sources in relation to load patterns as well as its inherent statistical uncertainty. The treatment of intermittent generation can be accomplished by adding the contribution from embedded generation back into the historical regional load profile and then modelling the embedded sources explicitly. The intermittent generation may then modelled by various alternative methods according to the amount of performance data available.

10.4 Applying the Reliability Standard

11. It is inappropriate to be basing intervention on capacity reserve levels derived from the expected level of unserved energy. An uncertainty margin should be applied.

12. The uncertainty margin would reduce the reserve margin for intervention by about 50 MW in South Australia, 80 MW in NSW and 100 MW for Victoria and Queensland.

13. It does not matter what peak demand basis is used to determine long-term reserve margins. In the end a capacity level must be determined as the basis for monitoring and intervention. Stating the capacity level on a 50% POE basis for publication purposes might give more comfort to the general public that they are adequate and in accordance with international practice.

14. The annual unserved energy not occurring in the peak months should be distributed equally in the non-peak months to provide a short-term reliability target for monitoring maintenance scheduling.

15. Properly estimating the reliability uncertainty in the longer term and reducing the risk of intervention would allow NEMMCO to act as a reserve trader for up to three years ahead to cover the risk of new entry failure.

10.5 Relationship to Distribution Reliability

16. Distribution and bulk system reliability are separate issues and there is no benefit in arbitrarily linking their reliability standards. Reliability levels should be based upon cost/benefit analysis. The costs to provide higher reliability should be matched to the value as appreciated by customers on the basis of their willingness to pay for a given level of reliability or the demonstrated economic value of their activities as affected by the particular pattern of unreliability of the electricity supply. This approach requires a demonstrated link between the aspect of supply

disruption that is of concern and the most economic means to reduce that exposure to disruption.

10.6 Load Diversity

17. The modelling of load diversity between constrained NEM regions can be improved by further analysis of the relationship between peak demand and weather and the longer-term trends in this sensitivity and the weather itself. This would be an improvement over just taking a historical snapshot and using that for a specified POE of peak demand.

10.7 System Security Issues

18. The classification of unserved energy events in measuring and modelling exposure of customer load to disconnection should relate to the most economic mitigation measure.

19. If the unserved energy event could be economically mitigated with regionally located reserve generation capacity, demand side response or augmented inter-regional transmission capacity with a neighbouring system with diversified load, then that event should be related to the management of bulk system reliability. If not then the unserved energy event should be classified according to its most economic mitigation measure so that the appropriate focus can be applied to the management of that risk and not be confused with bulk system capacity management.

20. If credible multiple contingencies, such as double circuit line outages in the presence of lightning, require pre-contingent load shedding to mitigate the risk to system security because of the available generation profile, then such events should be included in the bulk system reliability modelling and standard. The reason is that the pre-contingent load shedding could be reduced by means of demand side response or reserve generating capacity in normal situations.

APPENDIX A REFERENCE DOCUMENTS

The following documents were referred to in this project as summarised in Table A- 1.

Table A- 1 Reference Documents

No	Document Title and Date	Source and Context	Relevant Elements
1	"Assessment of NEMMCO's 2001 Calculation of Reserve Margins", 10th September 2002	MMA report to Reliability Panel reviewing NEMMCO's methodology for reserve margin calculation and its application	Discussion of how a reserve margin should be calculated for the purpose of defining a basis for intervention.
2	"Critique of NEM Reliability Assessment Processes", 6th May 2004	ROAM Consulting Report to the National Generators Forum	
3	"Estimation of the Economically Optimal Reliability Standard for the National Electricity Market", 22 March 2006 (Draft 0.3)	MMA Report to EUAA outlining a basis for an economic reliability standard	Basis for disparate standards for each NEM region. Tasmania not considered due to lack of public information on hydrological and associated capacity risk.
4	"Determination on Reserve Trader and Direction Guidelines", June 1998	NECA Report from the Reliability Panel	Original basis for 0.002% and intervention based upon 10% POE peak plus the largest unit in a region.
5	"Review of Methodology and Assumptions Used in NEMMCO 2003/04 Minimum Reserve Level Assessment", 11 January 2005	KEMA Consulting review of NEMMCO practices.	States that the 0.002% standard is at the low reliability end (less stringent) for international comparisons.
6	"Forced Outage Data Collection Working Group: Final Report", 5th December 2005	NEMMCO based upon a consulting project by ROAM Consulting.	Provided recommended approaches for the gathering and interpretation of generator forced outage data.

No	Document Title and Date	Source and Context	Relevant Elements
7	"2004 Review of Minimum Reserve Levels - Queensland and New South Wales", 28th June 2004	NEMMCO based upon modelling conducted by ROAM Consulting	Assessed revised reserves for NSW and Queensland including the effects of load diversity and changes in assumed sharing of reserves between regions.

APPENDIX B APPROACH TO SURVEY OF VCR

B.1 Background

Investment in electricity transmission and distribution network capacity and reliability has traditionally been governed by criteria such as meeting 1-in-20 year peak demand capacity requirements. While such criteria provide easy to understand measures of the risk of supply failure (the need to curtail some electricity users involuntarily), they do not provide any assurance that the economically appropriate level of investment is made in capacity or reliability.

The economically appropriate investment is the level at which the marginal cost of investment (measured by dollars spent divided by throughput weighted by the probability that it will be used) is equal to the value of the electricity supplied to the marginal customer that would be curtailed involuntarily. To determine the level of investment, it is therefore necessary to measure and understand the VCR.

The process of determining an economic level of reliability in the NEM requires a study to calculate the values of VCR for electricity from quantitative surveys of customers who would be affected by unreliable supplies. VenCorp conducted a similar study for electricity in 2002 and MMA carried out a similar study for it for gas in 2005. This section discusses those lessons and related issues under the headings of:

- The scenario
- Customer segments.

B.2 The scenario

The survey instrument should be based on a realistic scenario and prepared using information taken from various sources, including previous studies. The following issues should be considered when preparing the scenario:

- Will the scenario use a large-scale outage or a localised outage?
- Will participants be told when the interruption will end?
- Are VCR values required for different durations of outages, such as a few minutes, an hour eight hours, twenty-four hours or seven days?
- Will the interruption to electricity supplies also curtail gas supplies?

Based on the experience of similar studies, we recommend that the following be considered in the preparation of the scenario for agricultural, commercial and industrial participants:

- cost of operating back-up equipment

- loss or spoilage of products, raw materials, loss of livestock, dairy, eggs, fruit or vegetable produce
- damage to plant or equipment
- pay for staff who are unable to work
- loss of sales or customers during the failure
- costs to bring business back to normal operations
- cost to repair possible damage to the environment
- cost to recover data lost from computer systems
- cost of overtime labour to make up lost production
- sales foregone after the failure
- loss of profits.

The scenario should also consider how organisations that have alternative fuels should be treated. The instrument would also provide an estimate of the number of organisations using alternative fuels and the type of alternative fuel used by these organisations.

B.3 Customer segments

The VCR studies for electricity in 1997[4] and 2002[5] calculated values for five customer segments:

- residential
- commercial
- industrial
- large industrial
- agricultural.

B.4 Possible approaches to VCR

This section assesses a number of possible approaches that could be used to develop the information that the Reliability Panel requires.

Identifying and assessing customer preferences regarding quality of supply is complicated by the need to minimise strategic gaming by respondents. This gaming could lead

4 The 1997 study was conducted by Monash University.
5 The 2002 study was conducted by Charles River Associates.

respondents to try to influence outcomes in their favour by being selective in their answers about their needs, the impact of outages and the costs they incur.[6]

It is not possible to operate an electricity distribution system to ensure that energy is continuously available. Distribution networks are therefore designed to perform at a level that is economical, but with acceptable degrees of continuity and quality.

Networks provide a level of benefits at a cost. The ultimate goal of this assignment is to identify the costs that customers incur when the supply of electricity is disrupted. Two methodologies lend themselves to such a task. They are:

- the VCR methodology
- the stated preference methodology.

Each of these methodologies is described in the following sections.

Value of customer reliability methodology

The analysis and calculation of VCR or reliability worth is based on:

- the number of interruptions experienced by customers, which may be planned interruptions (when customers are warned), or unplanned interruptions (when they are not)
- the duration of these interruptions
- the costs incurred as a result of interruptions.

For household customers, the costs are a consequence of not being able to use equipment and the likely damage to that equipment. For commercial and industrial customers, the costs are the direct costs incurred and the value of lost production.

Because of these different types of costs, the survey instruments are different. The cost estimates for residential customers are based on the alternatives that they use to replace the electricity which is not available. The cost estimates for non-residential customers are collected by providing respondents with a survey instrument which they complete based on their experience of outages.

The survey instruments for the VCR methodology are usually paper-based questionnaires designed for self-completion. The cost data obtained from the individual customer surveys is used to calculate parameters for segments of customers, from which an assessment of the potential value of supply is obtained. This can be expressed in a variety of metrics, eg $ / interruption, $ / kW of maximum demand, or $ / kWh of annual energy consumed.

6 Allen Consulting Group, 2001, The Incorporation of Service Quality in the Regulation of Utility Prices: A Discussion Paper, Report to IPART, March 2001, page 6.

Customer data is calculated at segment level by using averaging and aggregating processes.

The output of the VCR methodology puts a monetary value on reliability, which can be compared with the monetary cost of providing that level of reliability.

In order to calculate a regional or state-wide value for VCR for electricity, it will be necessary to aggregate the estimates for each segment using weighting data from external sources such as metering data on the number of customers and the volume of electricity they consume, and data on the duration and frequency of planned and unplanned outages.

Stated preference methodologies

Two widely-used stated preference methodologies are conjoint and discrete choice modelling. Each is described in the following sections.

Conjoint analysis

Choice modelling often uses conjoint analysis procedures. Conjoint, which is derived from the terms considered jointly, is a methodology used to assess customers' preferences when they base their choice of a product on the simultaneous consideration of two or more features, and each feature has two or more levels. Typical examples of features for consumer products are price, size, brand and colour. It is one of a family of choice modelling methodologies, all of which ask respondents to choose between two or more offers. Choice modelling methodologies work best when the respondent is obliged to choose between closed options.

There are three distinct types of models available within the conjoint methodology:

- the *part-worth* model is appropriate to categorical or qualitative features, for example the features on a television set
- the *vector* model is appropriate for quantitative features such as price, and assumes that a respondent's preference varies in a linear way with changes in a feature
- the *ideal-point* model is also appropriate for quantitative or continuous features, but the model allows for non-linear relationships.

Conjoint methodologies were used by TXU and Powercor to provide support for their submissions to the first electricity distribution price review in Victoria. For the Reliability Panel, the key product features for a conjoint study might be:

- reliability of supply[7]
- quality of supply

7 Reliability of supply includes the length of advance warning for planned outages.

- price
- response to telephone calls about interruptions.

The survey instruments for the conjoint methodology are usually paper-based questionnaires for self-completion, or computer-based questionnaires for self-completion during face-to-face interviews.

The output of the conjoint methodology is estimates of the dollar values that customers place on different levels of the features; in this case of different levels of reliability and quality of supply. These can be weighted to give average values for customer segments or aggregations of segments.

As pointed out in the literature,[8] there are several limitations with conjoint methodology:

- data are usually analysed using Ordinary Least Squares (OLS), but the resultant values are generally biased because OLS is not an appropriate estimate
- ratings are ordinal and discrete, which violates the assumptions underlying OLS
- the model is merely a rating (or ranking) on a preference scale and hence does not predict behaviour or level of demand for a particular alternative
- problems also can arise in asking respondents to rate or rank product profiles.

Discrete Choice Modelling (DCM)[9]

With DCM, respondents see products or services alongside competitive products in a series of market scenarios. They are asked to look at each scenario, and answer a simple question: "If these were all the choices available, which would you choose, if any?" Once the respondent has done this, he or she simply goes on to the next scenario and makes the same simple decision.

Some of the benefits are outlined below:

- the respondent makes a choice, decision or purchase, rather than just stating a preference
- there is a great deal of theoretical support (underpinned by random utility theory)
- it avoids impossible combinations and forced choice problems, while preserving and even extending the estimating power of conjoint.

It does, however, have some limitations, as listed below:

8 Centre for International Economics, 2001, Review of willingness-to-pay methodologies, prepared for the Independent Pricing and Regulatory Tribunal of NSW, August 2001 and Budiyani, R., and C. Coombes, 2000, Electricity Tariffs and Security of Supply, Information Paper number 1, SAIIR, June 2000.

9 This section draws from Struhl, S. 'Discrete Choice Modelling: Understanding A Better Conjoint than Conjoint' Quirk's Marketing Research Review, June/July 1994.

- analysis can be done at the aggregate level only[10] and hence no individual level utilities can be estimated. Segmentation based on conjoint utilities often provides tremendously useful results. The groups that emerge usually have sharply different wants and needs related to the product in question
- it places a greater cognitive demand on respondents
- lower response rates tend to prevail
- it is more complex than conjoint analysis
- it uses iterative analytical procedures and models that must 'converge' or be 'solved'.

DCM typically uses estimation by logistic regression procedures. Multinomial (or polytomous) logistic regression is used for choices among more than two alternatives. When more than two alternatives are tested, DCM also must make an important mathematical assumption, the independence of irrelevant alternatives (IIA). IIA is a key property of DCM.[11]

Guidelines for choice valuation studies, produced by the US National Oceanic and Atmospheric Administration (NOAA)[12] are outlined below:

- respondents need to understand and believe the context in which the services are being presented for valuation
- the payment vehicle must be meaningful to respondents
- the questionnaire will be pilot tested
- follow-up questions and checks on respondents' understanding and acceptance of the valuation task will be included
- the questionnaire will be administered face-to-to-face where practicable
- a split-sample test will be conducted to examine whether respondent values are sensitive to the scope (or amount) of the service under investigation.

Based on this review of potential methodologies, we recommend the use of the same VCR methodology as used in the Monash and Vencorp electricity studies because:

- it is less demanding on respondents
- the analysis of the data is straight-forward and can be easily replicated and explained
- it does not require respondents to complete a computer-hosted survey

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10 This is a consequence of logistic regression, which works in terms of likelihoods or odds. Odds, of course, can only be estimated at the group or aggregate level.

11 For a discussion of the types of models, see McFadden, D. and Train, K., 2000, Mixed MNL Models for Discrete Response, Journal of Applied Econometrics, Volume 15, Number 5, 2000, pages. 447-470.

12 Arrow, K.R., Solow, P.R., Portney, E.E., Leamer, R., Radner, R. and Schuman, H., 1992, Report of the NOAA Panel on Contingent Valuation, Federal Register. January 15, 1993, Volume 58, Number. 10, pages 4601-4614.

- it achieves higher response rates
- the assignment can build on the lessons learnt in VENCorp's VCR study for electricity in 2002 and its gas study in 2005.

We also recommend that the survey instrument be based on costs incurred by the interruption for industrial, commercial and agricultural customers, and on the cost of alternatives for residential customers.