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Reliability Standard and Settings Review

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1) DEFINITIONS

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
ANTS	Annual National Transmission Statement (now NTS)
APC	Administered Price Cap
APP	Administered Price Period
Capex	Capital Expenditure
CCGT	Combined Cycle Gas Turbine
CPRS	Carbon Pollution Reduction Scheme
CPT	Cumulative Price Threshold
CRA	CRA International
CRR	Comprehensive Reliability Review (2007)
DSM	Demand Side Management
DSP	Demand Side Participation
ESAS	Electricity Sector Adjustment Scheme
ESOO	Electricity Statement of Opportunities (prepared by AEMO, was NEMMCO SOO)
FOR	Forced Outage Rate
GWh	Gigawatt hours
LRMC	Long run marginal cost
MCE	Ministerial Council on Energy
MD	Maximum Demand (MW)
MPC	Market Price Cap
MRET	Mandatory Renewable Energy Target
MRL	Minimum Reserve Level (Reserve Margin required to meet the Reliability Standard)
MW	Megawatts
MWh	Megawatt hours
NEM	National Energy Market
NEMMCO	National Electricity Market Management Company (now AEMO)
NIEIR	National Institute of Economic and Industry Research
NTS	National Transmission Statement (previously ANTS)
OCGT	Open Cycle Gas Turbine
PoE	Probability of Exceedence (%)
ROAM	ROAM Consulting
RET	Renewable Energy Target
RSSR	Reliability Standard and Settings Review
SOO	Statement of Opportunities (prepared by NEMMCO, now ESOO prepared by AEMO)
USE	Unserved Energy (% of energy supplied)
VoLL	Value of Lost Load
WACC	Weighted Average Cost of Capital

2) INTRODUCTION

The Australian Energy Market Commission, on behalf of the Reliability Panel, has appointed ROAM Consulting (ROAM) to provide analyses and recommendations on the values of the reliability settings to apply from 1 July 2012 such that the Reliability Standard is met.

The Reliability Standard was set at 0.002 % unserved energy (USE) per annum by the Reliability Panel (Panel) at market start in 1998 and has remained unchanged since that time.[1] The Standard describes the minimum acceptable level of bulk electricity supply at risk measured against the total demand of consumers. For example, the practice to date has been to measure the Standard over the long term – the past ten financial years. Thus, if consumer energy demand was 100,000MWh, the Standard would require the supply of no less than 99,998MWh over the long term.

The National Electricity Market (NEM) is an energy only market that is operated with reliability settings that aim to achieve the Reliability Standard. The reliability settings in the NEM are:

- the market price cap (MPC), previously known as the value of lost load (VoLL), that sets the maximum spot price in a region for a dispatch interval;
- the market floor price that sets the minimum spot price in a region for a dispatch interval; and
- the cumulative price threshold (CPT) that is an explicit risk management mechanism whereby, if the sum of the trading interval spot prices over a rolling seven day period total or exceed this threshold, the spot prices are capped at the administered price cap.[2]

Currently the MPC is set at $10,000/MWh, the market floor price is set at -$1,000/MWh and the CPT is set at $150,000.

The most recent review of the reliability settings was performed by the Panel as part of its Comprehensive Reliability Review.[3] The AEMC engaged CRA International (CRA) to assist the Panel with this review, including the economic modelling associated with determining the recommended reliability settings.[4]

The current review will consider changes to the form and level of the Reliability Standard based on comments raised by stakeholders during consultation. Following this analysis the Panel will make recommendations for the form and level of the Reliability Standard to apply in the NEM in the future.

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[1] The Reliability Standard was reviewed as part of the AEMC Reliability Panel 2008, *Comprehensive Reliability Review – Final Report*, December 2007. At this time the Panel left the form and level of the standard unchanged but clarified the definition of the standard and how compliance with the standard would be measured.

[2] *Determination of Schedule for the Administered Price Cap*, AEMC, 20 May 2008, available on the AEMC website at http://www.aemc.gov.au/Market-Reviews/Completed/Determination-of-Schedule-for-the-Administered-Price-Cap.html

[3] *Comprehensive Reliability Review – Final Report*, December 2007, available on the AEMC website at: http://www.aemc.gov.au/Market-Reviews/Completed/Comprehensive-Reliability-Review.html

[4] The Panel published the CRA analysis as an Appendix to its Comprehensive Reliability Review.

The review will take into account:

(i) the analysis undertaken previously by CRA International;
(ii) the 2009 Annual Planning Reports from all the Jurisdictional Planning Bodies;
(iii) the 2009 AEMO ESOO; and
(iv) proposed commencement of the CPRS.

ROAM's modelling provides an analytical basis to support the Reliability Panel recommendations.

3) CONTENTS OF THIS DRAFT REPORT

This report is targeted at detailed analysis and discussion of the reliability settings which would be required from 1st July 2012 to meet the Reliability Standard. The ROAM modelling has not addressed other policy variables. The report includes a description of the modelling methodology adopted for this review, as well as an assessment of the methodology against the findings of the CRA review undertaken in the 2007 Comprehensive Reliability Review.

4) ASSUMPTIONS AND METHODOLOGY

4.1) MODELLING INPUTS

ROAM has used input data from a number of recognised sources for the RSSR and CRA modelling study, including:

- Reliability Standard and Settings Review
  - 2009 AEMO Electricity Statement of Opportunities
  - 2009 AEMO Energy and Demand Projections
  - 2009 ACIL Tasman Report to NEMMCO *Fuel Resource, new entry and generation costs in the NEM, April 2009*

- CRA Benchmarking
  - 2007 NEMMCO Statement of Opportunities
  - 2007 NEMMCO Energy and Demand Projections
  - 2007 ACIL Tasman Report to NEMMCO *Fuel Resource, new entry and generation costs in the NEM, March 2007*
  - CRA International Final 2007 CRR Report Appendix *Modelling Methodology, Input Assumptions and Results Second Stage Modelling*, *December 2007*

ROAM has modelled the nine year period from 2010-11 to 2018-19.

4.2) MODELLING ASSUMPTIONS

The appendices to this report (Appendix A) provide more detail on the modelling assumptions used in this study.

4.3) RSSR AND CRA SCENARIOS

For these studies, ROAM has modelled the 10% PoE and 50% PoE demand forecasts independently to assess the resulting USE. The USE outcomes of the two demand scenarios are then weighted to create an expected USE, with the weights determined according to the Demand Weighting methodology developed and presently used by AEMO[5]. These demand weightings are the same as those previously used in 2007 by NEMMCO.

5) METHODOLOGY DESCRIPTION

ROAM has used the 2-4-C market modelling software suite to model the NEM for this assessment.

The purpose of the key Reliability Setting, the Marginal Price Cap, is to provide sufficient incentive for generation to enter the market such that the Reliability Standard will be met. To ensure an effective incentive for new entrant peaking capacity to enter the market, the MPC should be set at a level that will provide sufficient revenue in the very few running hours which the last generator to be dispatched would need to achieve so as to recover its capital, fixed and variable operating costs and achieve its investor's required rate of return. New entrant peaking generation capacity will not be incentivised to enter if the MPC is not high enough to achieve its rate of return and the NEM may fall short of meeting the Reliability Standard.

The Reliability Standard requires the expected[6] USE in each region in each year to be less than 0.002% of annual energy. The methodology ROAM has adopted for this review has two complementary approaches, both of which are modelled to achieve the Reliability Standard:

- Install sufficient committed, advanced or announced capacity such that the marginal peaking generator remains profitable given a set MPC and assess the resulting USE.
- Install sufficient committed, advanced or announced capacity to achieve the Reliability Standard in each region in each year of the modelling period and assess the associated MPC.

6) BENCHMARKING THE CRA OUTCOMES WITH ROAM'S METHODOLOGY

6.1) BENCHMARK MODELLING ASSUMPTIONS

See the appendices to this report (Appendix A) for the CRA Benchmarking Assumptions.

[5] The 50% PoE and 10% PoE are weighted 70%/30%

[6] The Reliability Standard is measured using the *expected* level of USE. That is, the Reliability Standard is forecast to be achieved if the forward looking level of USE is below 0.002% annual energy in each region, in each year.

6.2) BENCHMARKING OUTCOMES

ROAM modelled the NEM on a six region basis[7] half hourly for 25 iterations of Monte Carlo random forced outage simulations. All outcomes have been modelled for both 10% PoE and 50% PoE demand forecasts and are shown as a weighted average of the two, with 70% weighting for the 50% PoE and 30% weighting for the 10% PoE, which is in line with the approach of the CRA report.

ROAM has modelled the 2007 conditions, targeting the Reliability Standard by commencing with the level of installed capacity published in the CRA Appendix to the CRR. To fine tune the capacity needed to meet the Reliability Standard for each year of the nine year forecast period, ROAM has installed peaking generators (open cycle gas turbines). As the lowest capital cost plant, OCGTs represent the type of plant which would be developed as the incremental generation in response to growing capacity shortfall and the incentives provided by the MPC.

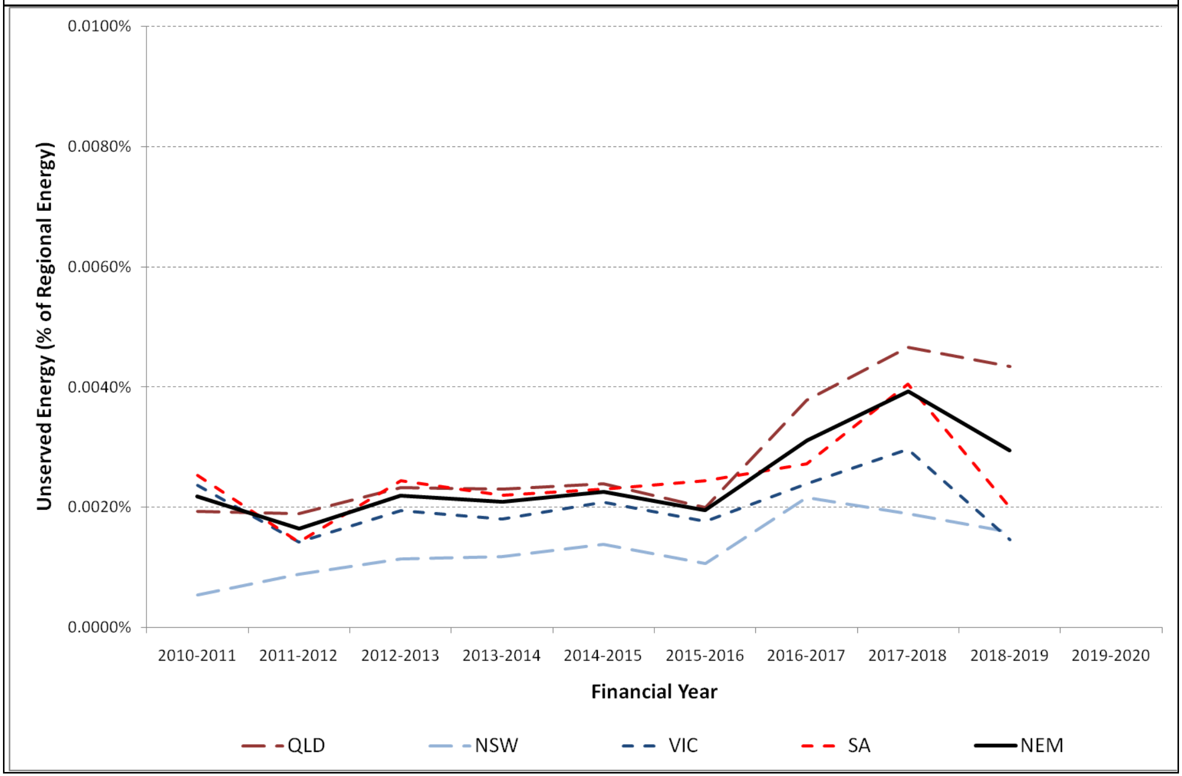
It is important to achieve a forecast level of USE in line with the Standard to accurately determine the MPC necessary to achieve profitability for the marginal generator. Since there is a non-linear relationship between USE and MPC, it is not valid to assess the MPC from a forecast which does not achieve (or is at least very near to) the Reliability Standard.

The figure below shows the USE outcome for the weighted average of the two independent demand profiles modelled for the CRA Benchmark scenario. As the figure shows, the model produces a close match in USE to the Reliability Standard for the regions of Queensland, Victoria and South Australia. New South Wales is more reliable than the Standard, which is an overhang from the high reserves initially in that region, owing to the planned installation of several new large stations (Tallawarra, Uranquinty and Colongra). The NEM weighted average line, highlighted in **BLACK**, shows the weighted average (by annual regional energy) of the three USE levels of each of the QLD, VIC and SA regions.

The period beyond 2015-16, and the New South Wales USE level, is not sufficiently near to the 0.002% USE Reliability Standard, and therefore including these results could skew the MPC estimate. In particular the lower than standard USE in NSW would mean that the extreme peaking generator in that state will operate with reduced running hours than if it just met the standard, and result in an excessive estimate of MPC. This is common also to the CRA modelling where the USE forecasts by region were spread over a range above and below the Standard. The remainder of this section therefore focuses on the period 2010-11 to 2015-16 for the QLD, VIC and SA regions of the NEM, for which the MPC can be more accurately computed.

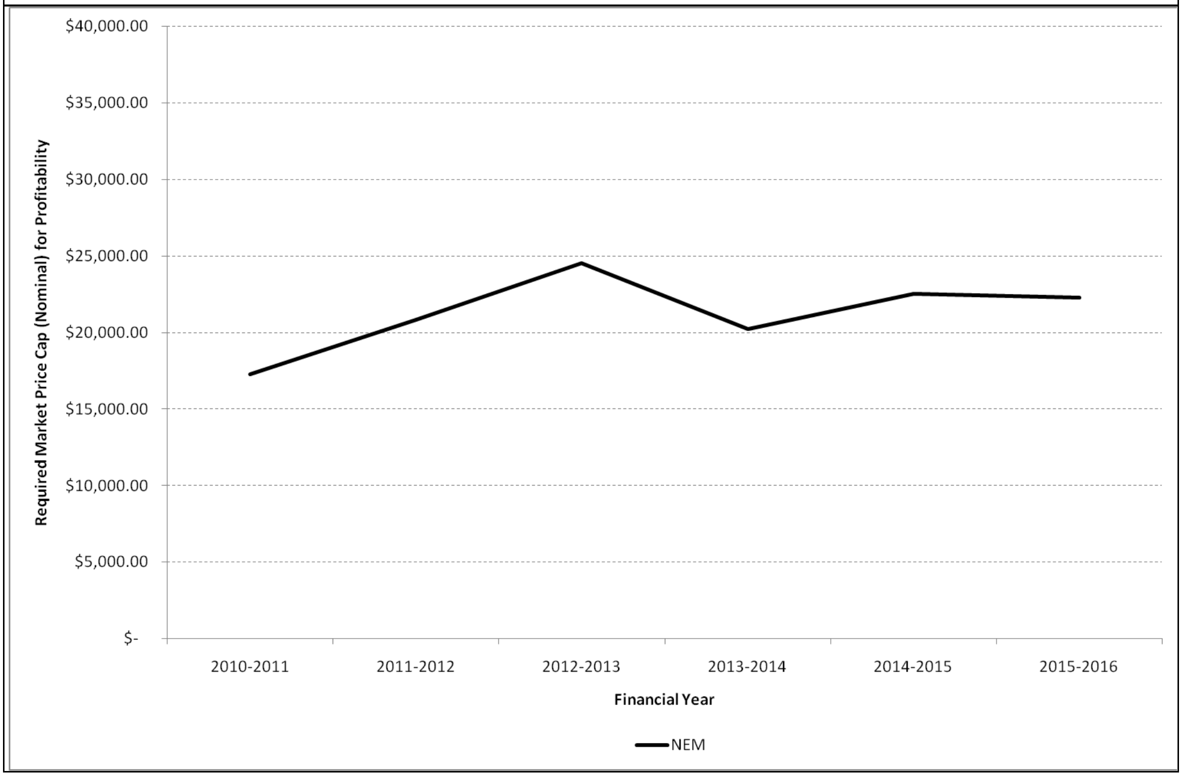
[7] In 2007, Snowy was a region of the NEM. The Snowy region was abolished from 1st July 2008 according to the amending rule 2007 No. 7. As such, the Snowy generators (Guthega, Murray and Tumut) were modelled for the CRA Benchmarking studies as part of the Snowy region, with VIC_SNO and SNO_NSW interconnectors linking Snowy with NSW and VIC.

Figure 6.1 – Unserved Energy Forecast in CRA Benchmarking Model



As previously discussed, the MPC is the value which achieves a profitable result for the extreme peaking generator with USE near the Standard. The following chart shows the resultant estimated MPC for the energy weighted average of the three regions Victoria, South Australia and Queensland. Leaving out NSW from the calculation has little effect on estimating the value of MPC for the benchmarking exercise, as each state can be expected to have a similar MPC at the level needed to just meet the Reliability Standard.

Figure 6.2 – Market Price Cap (Nominal) required to provide profitable returns [CRA]



6.2.1) CRA Results Comparison

ROAM's benchmarking of the CRA outcomes has produced a higher MPC than CRA predicted in the CRR Appendix. Figure 6.2 above shows that the ROAM modelling indicates an MPC of approximately $20,000/MWh over the six years, or approximately $17,500/MWh in 2010-11 increasing to $20,000/MWh in 2011-12. The reasons for this apparent discrepancy have been identified by comparing the key differences between the CRA modelling and ROAM benchmark.

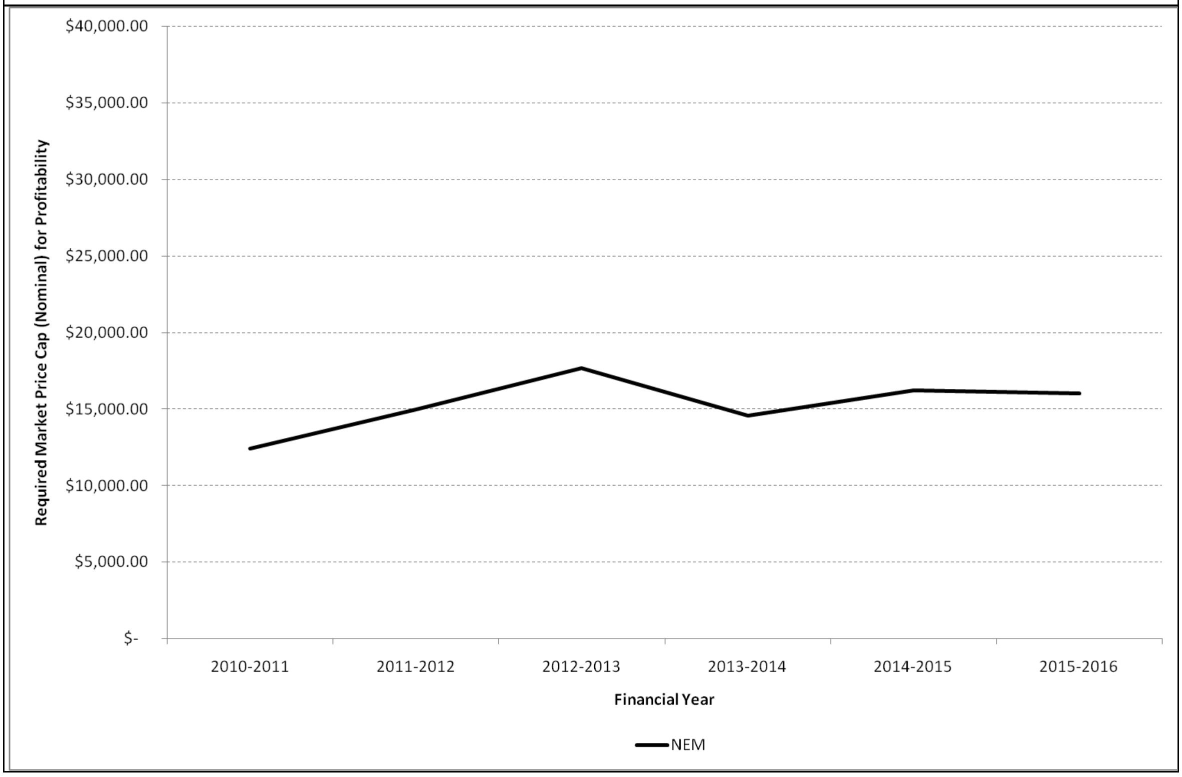
6.2.2) Marginal Generator Availability

The availability of each region's marginal generator has an impact on the profitability of the generator and the level of USE in the NEM. ROAM has used the generator data from the 2007 ANTS Consultation Report, which assumes an equivalent availability of peaking generation of approximately 72%.

Approximately 40% additional revenue could be achieved if the marginal generator is perfectly reliable. This would materially improve the profitability of each generator, and therefore reduce the necessary MPC level to meet the profitability requirements of investors.

If perfectly reliable, the MPC required would be significantly lower than that modelled than shown in Figure 6.2 above. Figure 6.3 below provides an estimate of the MPC if the marginal generator is perfectly reliable.

Figure 6.3 – MPC required to provide profitable returns (High Reliability) [CRA]



In this case, the MPC necessary reduces to $12,500/MWh in 2010-11 and $15,000 in 2011-2012, in close alignment with the CRA findings.

Box 1 – CRA Benchmarking: Conclusions
By using the same input data as that used by CRA in its Appendix to the CRR, ROAM has achieved an outcome in close alignment with the CRA findings, adjusting for a higher generator availability than that of the 2007 ANTS Consultation Report. The CRR Appendix prepared by CRA did not state the forced outage rate used for peaking capacity, and therefore it is reasonable to assume that the results obtained by CRA *may* have incorporated high reliability for extreme peaking plant (while maintaining typical forced and partial outages on the remaining generation portfolio). The modelling methodology applied by ROAM, although different in approach to CRA, is therefore a valid approach for the RSSR modelling.

7) Reliability Standard and Settings Review Modelling

This section of the report presents the modelling results and discussions related to the RSSR assessment.

7.1) RSSR Modelling Assumptions

See the appendices to this report (Appendix A) for the RSSR modelling Assumptions.

The modelling incorporates demand traces which were developed from the half hourly 2008-2009 financial year reference load trace using regional energy targets and the regional 10% PoE and 50% PoE demand targets from the 2009 AEMO Demand and Energy Projections. The model employed contains the five existing NEM regions (i.e. post-Snowy abolition).

The CPRS is modelled to commence from 1st July 2012, and ROAM has incorporated the effect of this into the bidding strategies of all existing and new entrant generators from this time. ROAM has used the CPRS-5 carbon price projections as per the *October 2008 Low Pollution Future* report prepared by the Commonwealth Treasury. The modelled impact of the CPRS on the bidding of generators is contained within the appendices to this report.

ROAM has used committed, advanced and announced projects when developing the installation plan for the forecast period, with renewable generators installed to meet the RET. ROAM has modelled a single generation planting across both demand PoE scenarios as the generation installed by the market would be a single response to a range of weather conditions. Consequently the forecast USE is much higher in the 10% PoE case than the 50% PoE. The extreme peaking generators are therefore much more profitable in the 10% PoE than 50% PoE. Hence the spot market earnings of the peaking generators will be highly variable from year to year, depending on actual weather conditions.

7.2) RSSR OUTCOMES

ROAM has conducted the RSSR modelling by iteratively forecasting each year of the forecast period, annually adjusting the appropriate level of installed capacity necessary in order to achieve the Reliability Standard. The MPC is then found by calculating the profitability of each regional marginal peaking generator and selecting the MPC level which achieves a marginally profitable outcome for the plant.

In this way, the Reliability Standard is met on a weighted average basis, and the MPC is determined to be the level which provides sufficient incentive to the market to install only the level of capacity which is necessary to meet the Standard.

The results of the modelling are shown in the figures below.

Figure 7.1 – Annual Unserved Energy in RSSR Modelling

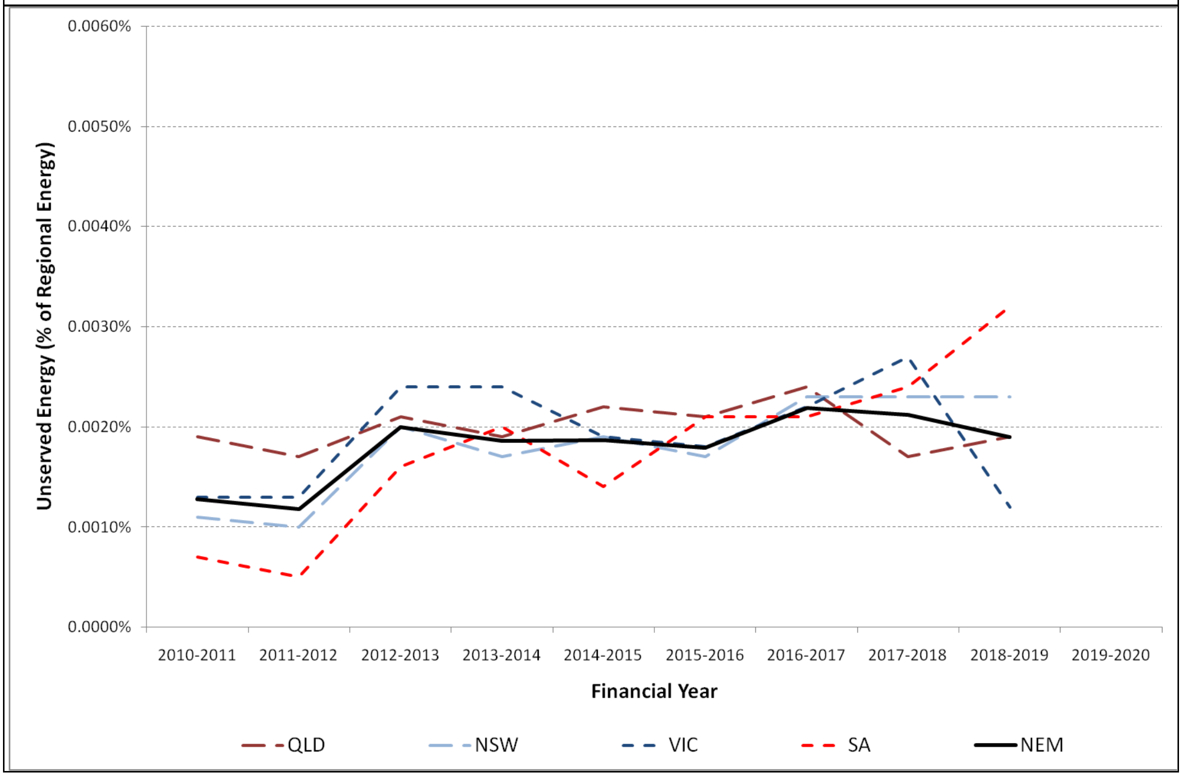


Figure 7.1 demonstrates that for each year of the modelling period the resulting level of USE in each year is close to the Reliability Standard of 0.002%. The Reliability Standard is exceeded in 2010-2011 and 2011-2012 since existing capacity will be in place to deliver a higher reliability than the Standard, based on modelling outcomes. As the focus of this report is the 2012-2013 and 2013-2014 period, the results for 2010-2011, 2011-2012 have therefore been excluded in calculating the MPC.

The modelling methodology (discussed in Section 5) has ensured that each region is largely achieving the 0.002% Standard, given the 'share the pain' principles discussed in the report appendices (Appendix A).

Figure 7.2 below provides the MPC necessary to provide just sufficient incentives to new entrant peaking plant, on an energy weighted basis across all NEM regions, so that the Reliability Standard is achieved.

Figure 7.2 – Market Price Cap (Nominal) required to provide profitable returns [RSSR]

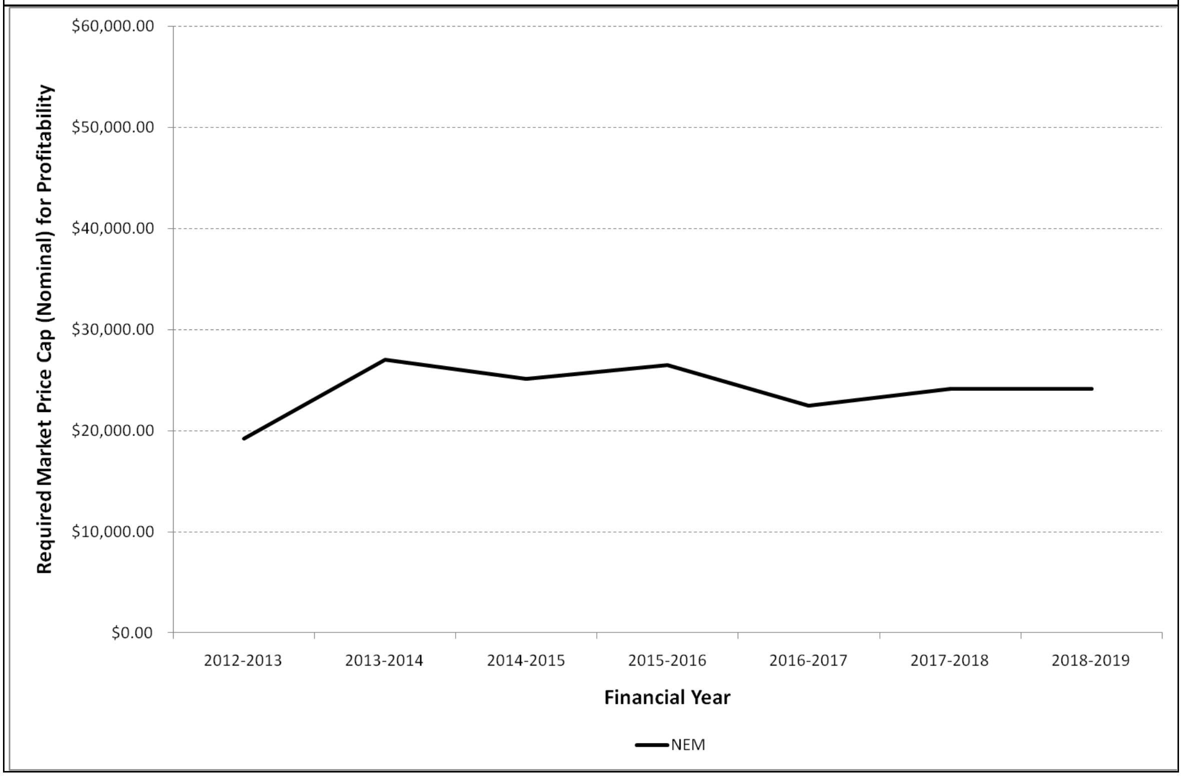
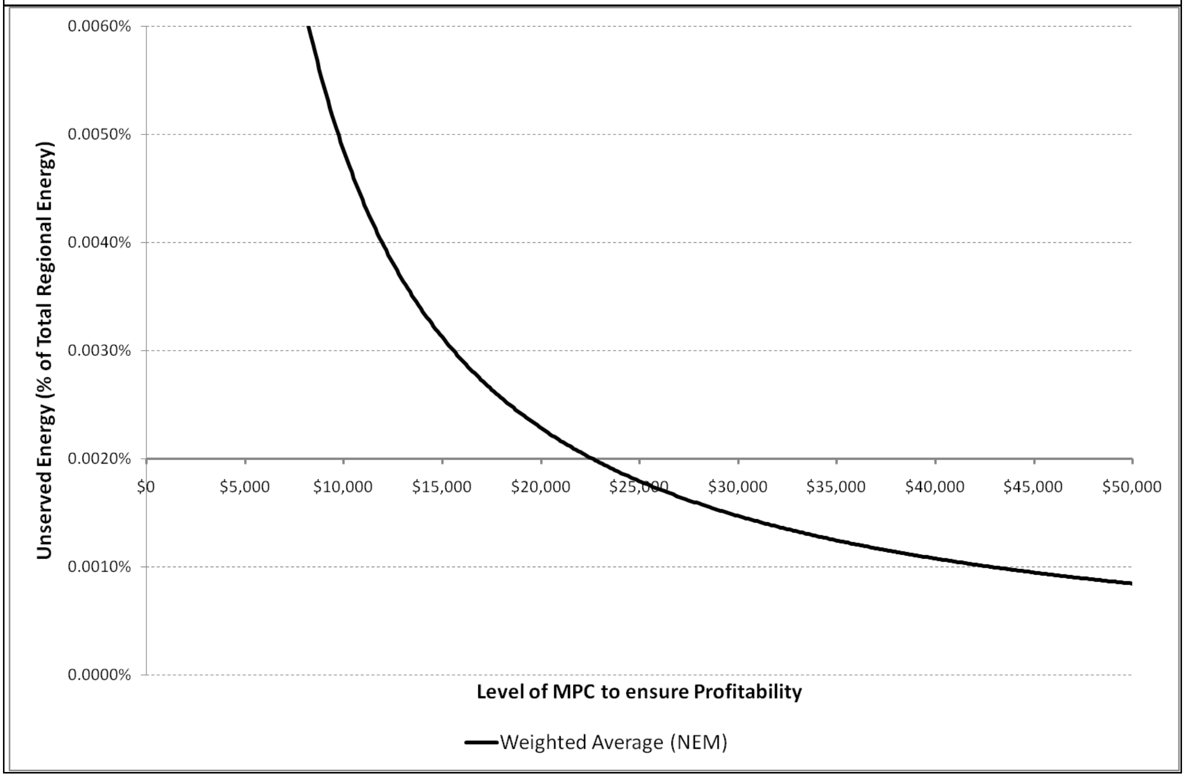


Figure 7.2 shows an MPC of approximately $24,000/MWh would be needed to ensure the Reliability Standard is met in the longer term. For the modelling period of primary interest (2012-2013 and 2013-2014), the MPC needed is calculated as approximately $20,000/MWh increasing to approximately $24,000/MWh.

ROAM has presented the results as a weighted average NEM MPC. The NEM MPC is calculated as the average of the required MPC of each region, weighted according to the regional annual energy. This includes the Tasmanian region, which is an energy limited system and (assuming hydro availability at peak demand times) not very susceptible to unserved energy events; this has been confirmed in the modelling.

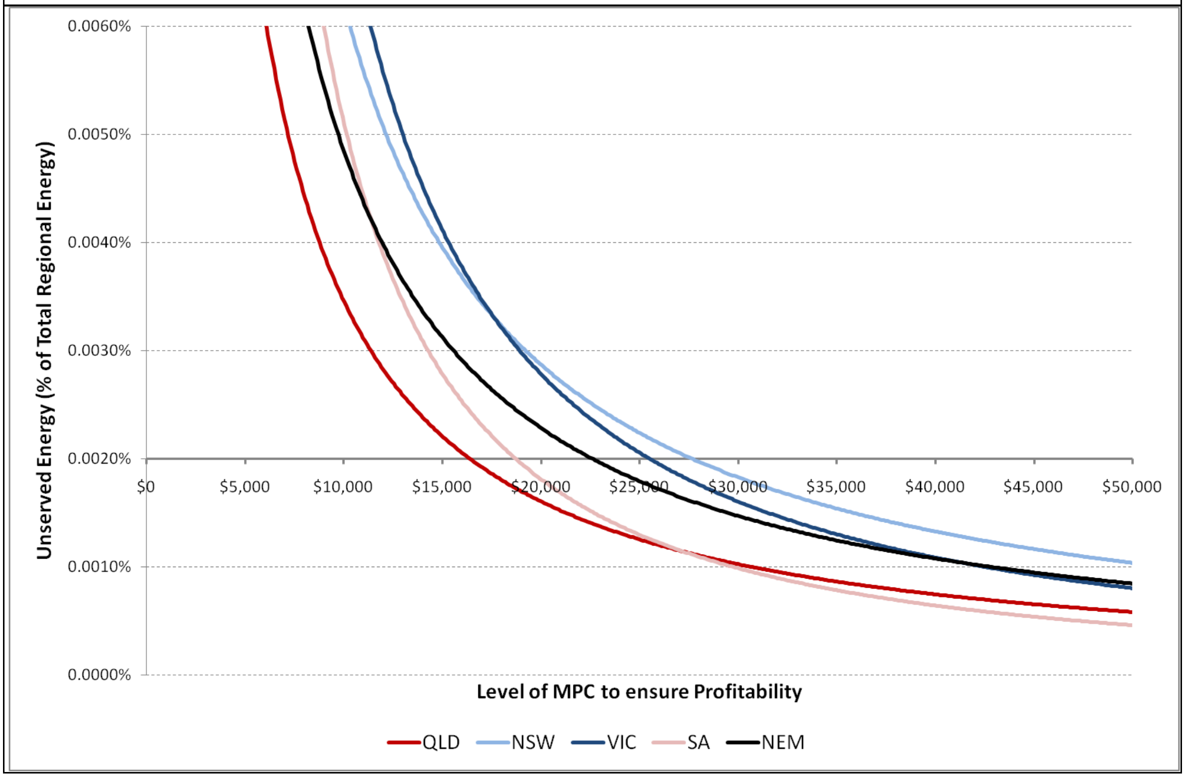
ROAM has also compared the relationship between USE and MPC over the full seven years in Figure 7.3. This shows the appropriate level to set the MPC to ensure sufficient incentive to encourage adequate new entrant generation would be approximately $22,500/MWh over a nine year period.

Figure 7.3 – Relationship between USE and MPC [RSSR – NEM Average; All Years]



The Reliability Standard is defined to deliver 0.002% USE in each region in each year, rather than weighted across all regions. Figure 7.4 shows that there is a relatively wide range across regions for the study period as to the estimated MPC to meet the Reliability Standard in that region. The range is a result of a combination of complex factors but is particularly associated with the differences between the shape of the extreme part of each region's load curve when peaking generators will be dispatched. New South Wales and Victoria show the need for a higher MPC, owing to a combination of high overall demand levels and more peaky demands (fewer periods of extreme weather).

Figure 7.4 – Relationship between USE and MPC [RSSR – All Regions; All Years]



Box 2 – RSSR Assessment: Longer term conclusion
ROAM has found that an MPC of approximately $22,500/MWh is needed over the forecast period to ensure sufficient incentive for the recovery of capital, fixed and operating costs associated with an extreme peaking gas turbine while meeting the Reliability Standard of 0.002% USE.

7.2.1) A cautious approach: Gradually increasing the MPC

Figure 7.3 and Figure 7.4 in the previous section showed the relationship between USE and MPC over all Monte Carlo simulations for all regions and all years modelled (i.e. between 2012-13 and 2018-19). The primary focus of the current review of the Reliability Standards and Settings is the 2012-13 and 2013-14 period, with decreasing importance placed on the years which follow.

ROAM has analysed the USE versus MPC relationship for each individual year of the forecast period in order to determine the most appropriate value for the MPC for the shorter term. The following figures show the 2012-13 and 2013-14 relationship. In 2012-13, the value of MPC is estimated as $17,500/MWh and in 2013-14 as $20,000/MWh.

Figure 7.5 – Relationship between USE and MPC [RSSR – NEM Average; 2012-13]

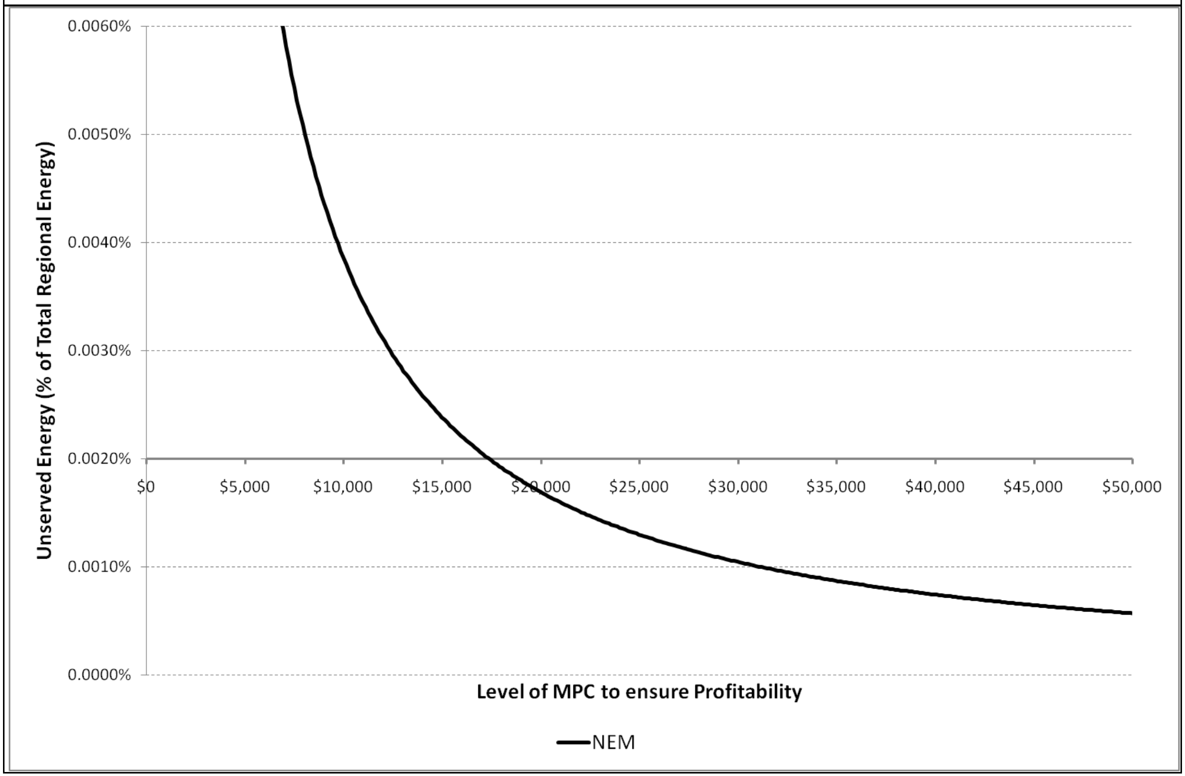


Figure 7.6 – Relationship between USE and MPC [RSSR – NEM Average; 2013-14]

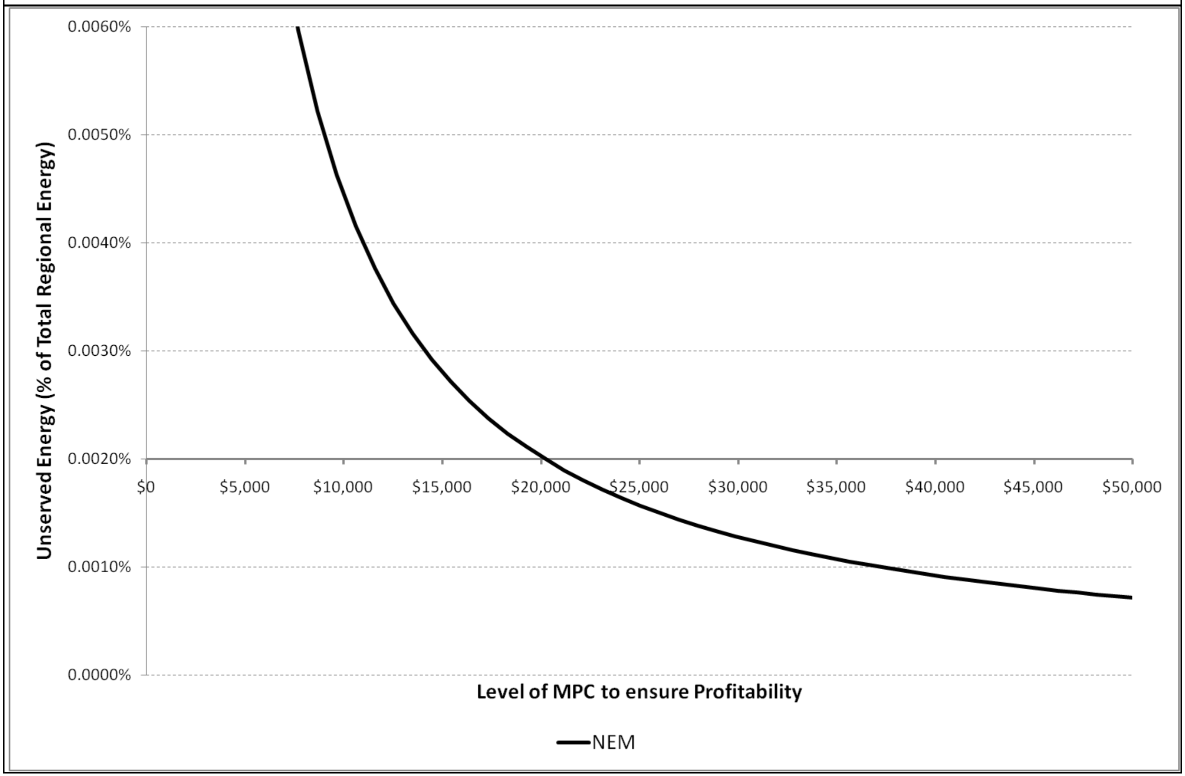


Figure 7.7 below demonstrates the annual movement in the necessary MPC to achieve a marginally profitable return for new entrant peaking capacity. The values represent the intercept of each annual USE versus MPC curve such that the level of USE is 0.002%. As such, this trend represents the necessary MPC as calculated through each of the 25 iterations of Monte Carlo simulations in each year of the forecast period. The figure shows that the MPC is trending upwards before settling at approximately $23,000/MWh.

Figure 7.7 – Relationship between USE and MPC [RSSR – NEM Average; Annual movements]

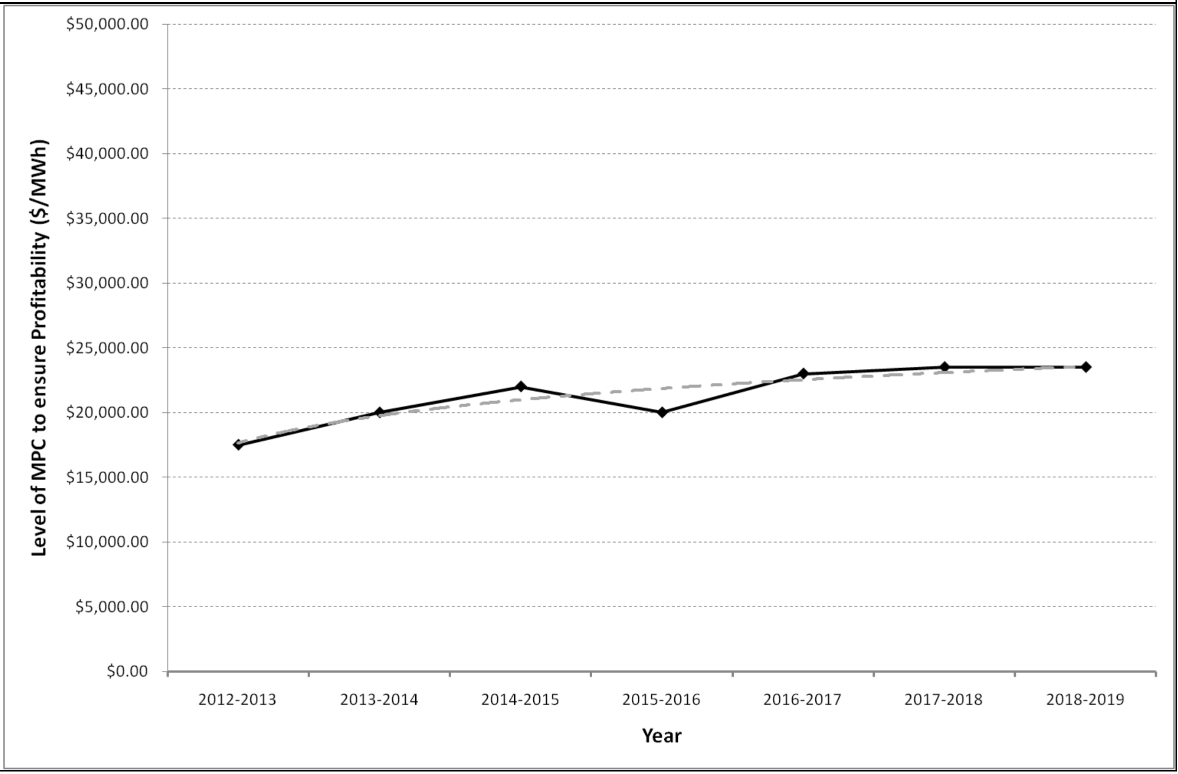


Table 7.1 – Relationship between USE and MPC [RSSR – NEM Average; Annual Movements]

	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
MPC	$ 17,500	$ 20,000	$ 22,000	$ 20,000	$ 23,000	$ 23,500	$ 23,500

Box 3 – A cautious approach: Moving the MPC gradually

ROAM has found that an MPC of approximately $22,500/MWh is needed for the recovery of capital, fixed and operating costs associated with an extreme peaking gas turbine while meeting the Reliability Standard of 0.002% USE *over the longer term*. This section (7.2.1) has shown that the MPC may be gradually increased while maintaining a marginally positive return for investors of extreme peaking plant. In particular, if gradually increased, ROAM concludes that the MPC may be gradually increased from $17,500/MWh in 2012-13 and $20,000/MWh in 2013-14 to $23,500 by 2018-19.

7.3) RATIONALE FOR A POSSIBLE INCREASE IN MARKET PRICE CAP

The decision to set the MPC at $12,500/MWh for 2010-11 and 2011-12 was made through the Comprehensive Reliability Review (CRR) in 2007. There have been a number of developments in market conditions since that time which indicate that the MPC may need to increase significantly above this level to ensure that the Reliability Standard will continue to be met. These factors include an increase in costs for peaking generators, forecasts of increasingly peaky demand over time, and the increased penetration of intermittent renewable generation through the RET legislation which will expand the RET from 9,500GWh/a to 45,000GWh/a by 2020.

Time value of money

The 2007 Reliability Review resulted in an increase of the MPC from the current level of $10,000/MWh to $12,500/MWh effective July 2010. This increase in the MPC is the first since the value was increased from $5,000/MWh to $10,000/MWh in 2002. The increase in 2010 is consistent with an annual growth rate of approximately 2.2% which is below the average level of inflation over that time period. If both the Reliability Standard and the reliability settings remain unchanged, it is possible that the standard will be breached in the near future.

This results from a variety of factors including the increased costs which occur through time and also the decreasing value of money. The MPC is a nominal value in the NEM and therefore, the real value of the MPC decreases continuously through time. In conjunction with the expected increase in costs over time, real generator profitability will decrease in the future, all else being held constant.

Increased Generation Costs

The benchmark capital costs for an open cycle gas turbine (OCGT) generator have increased by approximately 22% in real terms in the past two years. This increase in costs suggests that peaking generators will need proportionally higher revenues to achieve their required rate of return, i.e. the level of revenue needed to meet their LRMC's at their target WACC. An estimated increase of 22% in the real value of the MPC would be required to offset the increase in OCGT capital costs. The following table compares the capital costs for an OCGT generator at $2009 price levels using current information and the available information in 2007.[8]

Table 7.2 – Capital Cost of OCGTs ($/kW)

	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
2007 Data[9] ($2009)	756	753	749	745	741	738	734	731
2009 Data ($2009)	985	918	916	900	888	886	883	880
% Increase	30%	22%	22%	21%	20%	20%	20%	20%

[8] Data taken from ACIL Tasman reports to NEMMCO 2007 and 2009.

[9] Data taken from ACIL Tasman report to NEMMCO 2007, uplifted from real $2007 to real $2009.

ROAM recognises that the capital cost of investment may not incorporate the increasing real cost associated with locating generation plant, particularly peaking plant which is critical to be located 'downstream' of any network constraints. That is, peaking plant which fulfils a reliability role whereby it generates only at periods of extreme demand events such as the extreme peaking plant referred to in this report should be located electrically close to the load it is to serve, and without dispatch risk caused by transmission limitations.

Extreme peaking versus shoulder plant

ROAM recognises that generation developers presently are committing to the development of open cycle gas turbines in many regions of the NEM, despite the relatively high cost of capital and the current MPC being half of the MPC recommended by this report. ROAM considers that the generation being developed however fulfils a different role than the extreme peaking plant which is necessary to ensure the Reliability Standard is met, only operating a small number of hours per year. This 'shoulder' plant which is presently being developed does not rely solely from income derived through the wholesale electricity market, and are not being incentivised primarily by the MPC, but the level of contracting which underpin these developments.

For this assessment the MPC is calculated from a notional peaking generator which derives its income solely from the wholesale market, and operates only to avoid unserved energy, rather than providing energy in shoulder periods. The MPC is therefore determined to be the level of price that an independent, standalone generator would require to achieve a marginally profitable return for its investors.

Wihout such a class of generation, which has been previously filled by liquid fuelled, fast start generation, the market will progressively become less competitive and less likely to deliver the capacity to meet extreme events that the Reliability Standard is intended to insure against.

Demand Shape

The shape of the demand curve will also affect the expectation of the level of MPC required to meet the reliability standard. A more peaky demand profile will result in the increased occurrence of large magnitude, short duration USE events. These large magnitude USE events contribute significantly towards the total volume of USE in the market. However, although these large events of short duration increase the level of USE, they are not greatly beneficial to a peaking generator. Peaking generators would prefer smaller and more regular USE events to allow them to more frequently operate up to their maximum capacity, thus alleviating customer load shedding while minimising USE.

The forecast demand profile for the ten year outlook period has become more peaky across all regions in the last two years. As the following table shows, the difference in growth rates of energy and peak demand across all regions demonstrates the increasingly peaky nature of load forecasts.

Table 7.3 – 10-year Energy and Peak Demand Growth Rates[10]			
Region	**10-Year Energy Growth Rate**	**10% PoE Summer Peak Demand Growth Rate**	**Difference**
QLD	3.2%	3.6%	0.4%
NSW	1.5%	2.2%	0.7%
VIC	1.2%	2.2%	1.0%
SA	2.0%	2.0%	0.0%
TAS	1.1%	1.6%	0.5%

Another factor that may impact the reliability of the network in the future is the prevalence of intermittent renewable generation incentivised through external market stimuli such as government environmental policies, including the RET scheme. These generation technologies, particularly wind turbines, will exacerbate the peakiness of load as they may or may not be producing in peak periods and may therefore reduce the profitability of thermal generators.

Peaking Generator Availability

A further factor for peaking generation is its availability, or the proportion of time the generator is able to respond to high prices. If a proportion of price spikes is missed owing to generator failure, USE will increase, hampering the ability for those peaking generators to produce a profitable return and increasing the MPC necessary to achieve the Reliability Standard.

For this study, ROAM has modelled a 3% forced outage rate for extreme peaking generators, in line with the expected reliability of new entrant 'best practice' gas turbines[11].

The appendices to this report (Appendix A) provide more detail on the forced outage rates of peaking generators.

Summary of key factors impacting MPC

Due to the increase in the cost of generation, the decreasing value of money through time, the increase in the amount of intermittent generation, the forecast increase in peakiness of demand and the availability of peaking generators, the current reliability standard may not be met over the long term if the reliability settings remain unchanged.

[10] AEMO, Electricity Statement of Opportunities Executive Briefing, 2009

[11] As sourced from *Predicted Reliability, Availability, Maintainability for the General Electric 7H Gas Turbine*, GE Power Systems, (DOE Cooperative Agreement No: DE-FC21-95MC31176), Page 4.

7.4) *Effects of Changing the Reliability Standard*

The Reliability Panel has requested that ROAM consider the impact of a change to the Reliability Standard.

ROAM has performed a sensitivity to the RSSR scenario to assess the impact of a reduction of the MRL on the level of USE.

It is expected that such an analysis will reveal a non-linear trend in comparing the amount of capacity withdrawn and the increase in unserved energy. As more capacity is withdrawn from the system, the probability that this will result in unserved energy increases. For example, the first 100MW of withdrawn capacity will increase USE in those times in which excess capacity was less than 100MW. The next 100MW withdrawn would result in USE occurring when excess capacity was between 200MW and 100MW. Although this is the same magnitude of shortfall, the regularity with which it occurs would increase. Therefore, the increase in USE would be greater for the second capacity withdrawal.

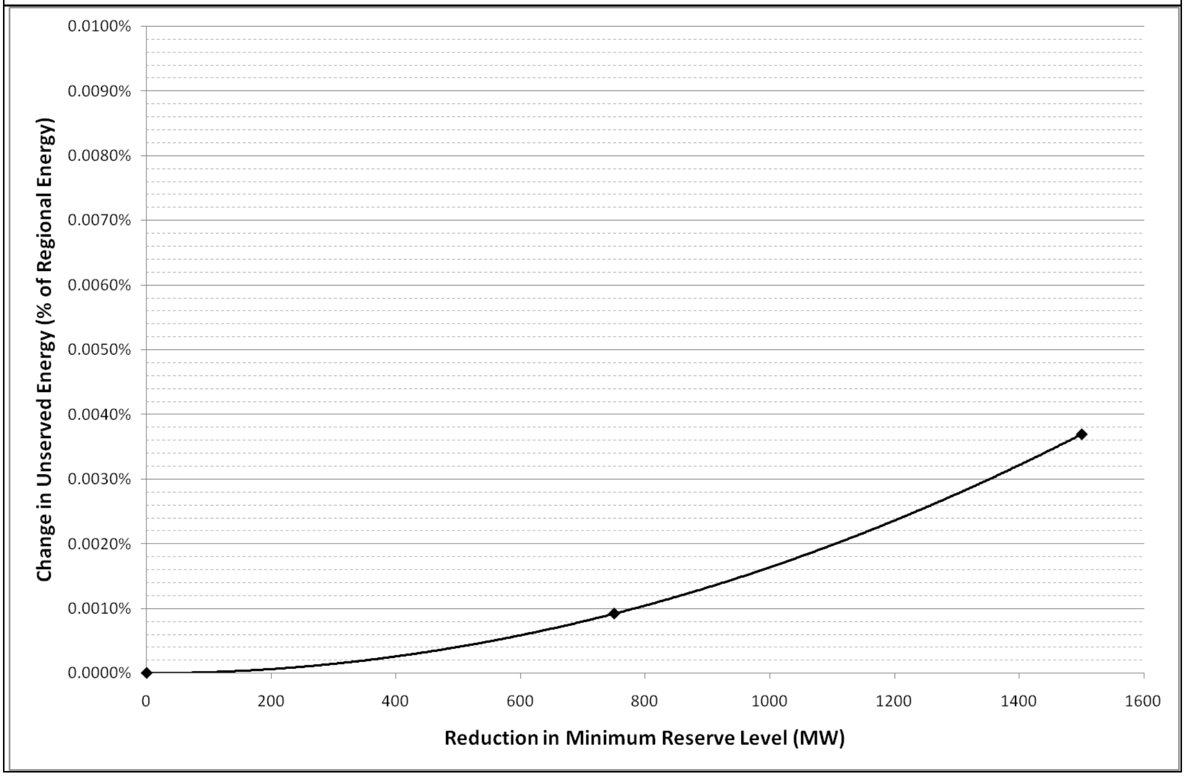
The following table shows where capacity was withdrawn in the two cases in 2012-2013:

Table 7.4 – Installed Capacity relative to Base Case (MW)

Region	-750MW Withdrawal	-1500MW Withdrawal
QLD	162	567
NSW	44	44
VIC	320	470
SA	224	414
NEM	**750**	**1495**

The following figure shows the non-linear relationship between the level of USE and the installed capacity. The figure shows that, for a 750MW reduction in installed capacity (or MRL), the level of USE would increase by approximately 0.001%. A reduction in capacity by 750MW would therefore result in a 50% change in USE, from 0.002% to 0.003%. Doubling the change in capacity to 1500MW would result in about four times the increase in USE.

Figure 7.8 – Changing the Reliability Standard – the impact of installed capacity on USE



7.5) THE CUMULATIVE PRICE THRESHOLD, FACTORS THAT CAUSE HIGH PRICES AND THE RELEVANCE OF GENERATOR BIDDING STRATEGIES FOR RELIABILITY MODELLING

Cumulative Price Threshold

The cumulative price threshold exists to limit the financial risk for market participants, particularly retailers, against the occurrence of extreme events which cause the spot price to remain at high levels for prolonged periods of time. The CPT should not influence the market at other times. CPT should provide some risk protection for retailers but not dampen price signals from the market.

The occurrence of sustained high prices is generally a result of an extreme event such as:

- Extended periods of high demand
- Transmission or generator outages
- Interruptions to fuel supply
- Prolonged periods of extreme weather.

The occurrence of prolonged periods of high prices is also affected by the mix of generation which exists within the market. For example, the addition of many peaking generators into the market may cause prices to remain at high levels for a longer period of time than would occur if baseload generation had been built.

High prices may be sustained for longer periods as a result of an increase in renewable generation. Greenhouse gas policies are expected to lead to a greater reliance on renewable generation technologies such as wind power. However, these generation technologies are more susceptible to events which may render them unavailable for long periods of time. A long heatwave without wind may eliminate price suppression otherwise provided by wind generators. As observed in recent years, prolonged drought has reduced the availability of hydro generators (and some wet-cooled thermal generators) which in turn raised the pool price for extended periods. As hydro generators are typically clustered, even localised water inflow reductions could result in a significant reduction in generator availability. Furthermore, the intermittency of wind farms and the increasing penetration of this technology could produce very high prices when wind speeds are low, although geographical diversity of wind development would minimise this risk.

Therefore it is probable that, in addition to those factors which would lead to sustained high prices listed above, the mix of generation technology can also have an effect on the likelihood of breaching the CPT.

The introduction of the CPRS will provide a further uplift in prices which will materially increase the likelihood of breaching the CPT if it is not increased. Since the CPT level from 2010-11 of $187,500 is equivalent to $558/MWh over a single week, a pool price increase in the range of $30/MWh - $40/MWh in 2012-2013 from the CPRS will inevitably increase the number of CPT breaches.

As ROAM's 2-4-C modelling is a time sequential half hourly forecast, ROAM can forecast the duration of time which is expected to breach the CPT. ROAM has noted that the CPT is presently set to be a multiple of fifteen times greater than the MPC. For this analysis, ROAM has assessed the effect of maintaining that ratio, with the MPC set at $20,000/MWh and the CPT set at $300,000. The following collection of statistics relate to the 50% PoE demand scenario for the 2012-2013 financial year.

Table 7.5 – Cumulative Price Threshold Statistics (50% Probability of Exceedence - 2012-2013)

Region	Average Number of Breaches per annum	Percentage of MPC periods where APC would be invoked
QLD	0.40	22%
NSW	0.28	15%
VIC	0.08	5%
SA	0.08	14%

Table 7.5 above shows that a total of 5 to 22% of all MPC periods are forecast to occur during an administered price period where the administered price cap ($300/MWh presently) would apply in the 50% PoE scenario. This is a potentially significant reduction in revenue which would be lost by extreme peaking generators if off-market compensation is not achieved.

ROAM has considered various multipliers in relation to the level of CPT above the MPC. ROAM's analysis has concluded that there is clear relationship between the two values, and any reduction in the multiplier would increase the number of MPC events affected by the administered price cap, which will impact on the profitability of peaking generators.

ROAM has not considered the effects that breaching the CPT may have on generator revenues when assessing the recommended MPC. As such, if compensation mechanisms[12] are not sufficient to recover sufficient revenues for extreme peaking generators to negate the effect of a CPT breach, it is likely that the MPC would need to be higher than that recommended to ensure that for those MPC periods not affected by the APC, sufficient revenues are earned to meet their revenue requirements.

Bid Optimisation Models

The bidding strategies used by generators in the NEM are of importance to the review of the efficiency with which the reliability settings achieve their targeted objective.

The most common model used when analysing the bidding behaviour of generators in electricity markets is the Cournot model which assumes that all generators are profit maximising Cournot players. In this model, generators compete with each other by using the quantity of electricity offered to achieve the highest possible revenue. An example of a Cournot bidding strategy would be if a large generator withdrew some of its capacity, or moved this capacity to higher price bid bands, with the objective of forcing generators which are higher in the merit order to set the price. The objective is therefore to increase the price to a level that outweighs the reduction in the level of generation that the generator supplies and therefore, maximise the product of output and pool price.

The use of a Cournot game in modelling generator bidding strategies has a number of complications. These factors undermine the assumptions of a Cournot model, particularly the assumption that all generators are operating with the same objective. The most prominent of these factors are:

- Generation technology
- Financial position
- Relationship with other generators (coalitions)
- Retail arrangements
- Risk tolerance.

[12] Generators are eligible for compensation if their resultant spot price or receivable revenue during an APP was less than the price specified in their dispatch offer or bid for that trading interval. These 'constrained-on' generators would be subject to a review by a three-member AEMO Expert Panel which would convene to determine what level of compensation is 'fair and reasonable' – which may be substantially less than the MPC if the Panel considers. Therefore, the correlation between CPT breaches and MPC periods is a material risk for extreme peaking generators which require a price at or near the MPC to be profitable.

These factors all influence the agenda with which each generator constructs their bids. For example, a generator owned by a company which also acts as a retailer may not wish to simply increase the price to the level which maximises its generation revenue if this causes a greater reduction in the profitability of its retail arm. Similarly, fully contracted generators have no incentive to influence price, as the contract price rather than the wholesale spot price will dictate the revenue they achieve. Any bidding optimisation model therefore should not include all generators as potential players in the game.

System Reliability Modelling and Generator Bidding

In the examination of reliability, the bidding strategy and interaction of generators at times when prices are low is of relatively little importance compared to those times when prices are high and the occurrence of USE is possible. However, at these times it is reasonable to assume that all generators are bidding all of their available generation capacity at a price that is at or below the MPC.

Analysis of bidding behaviour shows that the majority of generating capacity is offered at prices which are in a reasonably tight range around the level of short run marginal costs of generators. Only a small percentage of capacity is withheld to prices that are near the level of the MPC.

Given that the use of a Cournot model involves a large number of assumptions and that the bidding strategies of most generators are of little importance to the study of reliability, ROAM considers it appropriate to instead construct generator bids by using a bid analyser process[13]. This process models the bids of generators at different times based upon historical information with the objective to match observed outcomes as closely as possible. This strategy yields results which accurately model the real market behaviour for the majority of the time and ensures generators offer their available capacity into the market at or below the MPC. It therefore provides an appropriate method for modelling generator bids for this project.

Box 4 – System Reliability Modelling and Generator Bidding
The primary focus of the Reliability Settings are to ensure that, in the event of market failure, sufficient incentives exist in the market such that the capital, fixed and operating costs of peaking generators may be recovered such that capacity is installed to meet the Reliability Standard. ROAM has used historical generator bidding strategies for each of the existing generators modelled, and new entrant generators also adopt typical bidding strategies of their generation technology. The MPC should be determined by considering the 'market failure' case, where extreme peaking generators ***only*** operate at times of necessity. Although generators may increase their running hours by bidding and operating at a lower price than the MPC, the Reliability Settings should be evaluated against a withdrawal of this extreme peaking capacity to the cap. Determining the MPC by including increased operation through 'opportunistic bidding' may not provide sufficient incentive to enter for those generators unable or unwilling to operate in such a fashion. ROAM therefore considers the use of a static but realistic bidding module for all generators the most appropriate method for the RSSR assessment.

[13] The technique applied for this project has been to choose bids for every generator that minimise the sum of the squares of the difference between generator historical and forecast production throughout the year.

7.6) VARIABILITY OF USE

The following charts show the level of forecast variability in USE for each of the 25 Monte Carlo outage scenarios for the 50% and 10% PoE forecasts. In some outage scenarios, the USE will be zero, while for the same PoE demand, the USE may exceed the standard with alternate generator outage timings. The charts below demonstrate the forecast result for the 2012-2013 financial year for the RSSR Scenario.

Figure 7.9 – Variability of USE (10% PoE and 50% PoE Demand Profiles)

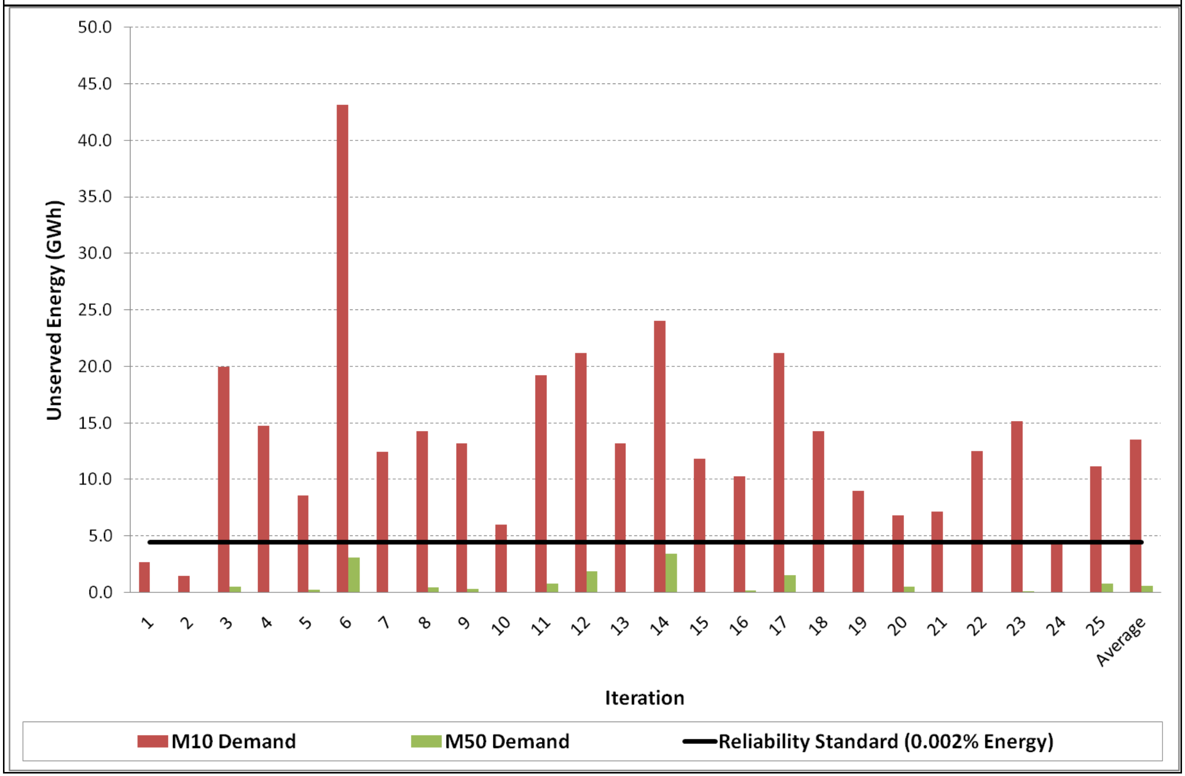
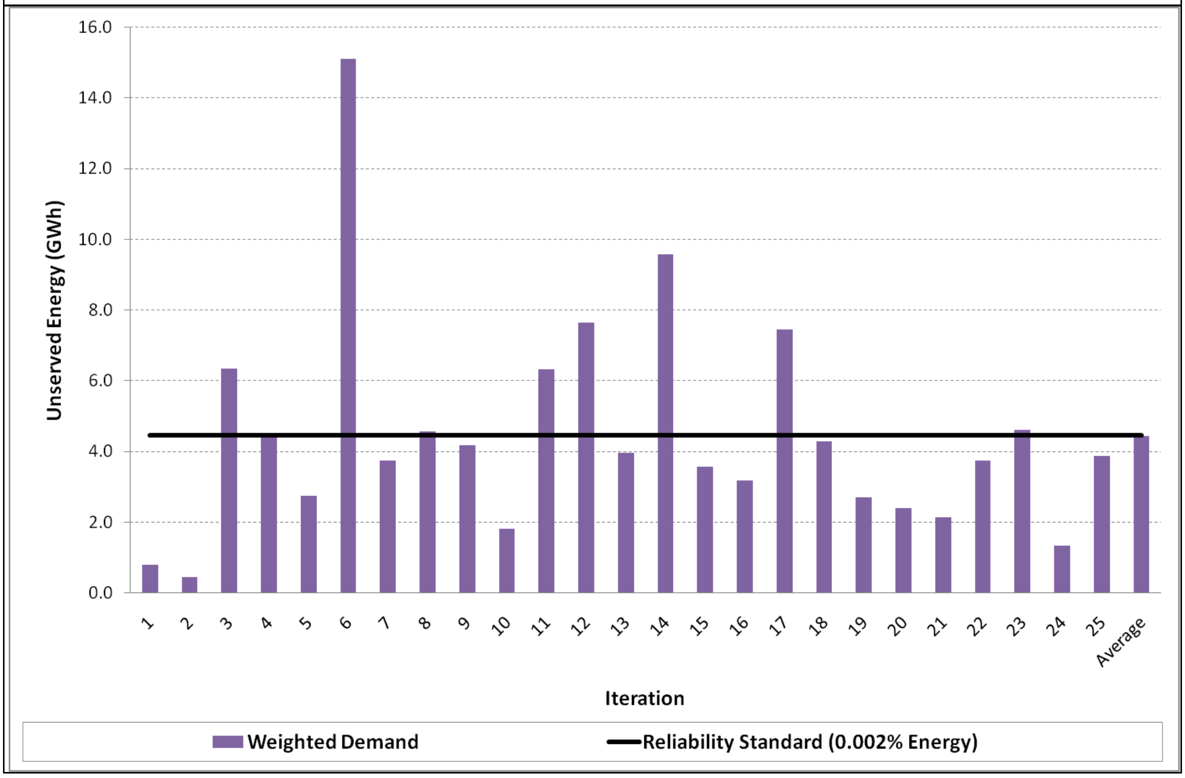


Figure 7.10 – Variability of USE (Weighted Average Demand)



7.7) *Risks Associated with Increasing the MPC*

Although ROAM considers that the change in MPC recommended by this report is necessary to ensure the continued achievement of the Reliability Standard, ROAM recognises that there are a number of risks associated with such an increase.

Risks on the Demand Side

There are significant risks which might be faced by energy customers due to the changes recommended within this report which need to be considered.

Firstly, by raising the MPC to $20,000 /MWh (or a gradual increase to the price cap) the risk of increased spot prices is increased. Although there exists significant competition in the NEM, and individual generators are unlikely to be capable of exerting market power, during periods of system stress where demand and network utilisation is high, the risk of opportunistic bidding practices being employed to artificially increase the spot price remains. By allowing the spot price to increase to the higher MPC, uncontracted retailers and customers are exposed to significant financial costs during these rare extreme price events.

The value of contracting is also likely to increase as loads seek to avoid this risk, driving up the competition for contracts. Furthermore, as the potential lost value to generators increases during periods of extreme price, the price for contracts will increase.

Concept Economics[14] has reported that changes to the MPC may increase the incentives for aggressive trading strategies by generators, which would serve to increase the spot price of energy.

ROAM has not considered the impact that the change in MPC may have on the level of demand side participation. This review has assumed that peaking capacity is the lowest cost option of avoiding unserved energy, however at the MPC recommended by this report some DSP may provide a lower cost alternative[15]. Increasing participation in demand side management may reduce the necessity for the MPC to be increased to the recommended level. On the other hand, such stimulation of DSP would still assist in delivering the Reliability Standard. Furthermore, the assumptions which NIEIR have used when developing the 2009 peak demand forecasts for AEMO (subsequently used in this report) may not hold true at a materially different price point such as the MPC level recommended in this report. The impact that the increased MPC may have on demand elasticity is beyond the scope of this report.

Risks on the Supply Side

The focus of this report has been to ensure that generators remain profitable in the long run in order to ensure sufficient generation capacity enters to maintain the Reliability Standard. However, material risks are presented to generators by the proposed increase in MPC.

The risk of generator failure during periods of MPC would result in significant financial loss if the generator supplies a contracted demand position. The increased magnitude associated with the risk of generator failure at peak times may reduce the willingness of generators to enter into capacity contracts with retailers and/or other customers.

The possibility of a breach of the CPT would significantly reduce the value associated with dispatch during these periods. While avenues exist for 'constrained on' generation to be compensated fairly during these periods, for baseload and intermediate generators there exists a significant gap between a 'fair compensation' level and the MPC. As such, for non peaking generation the breaching of the CPT could have a significant effect on the profitability of that plant which may discourage new entrant capacity for energy purposes.

Increased DSP would be a significant competitor to peaking capacity, as DSM is effectively 'dispatched' ahead of scheduled generators. If the MPC was to encourage significantly greater participation in DSM, this could materially impact upon generator profitability.

The risks associated with the demand and supply sides of the NEM must be carefully considered before reaching a final recommendation.

[14] Concept Economics, Risk Assessment of raising VOLL and the CPT, 13th October 2008

[15] The Victorian region of the NEM has identified a value of Customer Reliability up to $55,000/MWh in their Victorian Annual Planning Report, 2009.

7.8) *MARKET FLOOR PRICE*

The market floor price sets the minimum spot price in a region for a dispatch interval, and is presently set to -$1,000/MWh. The floor price is not related to the incentives provided by the MPC to ensure the Reliability Standard is met, however it, and the MPC, does define the price envelope for which the settlement of the wholesale pool is bound.

ROAM considers that there is no justification for recommending any change to the market floor price. The forecast introduction of the CPRS is expected to reduce the frequency at which the market price is set at the floor price, as generators incorporate the additional costs associated with carbon emissions into their bidding strategies.

8) DISCUSSION

ROAM has found that, for the years 2012-2013 and 2013-2014, an MPC of approximately $20,000/MWh is necessary to ensure sufficient incentive exists for the recovery of an investors required rate of return for an extreme peaking gas turbine while meeting the Reliability Standard of 0.002% USE.

If progressively increased, ROAM has found that the MPC may increase to $17,500/MWh in 2012-2013, increasing to $20,000/MWh in 2013-14.

Increasing capital costs of peaking capacity, increasing peakiness of load, the decreasing value of money and the increasing penetration of intermittent generators all have influenced the need for a higher MPC than that determined in the 2007 Comprehensive Reliability Review.

Appendix A) Modelling Assumptions

A.1) *Unserved Energy Pain Sharing*

In ROAM's modelling, USE is determined within the simulation model. The outcomes are then adjusted as a post process to account for the principle of 'pain sharing' in the NEM. This principle requires that where a supply shortfall exists in one region, the shortfall should be shared as far as interconnector capacity allows, in proportion to the respective regional demands[16].

Where spare transmission capacity is available during periods of unserved energy between Queensland and New South Wales, and separately between Victoria and South Australia, the distribution of unserved energy is shared between the two adjoining regions in relation to their demand magnitudes. ROAM considers this to be a reasonable approximation of the principles of pain sharing, and provides better accuracy than if the pain-sharing adjustment was not performed.

A.2) *Installed Capacity*

CRA Benchmark

ROAM has used the Minimum Reserve Levels as published in the 2007 NEMMCO SOO as a guide for the installation of new entrant capacity, which was developed to be consistent with the present Reliability Standard.

ROAM has installed sufficient capacity to meet the Minimum Reserve Levels in each region as a starting point for the simulations. The planting schedule was further refined from this point in order to ensure that the Reliability Standard was achieved but not exceeded.

RSSR Assessment

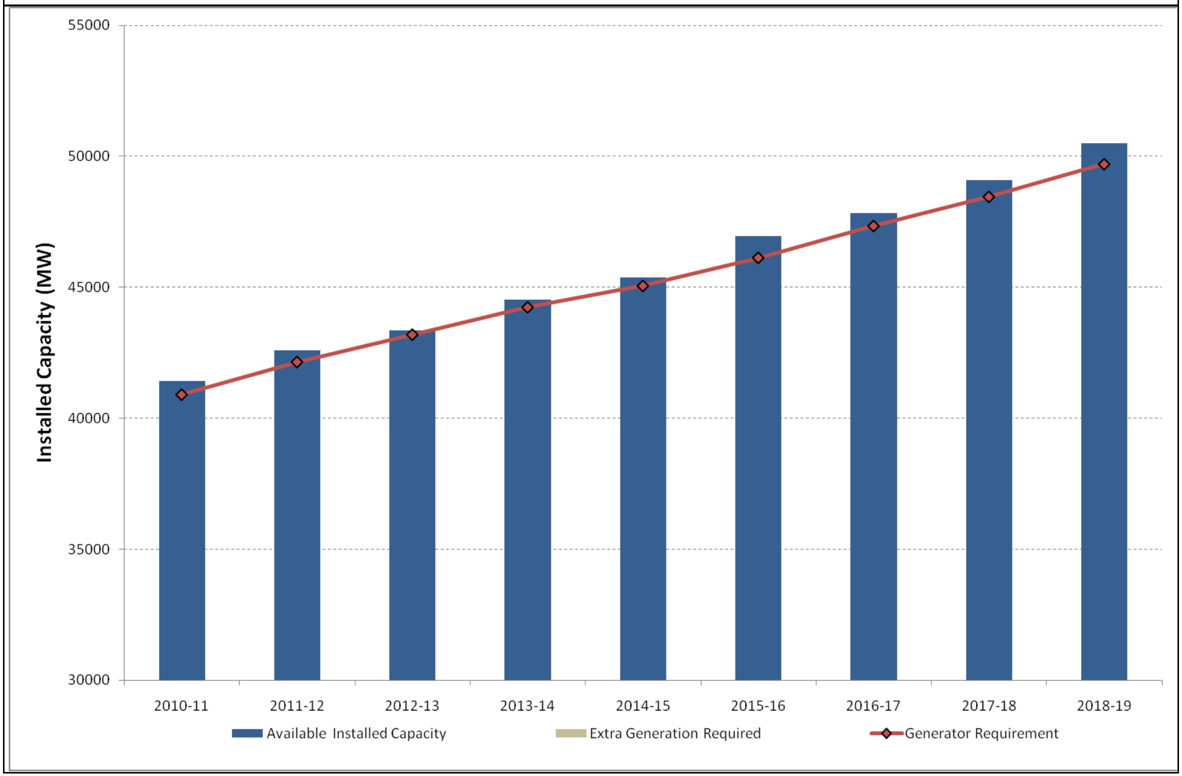
ROAM has used the Minimum Reserve Levels as published in the 2009 AEMO ESOO as a guide for the installation of new entrant capacity, which was developed to be consistent with the present Reliability Standard.

ROAM has installed sufficient capacity to meet the Minimum Reserve Levels in each region as a starting point for the simulations. The planting schedule was further refined from this point in order to ensure that the Reliability Standard was achieved but not exceeded.

The following figure demonstrates the level of installed capacity installed by ROAM for these studies across the NEM during the forecast period.

[16] NEMMCO, *Potential Drought Impacts on Electricity Supplies in the NEM: Final Report*, April 2007

Figure A.1 – Generation Installation schedule to 2018-19



A.3) *Renewable Energy*

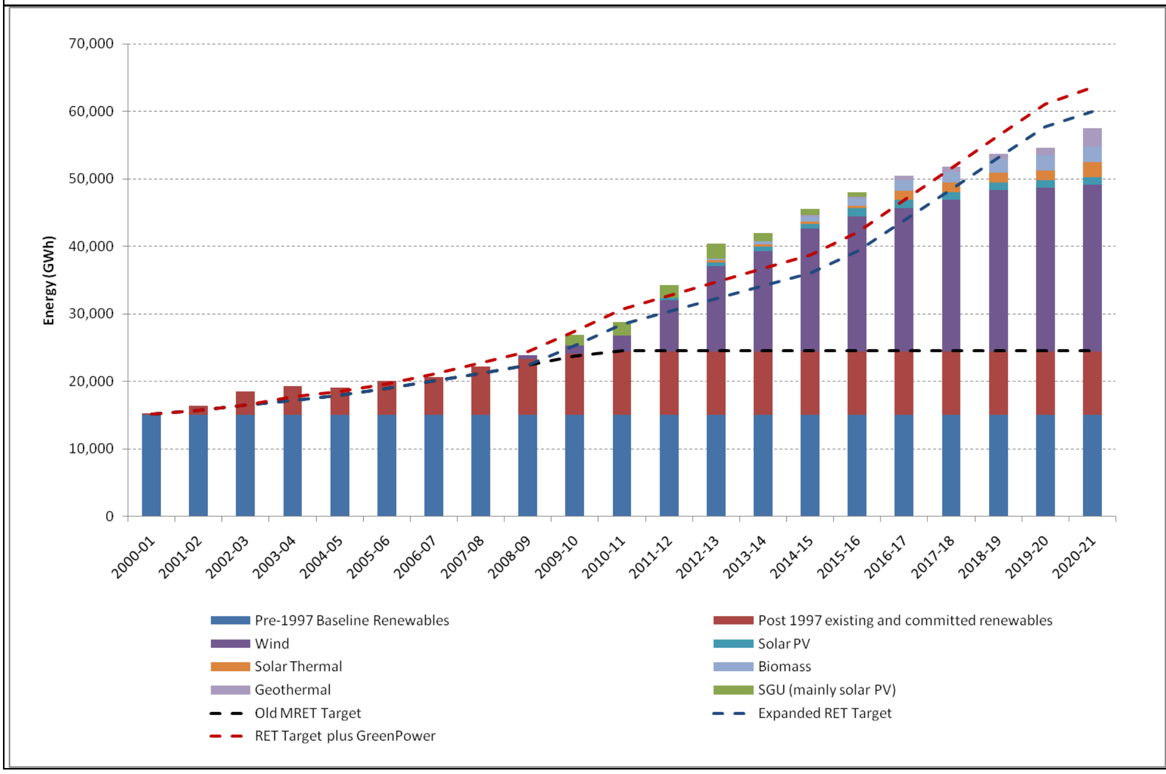
CRA Benchmark

In 2007 renewable generators were encouraged to meet the MRET scheme, which required an additional 9,500GWh of energy from renewable sources by 2010. To meet the target, little new entrant capacity was deemed necessary beyond those wind farms which are already installed and contribute to the scheme. As such, ROAM has not modelled any significant new entrant renewable generators in the CRA Benchmarking study.

RSSR Assessment

ROAM has installed sufficient new entrant renewable energy generators to meet the required RET targets of 20% by 2020 with a mild degree of certificate banking. This is in line with ROAM's internal October 2009 review of the mix of renewables to meet the RET.

Figure A.2 – Installation schedule for Renewable Generators to 2020-21



The contribution that renewable generators provide to serving peak demand varies depending upon the generation technology and location. The table below shows the contribution factors assumed for renewable generators, as compared to their annual capacity factor. The values for wind are those presently applied by AEMO in assessing the supply demand balance.

Table A.1 – Generator Contribution to Peak Demand / Capacity Factor

Generator Type	QLD	NSW	VIC	SA
Wind	0.0% / 30.1%	5.0% / 28.4%	8.0% / 29.3%	3.0% / 30.7%
Solar PV	50.0% / 20.0%	50.0% / 20.0%	50.0% / 20.0%	50.0% / 20.0%
Solar Thermal	50.0% / 20.0%	50.0% / 20.0%	50.0% / 20.0%	50.0% / 40.0%
Bagasse and Biomass	100.0% / 50.0%	100.0% / 75.0%	100.0% / 75.0%	100.0% / 75.0%
Geothermal	100.0% / 90.0%	100.0% / 90.0%	100.0% / 90.0%	100.0% / 90.0%

The capacity which may be relied upon for peak demand contribution is significant. To achieve the minimum reserve levels in each region, sufficient *reliable* capacity must be installed, which typically requires peaking plant to accompany intermittent renewable generators, particularly wind farms. However, these generators may contribute up to 100% of installed capacity in any one period, and therefore reliability may be improved due to low contribution factors presently adopted.

A.4) *Demand and Energy Assumptions*

CRA Benchmark

ROAM has used the 2007 NEMMCO Energy and Demand Projections to project energy and demand for the modelling period using the 2006-07 reference load trace as the basis for the half-hourly forecast load trace.

ROAM has modelled the following load profiles:

- Medium economic growth, 50% probability of exceedence peak demand (M50)
- Medium economic growth, 10% probability of exceedence peak demand (M10)

RSSR Assessment

ROAM has used the 2009 AEMO Energy and Demand Projections to project energy and demand for the modelling period using the 2008-09 reference load trace as the basis for the half-hourly forecast load trace.

ROAM has modelled the following load profiles:

- Medium economic growth, 50% probability of exceedence peak demand (M50)
- Medium economic growth, 10% probability of exceedence peak demand (M10)

ROAM has used the raw 2008-09 load traces as the basis for the half hourly load profile, configured to meet the targets of the 2009 SOO.

A.5) *Supply Side Assumptions*

CRA Benchmark

New Entrant Generation

To assess the ability for the MPC to deliver market outcomes in line with the Reliability Standard, ROAM has incorporated new entrant generators to meet load growth and to exploit market opportunities.

For the CRA Benchmark, ROAM has selected a new entrant peaking generator to respond to any shortfall in capacity in each region of the model. As peaking plant is likely to be most capable of developed in response to the MPC level adopted, it was deemed appropriate that only peaking plant be incorporated in the new entrant generation portfolio.

Renewable energy generators have been installed to meet the 9,500GWh MRET. This is achieved through existing wind farm capacity.

ROAM has used the new entrant generator costs contained within the ACIL Tasman 2007 report which was also used by CRA when modelling the CRR Appendix.

Network model

The NEM existed as a six-region network, consisting of Queensland, New South Wales, Victoria, South Australia and Tasmania. Tasmania is connected electrically to the mainland through the Basslink transmission link. The sixth region consisted of the Snowy Mountains Hydro Scheme generators and straddled the Victorian and New South Wales border.

ROAM has modelled the transmission network according to the thermal limitations of the inter-regional interconnectors. The following table shows the transmission capacity between regions in this model.

Table A.2 – 2007 Transmission Thermal Limits

Interconnector	Region A	Region B	Maximum Transfer Capacity A → B (MW)	Maximum Transfer Capacity B → A (MW)
QNI	NSW	QLD	589	1078
Terranora	NSW	QLD	105	234
SNO_NSW	SNO	NSW	3559	1150
VIC_SNO	VIC	SNO	1313	1842
Heywood	VIC	SA	460	300
Murraylink	VIC	SA	220	214
Basslink	TAS	VIC	600	480

The adoption of the transmission model as described above is in line with the transmission methodology used by CRA in their modelling.

RSSR Assessment

New Entrant Generation

To assess the ability for the MPC to deliver market outcomes in line with the Reliability Standard, ROAM has incorporated new entrant generators to meet load growth and to exploit market opportunities.

ROAM has selected an appropriate generator from the portfolio of committed, advanced and announced projects when adding new entrant generators. New entrant timings have been determined by the objective of the study – installing new entrant generators only where there is a need for increased capacity to meet the Reliability Standard.

Renewable energy generators have been installed to meet the 20% Renewable Energy Target.

ROAM has used the new entrant generator costs contained within the ACIL Tasman 2009 report which was an appendix to the NTS report.

Transmission

The transmission model has been applied as per the 2009 NTS constraints 'workbook' provided by AEMO. This incorporates all intra- and inter-regional transmission constraints.

The Prophet function "region reserve based on flows" is not available in the 2-4-C model. That function is used only to select between the constraint sets V>>V_NIL_1A and V>>V_NIL_1D. As such the V>>V_NIL_1D constraint set will be applied always, which assumes that run-back schemes are enabled allowing for a higher import into the Victorian region.

Generator Technical and Bidding Assumptions

ROAM has used the 2009 ACIL Tasman report and the 2009 ESOO as sources for the generator assumptions in the RSSR modelling. This includes critical variables including:

- Generator Availability
- Capital and Operating Costs

The majority of technical information provided in the NTS consultation is sufficient for the RSSR modelling. A few points of clarification follow:

- Full and partial forced outage rates – these have been checked by ROAM and converted to a format compatible with 2-4-C.
- Bids – ROAM has used bids based on observed trading behaviour in the 2008/09 financial year.
- Unavailability – AEMO noted that some plants, particularly in Queensland, are quite unreliable. Also maintenance on coal plants is being deferred due to uncertainty concerning the CPRS targets, start date, ESAS compensation etc. ROAM has ensured consistency with the AEMO MRL studies in this respect.

ROAM has assumed that generators will arrange their planned maintenance periods outside of those periods at risk of unserved energy, and therefore will not influence the outcome of this reliability assessment.

Forced Outage Rates for New Entrant Capacity

The following generator availability data, as sourced from the 2009 Annual National Transmission Statement Consultation Report, has been used for the modelling:

Table A.3 – 2009 Generator Availability and Outage Rates				
Generator Type	**Forced Outage Rate (FOR)**	**Partial Forced Outage Rate (PFOR)**	**Partial Derating**	**Equivalent Forced Outage Rate (EFOR)**
Black Coal	2.64%	5.81%	20.77%	3.84%
Brown Coal	3.25%	14.13%	7.82%	4.36%
CCGT	4.24%	0.67%	57.24%	4.63%
OCGT	27.88%	0.00%	0.00%	27.88%
Gas (Other)	2.14%	2.15%	13.33%	2.43%
Hydro	3.54%	2.88%	31.17%	4.44%

ROAM has modelled all new entrant generators with the forced outage rates listed above. That is, for the new entrant peaking plant the FOR applicable is approximately 28%, in line with the data provided by the NTS Consultation report and gathered by the FODWG.

The MPC has been calculated through analysis of an extreme peaking generator which is considered 'best in class' and has an availability in line with world's best practice of 97%[17]. This has been managed by changing the forced outage rate of one of the modelled generators from approximately 28% to 3%.

ROAM considers this the most appropriate method to model the new entrant peaking generators. By specifying a peaking generator in each region as the 'best in class' generator for which the MPC is calculated, ROAM has maintained the historical availability of peaking generators while allowing the MPC to be set by a world's best practice availability. As the extreme peaker has only very few hours in which it expects to operate, it has a far greater incentive to be able to respond to price signals when called upon, and therefore it is considered appropriate to factor a significantly higher availability for these notional generators than what is assumed for other peaking plant which may operate in a more 'shoulder' strategy, operating to defend contract positions or at times of high (rather than extreme) price.

ROAM notes that less than half of all new entrant capacity is peaking capacity, with a significant capacity of combined cycle and renewable generation also included in the build programme.

Further discussion regarding the gathering and application of Forced Outage Rate data is provided in Appendix B.

[17] As sourced from *Predicted Reliability, Availability, Maintainability for the General Electric 7H Gas Turbine*, GE Power Systems, (DOE Cooperative Agreement No: DE-FC21-95MC31176), Page 4.

Electricity Sector Adjustment Scheme (ESAS)

The ESAS compensation scheme is designed to aid the transition to a lower emissions electricity sector through financial compensation for existing generators.

The ESAS will provide a fixed administrative allocation of permits to generators over five years (delivering around $3.8 billion of assistance in nominal terms, based on estimated carbon prices under a 5 per cent reduction in emissions from 2000 levels by 2020).

Assistance will be available to coal-fired generators that have an emissions intensity above 0.86 tonnes of CO2-e per megawatt hour generated, and that were in operation, or committed to be constructed, on 3 June 2007. Assistance will be allocated to individual generators on the basis of historical energy output and emissions intensity data. This approach targets assistance to those generators that are most likely to be heavily impacted, whilst maintaining their incentive to reduce emissions in response to the carbon price.

ROAM has not considered the effects of ESAS when determining the value of the MPC. The ESAS is intended to only support those existing coal fired generators which will be significantly impacted by the introduction of the proposed CPRS. As the MPC is determined by analysis of the marginal peaking generator, the impact that ESAS may have on the profitability of existing baseload and intermediate generators is immaterial.

Continued availability of existing capacity

The ESAS is conditional upon existing generators continuing to make their capacity available for dispatch when necessary to maintain secure energy supplies. ROAM has not considered any forced retirement of existing generators beyond those committed in the 2009 ESOO. As such, the simulations assume that existing capacity will continue to operate using CPRS-affected historical trends and no retirements will occur during the forecast period.

If retirements of existing coal fired generators was to eventuate, it is likely that this capacity and energy would be replaced by lower emissions gas fired combined cycle plant. Although this would have no net change on the available capacity, combined cycle plant have a higher equivalent forced outage rate than coal fired plant (as shown in Table A.3 above) and therefore the forced outage rate of the portfolio of generators would degrade.

ROAM has not considered the deterioration of the availability of generators as part of this assessment, consistent with the assumption that no plant beyond those committed in the 2009 ESOO will retire during the forecast period.

Generation Financial Assumptions

The following generator financial data has been used for all new entrant peaking generators for the CRA Benchmark studies and the RSSR Assessment:

Table A.4 – Generator Financial Assumptions (Real $2009)				
Simulation Set	**Economic Life (Yrs)**	**Thermal Efficiency (S-O HHV)**	**Fixed O&M ($/kW/annum)**	**Variable O&M ($/MWh)**
CRA Benchmark	30	32%	13.00	7.70
RSSR Assessment	30	31%	7.50	7.50

ROAM has used the following generator capital costs for each assessment:

Table A.5 – Capital Cost of OCGTs ($/kW)									
	2010-11	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**
2007 Data ($2007)	710	706	703	699	696	692	689	686	682
2009 Data ($2009)	918	916	900	888	886	883	880	876	873

ROAM has used the following WACCs in each assessment:

- CRA Benchmark
  - ROAM has used a real WACC of 6.58%, equivalent to the 2007 ACIL Tasman recommended WACC for post-tax real cash flows.
- RSSR Assessment
  - ROAM has used a real WACC of 6.82%, equivalent to the 2009 ACIL Tasman recommended WACC for post-tax real cash flows.

ROAM has used the 2007 and 2009 ACIL Tasman reported fuel costs and capital costs for the CRA benchmark and RSSR assessment respectively.

Nominal vs Real

ROAM has constructed the bidding strategies used by generators by analysing real cost data. Consequently, the generator bidding, and therefore the spot prices which result are modelled in real $2009. As such, the price which the marginal peaking generator achieves is the MPC, which the model values in real terms, inconsistent with the current MPC definition.

As the MPC is a nominal value in the NEM, a number of adjustments had to be made so that the revenues of the MPC generator in each region were consistent with a nominal MPC. To do this, the revenues in each year were discounted using a real WACC given that the revenues are real cash flows. This gives the net present value for a full year of each generator's revenue at the start of each year. However, a further discount was applied so that these revenues reflect the revenue that the generator would earn given that the MPC is in fact a nominal value. Therefore, the revenues had to be discounted back to 2009/10 at a rate of 2.5% per annum, consistent with average inflation levels. For an MPC generator, this process gives the real $2009 revenue for the generator using a nominal MPC. The reduction due to inflation essentially models the real $2009 revenue of the marginal generator at a nominal MPC in a given year.

Appendix B) Modelling Generator Forced Outage Rates

B.1) *Introduction*

The CASOM 16: ARE RELIABILITY MEASURES UNRELIABLE? PART 1, By Robert R. Richwine, Reliability Management Consultant paper provides an excellent summary of the many ways in which generator forced outage rates can be specified. It is in the interest of turbine manufacturers to defend a low forced outage rate, however the commercial and observed behaviour should ideally be taken into account. But what is the purpose of collecting and collating generator availability statistics if not to model them?

In modelling the overall reliability of an electricity system one of the key drivers for the reserve level (or margin) requirement is the reliability of generators. To appropriately model the reliability of generators there must be a clear definition of the way in which forced outage statistics are collected and collated and the way in which they are subsequently applied in the modelling software.

B.2) *Collection of Generator Forced Outage Rates in the NEM*

In April 2005, NEMMCO formed the Forced Outage Data Working Group (FODWG). The FODWG was specifically tasked with developing a recommendation for the collection and treatment of generator forced outage data for application in modelling the reliability of generators in the NEM system. The working group engaged ROAM to:

- collect detailed forced outage data from participants; and
- undertake a statistical analysis of the data to identify any issues with data quality, provide proposals regarding how these issues should be resolved and review NEMMCO's (now part of AEMO) methodology for the calculation of forced outage statistics.

An outworking of the FODWG was the development of the "Guidebook for Forced Outage Data Recording: Definitions and Assumptions, 16 Nov 2009 (filename: 0240-0003.pdf)". The guidebook provides an outline of:

- AEMO's requirements regarding the collection of generator forced outage data;
- AEMO's data collection process; and
- the definitions assumed by AEMO.

The guidebook details the calculation of generator forced outage rates which are in line with the NERC GADS Forced Outage Rate (FOR) statistic, which takes committed hours and outage hours into account. The quality of the data remains dependent on the power stations operators tasked with populating the forced outage data collection template. The guidebook does attempt to account for known issues relating to calculated FOR's, one of the most pronounced is the forced outage hours of extreme peaking generators. Note 2 of the following extract from the guidebook clearly illustrates such guidance.

7.9 Full Forced Outage Hours Committed State [FFOH (Committed State)]
The number of hours of Full Forced Outage from the Committed State (CS).
Note1: *Do not include Full Forced Outage hours due to failed starts as a Full Forced Outage from the Committed State.*
Note2: *For low utilisation units (for example, peaking gas turbines) or units in the Available, But Not Committed State, forced outages may be deliberately extended for market/commercial reasons. This can give rise to significant forced outage hours when in fact no effort was made to repair the unit. In such instances the forced outage hours may be time adjusted so that units' time to repair" for peak demand periods is not overestimated.*

B.3) *Application of Generator Forced Outage Rates in Modelling*

The Richwine paper discusses the calculation of the Forced Outage Factor (FOF) compared with the FOR. The key difference is the denominator of the calculation where the FOF denominator is total hours in the observation period, whilst in the FOR it is only running (service) hours and outage hours. An outworking of these calculation procedures is that FOR approaches FOF as the number of running hours increases. For low capacity factor plant the converse is true. The "Predicted Reliability, Availability, Maintainability For The General Electric 7H Gas Turbine, Submitted by: GE Power Systems, Schenectady, NY 12345" illustrates that for extreme peaking generators a FOF of 2-3% is equivalent to a FOR of around 30% for generators with an average age of 15 years. The GE paper suggests that OCGTs are much more reliable and compares them with CCGT plant with capacity factors in the order of 50%. In that case the CCGTs have an FOF of 1-2% with the FOR being only around double at 2-4%.

The data collection, collation and calculation of generator FOR statistics for the NEM depends on generator running hours. There must therefore be a reasonable link between the application of generator running hours in the simulation model, compared with the observed plant running hours on which the statistics were calculated.

In reliability modelling generator dispatch should ideally reflect the typical operating state of the system for a number of reasons. The application of generator FORs has been discussed however there may be other flow on effects such as modelling the capability of the transmission network through a constraint equation model which depends on typical generator behaviour.

B.4) *Applying FORs in the Simulation Model*

The simulation model should apply generator FORs as they have been specified. Calculation of generator FORs in the NEM effectively reflects the time that a generator is not available when it ought to have been available; when it wanted to run. The FOR can then effectively be applied to the entire time sequential simulation period without bias. In its application of the NEM based generator FOR the simulation model should continually schedule the availability of each generator whether it has been dispatched or not. The operation of the generator will then depend on its availability first, and then the market conditions.

B.5) *Modelling New Entry Generators*

Care should be taken in the application of generator FORs with new entry generators. New generators may well perform significantly better than ageing generators, however care should be taken when estimating the expected availability of new generators with respect to their expected operating behaviour. An extreme peaking generator which is expected to operate for only a few hours per annum may still suffer a much higher FOR, compared with a generator of the same technology but which operates for 50% of the year.