ROAM CONSULTING

Reliability Standard and Settings Review

ROAM Consulting Modelling Outcomes

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4 December 2013

Overview of Presentation

- Introduction to ROAM’s role in supporting the Reliability Panel in their review.
- Description of the modelling methodology applied in this review.
- Presentation and analysis of ROAM’s modelling outcomes.

INTRODUCTION TO THE REVIEW

- Overview of the Reliability Standard and Settings
- ROAM's role in this review
- Outline of the modelling scope

The Reliability Standard and Settings

- **The Reliability Standard**
  - The level of unserved energy (USE) should not exceed 0.002% of annual energy consumption in each region.

- **The Reliability Settings**
  - The Market Price Cap (MPC), which sets the maximum wholesale market spot price which can apply in any dispatch interval.
    - $13,100/MWh (indexed to CPI)
  - The Market Floor Price (MFP), which sets the minimum wholesale market spot price which can apply in any dispatch interval.
    - -$1,000/MWh (nominal)
  - The Cumulative Price Threshold (CPT) is a threshold which applies to the sum of the trading interval spot prices over a rolling seven day period. If this threshold is exceeded, the Administered Price Cap (APC) is applied to spot prices.
    - $197,100 (indexed to CPI) ≈ 15 x MPC

ROAM's Role in this Review

- ROAM has been engaged by the AEMC on behalf of the Reliability Panel to conduct quantitative modelling to support a review of the reliability standard and settings.
- ROAM has not been asked to provide a recommendation on the level of these settings.
  - The Panel has not yet reached any conclusions.
- ROAM also provides quantitative and qualitative analysis on a range of issues relating to the non-reliability impacts of the reliability settings.

Scope of Modelling

- **Stage 1:** To determine the MPC required to allow new entrant OCGT to profitably operate in market which achieves the reliability standard.
- **Stage 2:** A forecast of the level of reliability in a market which continues to operate with the existing reliability settings.
- **Stage 3:** To investigate the suitability of the existing reliability standard.
- **Stage 4:** A review of the value of the market floor price.
- **Stage 5:** Forecast modelling and historical analysis to explore the impact of the reliability settings in the NEM.

STAGE 1: MPC CALCULATION

- Outline of the approach applied in this modelling
    - How this approach differs from that applied in the previous review
- Critical input assumptions which influence the results of this modelling
- Description and analysis of modelling outcomes

Approaches to MPC Assessment

- 2010 RSSR used extreme peaker approach.
- 2014 RSSR uses improved cap defender approach.
  - Extreme peaker is provided for benchmarking and comparison.
- Both approaches based on a market with approximately 0.002% USE.

Critical Point

- The objective of Stage 1 is **not** to forecast the MPC that will result in 0.002% USE.
- The objective is to determine the MPC required such that if the reliability standard will be breached, that a new entrant, merchant peaking generator would be incentivised to enter the market.

Market with 0.002% expected USE

	Queensland	New South Wales	Victoria	South Australia
Thermal Capacity Withdrawn (MW)	–1,316	–3,796	–2,784	–706
Additional Renewable Capacity (MW)	225	1,443	1,237	603

2016-17

Modelling Features

- Five historical years of reference data are used to create demand and renewable generation traces.
- 125 Monte Carlo iterations of both the 10% and 50% P.O.E. scenarios.
- Dynamic portfolio based bidding approach.
- Half-hourly (trading interval) modelling.
- 1 MW size for new entrants – representative of marginal MW of capacity investment.

Cap Defender Approach

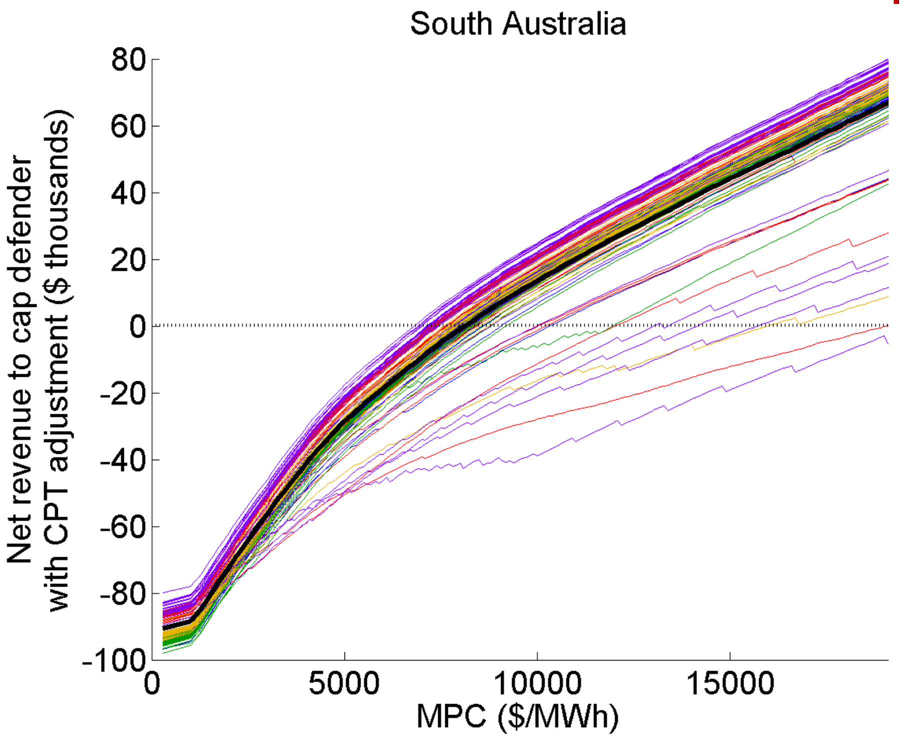
Net revenue = Pool revenue net SRMC

– Fixed costs

+ Contract value

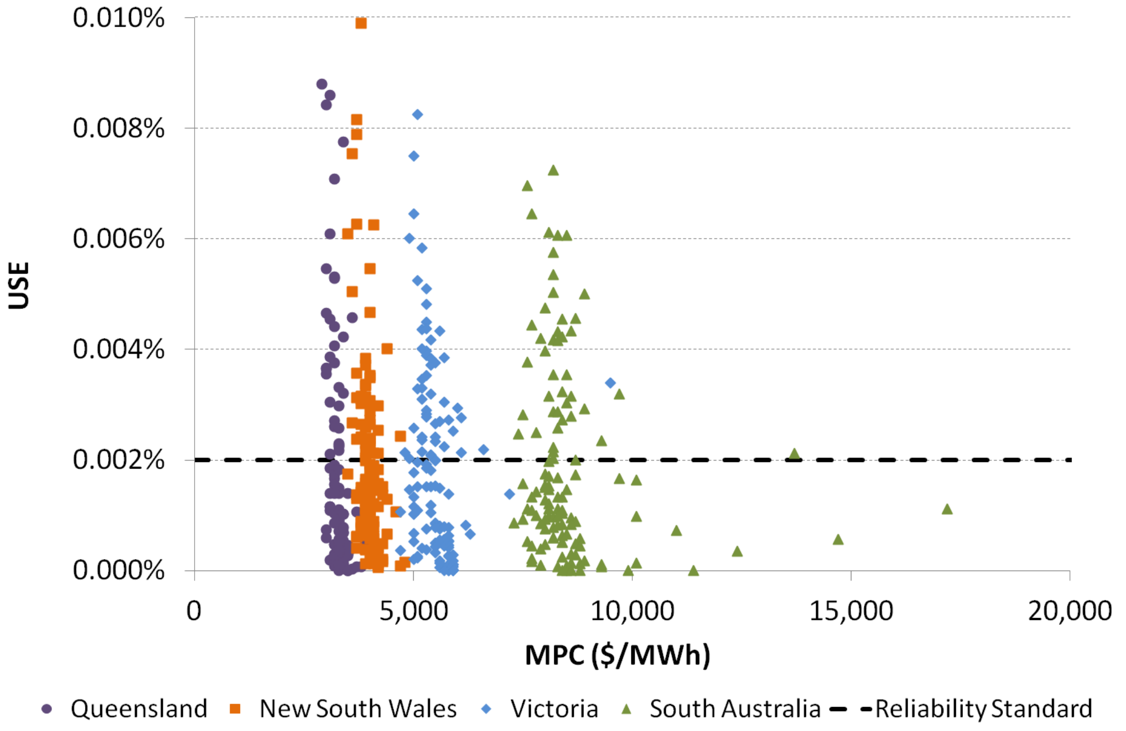
– Contract settlement

- Each iteration has:
  - a USE outcome
  - an MPC at which the cap defender recovers costs and a required rate of return (net revenue = 0)

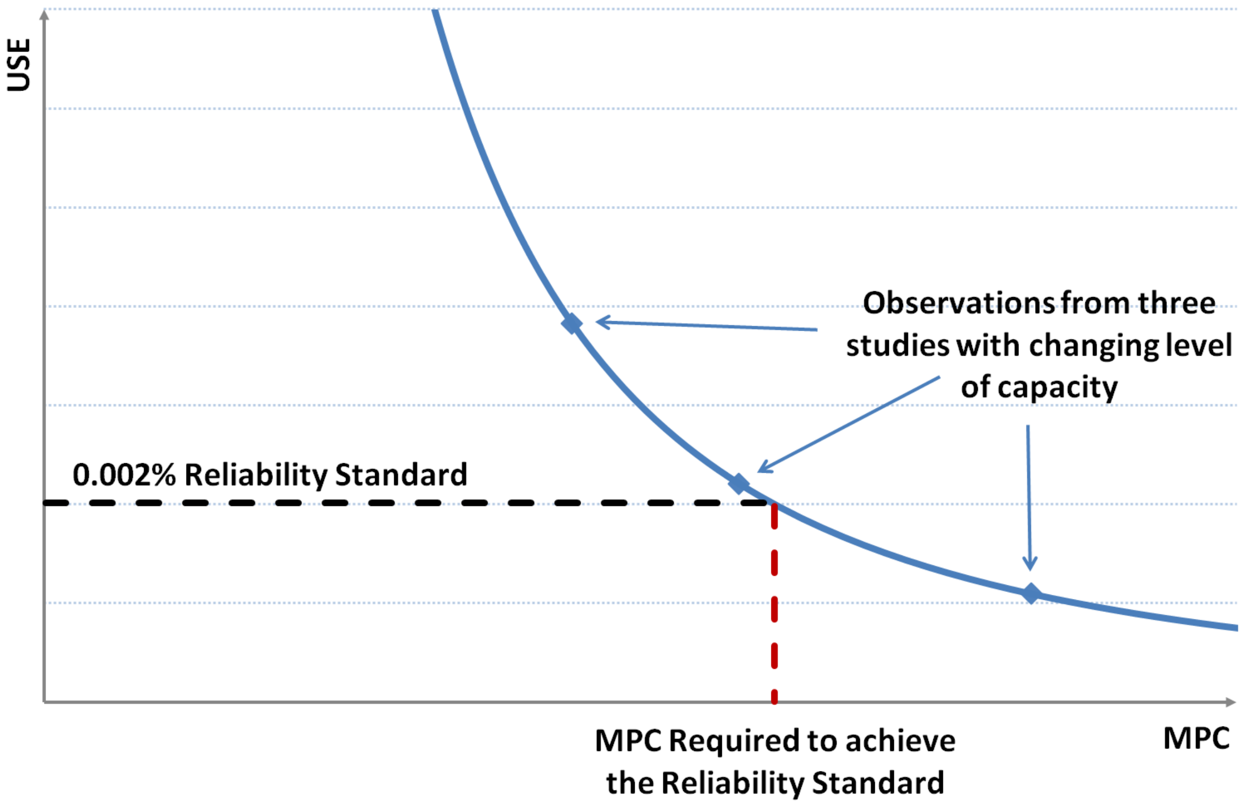


Cap Defender USE-MPC by Iteration

- Contract revenue constant between iterations.
- Contract revenue driven by expected USE across iterations.
- Look for MPC at which *average* net revenue is zero.



Cap Defender Approach



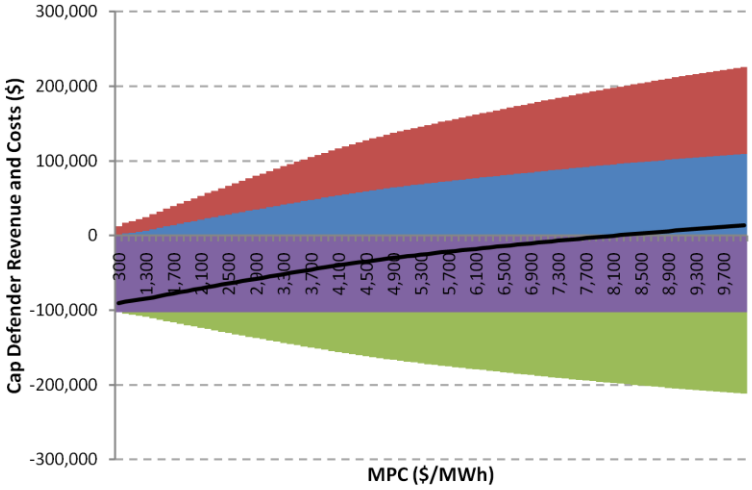
Cap Defender Contracting Level

$$\text{Net revenue} = \begin{matrix}\text{Pool revenue}\\ \text{net SRMC}\end{matrix} + \begin{matrix}\text{Contract}\\ \text{value}\end{matrix} - \begin{matrix}\text{Contract}\\ \text{settlement}\end{matrix} - \begin{matrix}\text{Fixed}\\ \text{costs}\end{matrix}$$

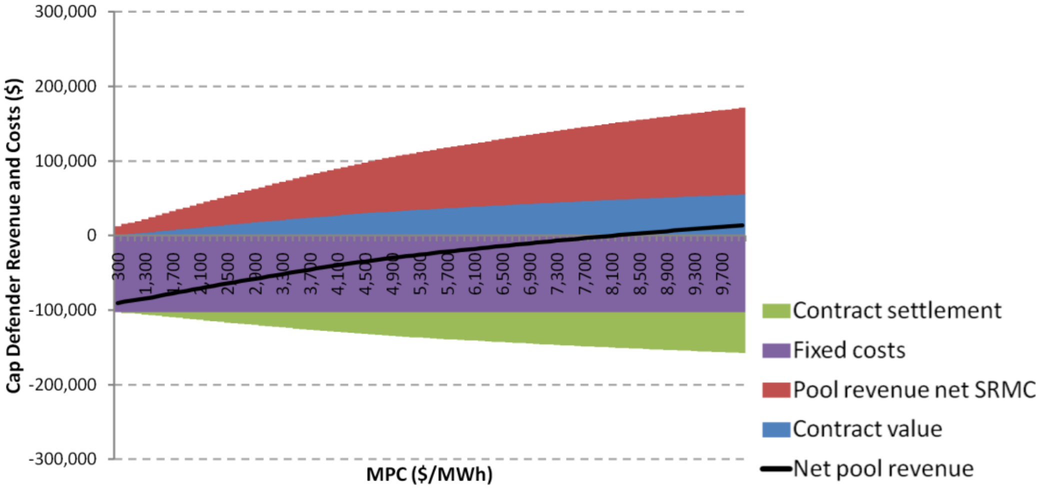
Contract value = Expected contract settlement for a fair-valued contract

Average over iterations

100% contracted



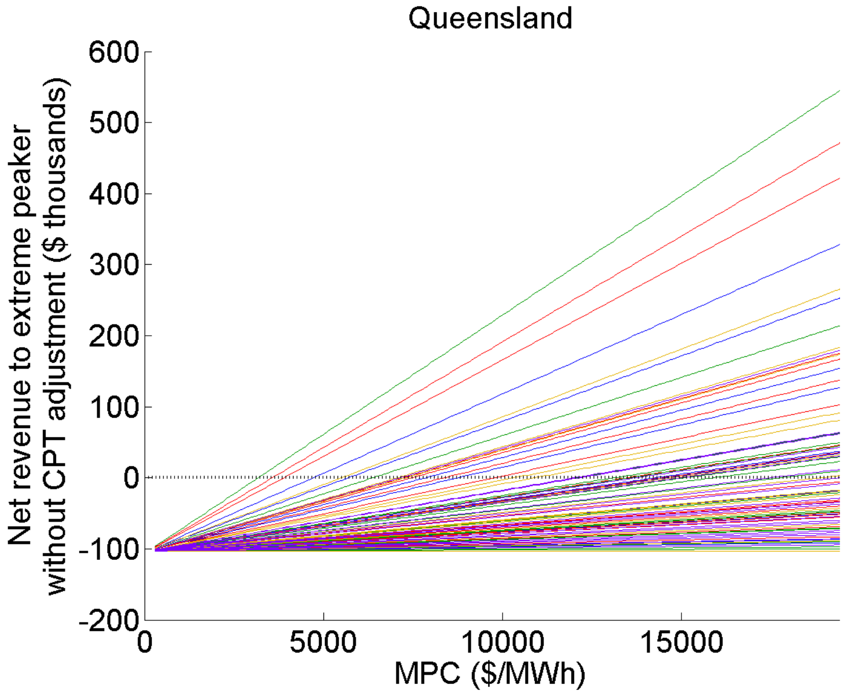
50% contracted



Extreme Peaker Approach

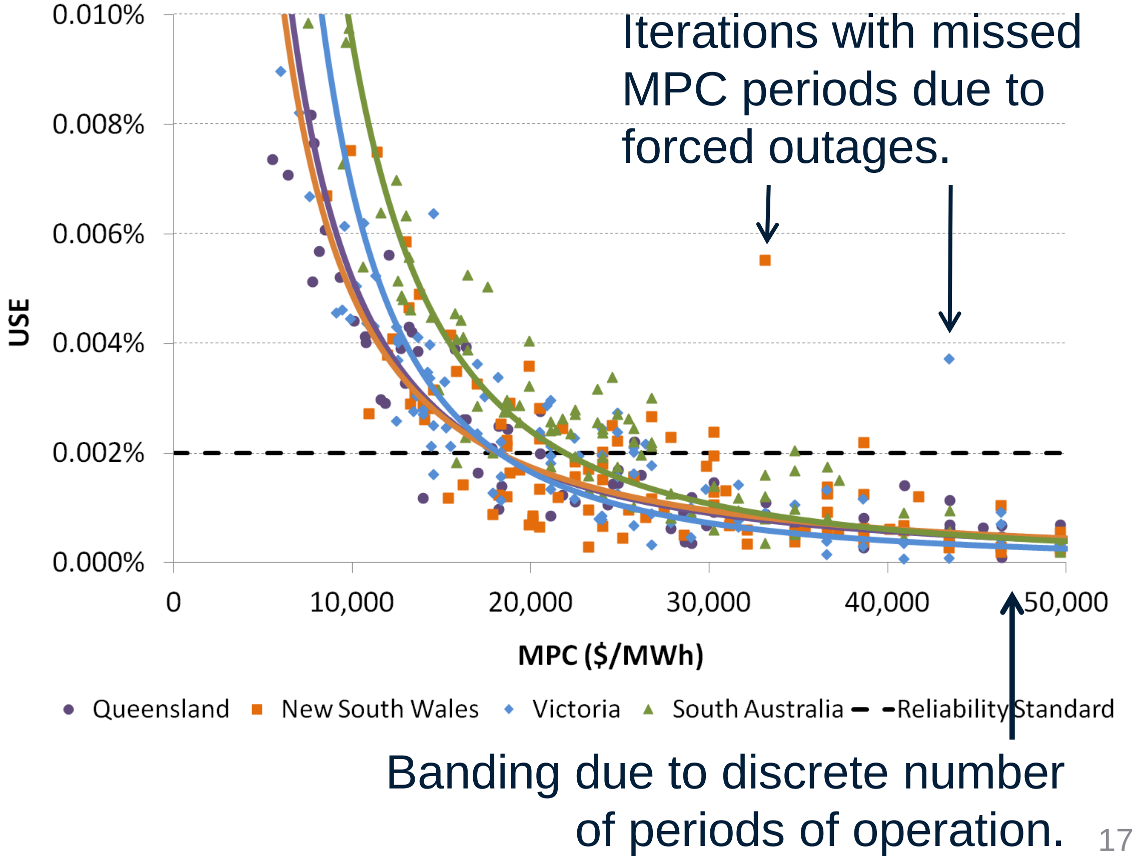
Net revenue = Pool revenue net SRMC – Fixed costs

- Each iteration has:
  - a USE outcome (%)
  - an MPC at which the extreme peaker recovers costs and a required rate of return (net revenue = 0)



Extreme Peaker USE-MPC by Iteration

- Plot all iterations.
- Fit power function.
- Determine MPC at which USE is exactly at reliability standard.



Comparison of Approaches

Cap defender	Extreme peaker
Operates when price exceeds $300/MWh	Operates when USE occurs (or would occur if the EP was not present)
Net revenue = Pool revenue net SRMC – Fixed costs + Contract value – Contract settlement	Net revenue = Pool revenue net SRMC – Fixed costs
Analysis based on USE and net revenue outcomes averaged over iterations	Analysis based on USE and net revenue in each individual iteration
CPT is applied	CPT is not applied

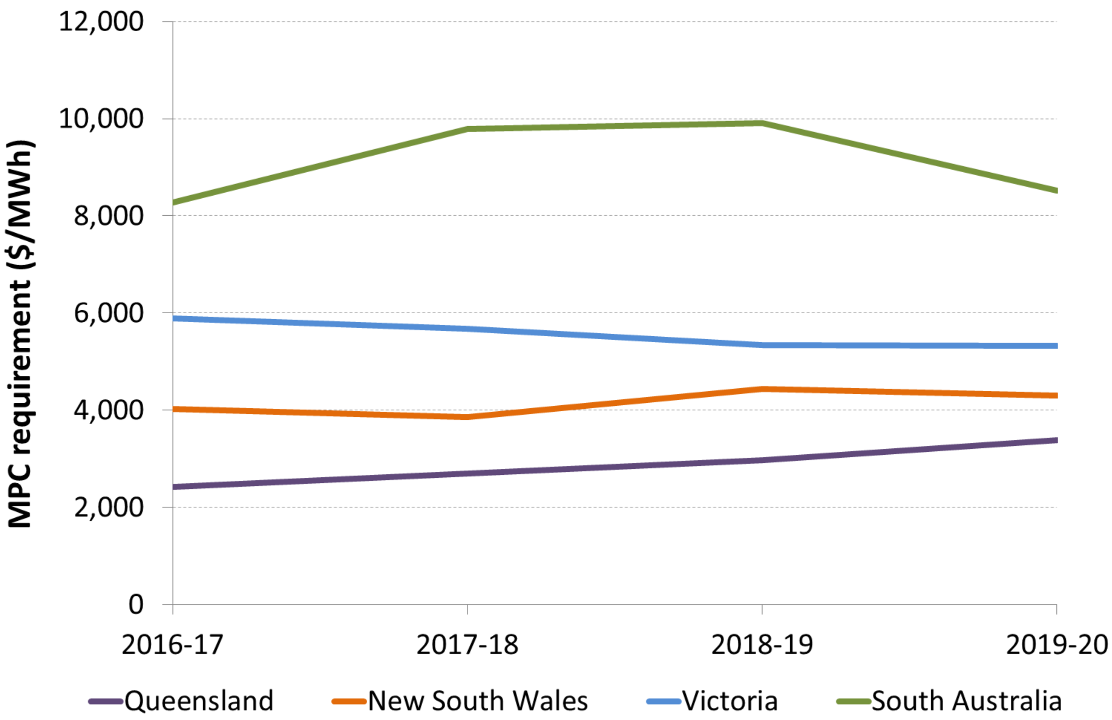
Purpose of the Two Approaches

- The cap defender is the preferred approach for this review as it includes consideration of market factors which influence the drivers of generation investment in the NEM.
- The extreme peaker provides a benchmark of the 2010 review and as a theoretical upper bound for the MPC requirement.

Stage 1: Sensitivities

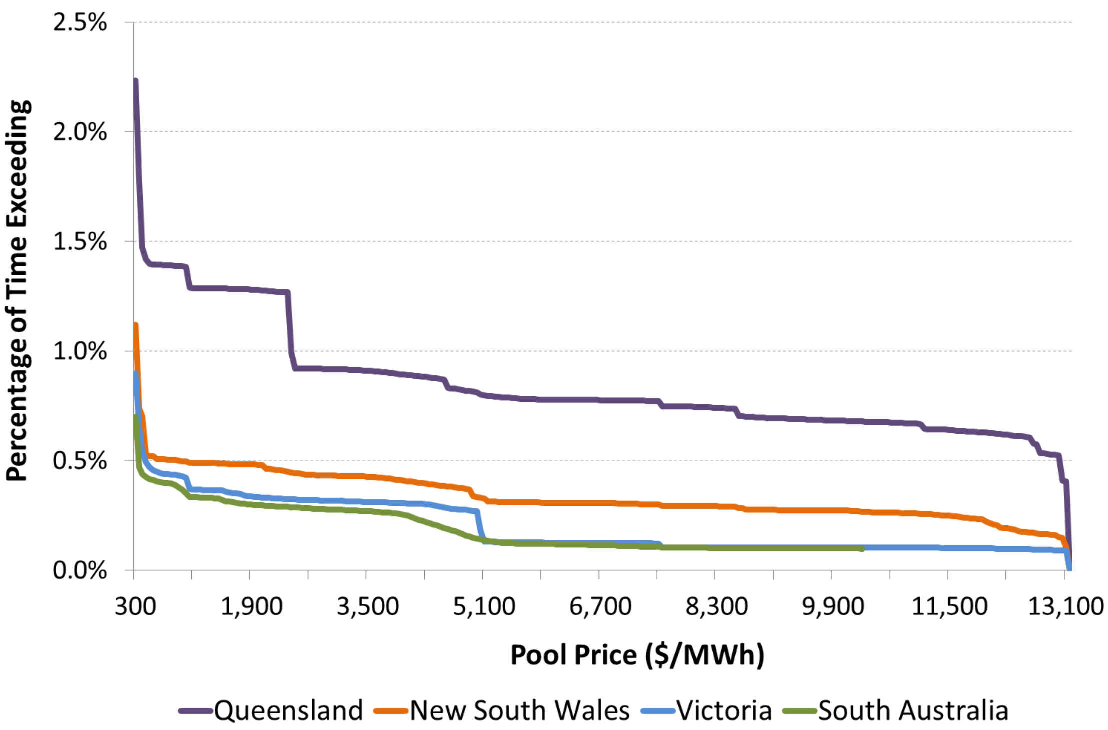
Assumption	Central assumption	Sensitivity
OCGT capital cost	$100,000/MW/year	$120,000/MW/year $80,000/MW/year
Annual energy and peak demand	Medium (AEMO NEFR 2013)	Low (AEMO NEFR 2013) High (AEMO NEFR 2013)
LRET	As legislated 41,000 GWh in 2020	Reduced LRET 27,000 GWh in 2020
Gas price	4-6 $/GJ rising to 7-10 $/GJ in 2022-23	3-6 $/GJ throughout
Carbon price	Repeal from 1 July 2015	Treasury Core trajectory
DSP	AEMO NEFR 2013	50% reduction in quantity of DSP

Stage 1 Modelling Outcomes



Stage 1: Cap defender, Base case outcomes

This is not a recommendation for different MPCs in different regions.



Stage 1: Regional pool prices

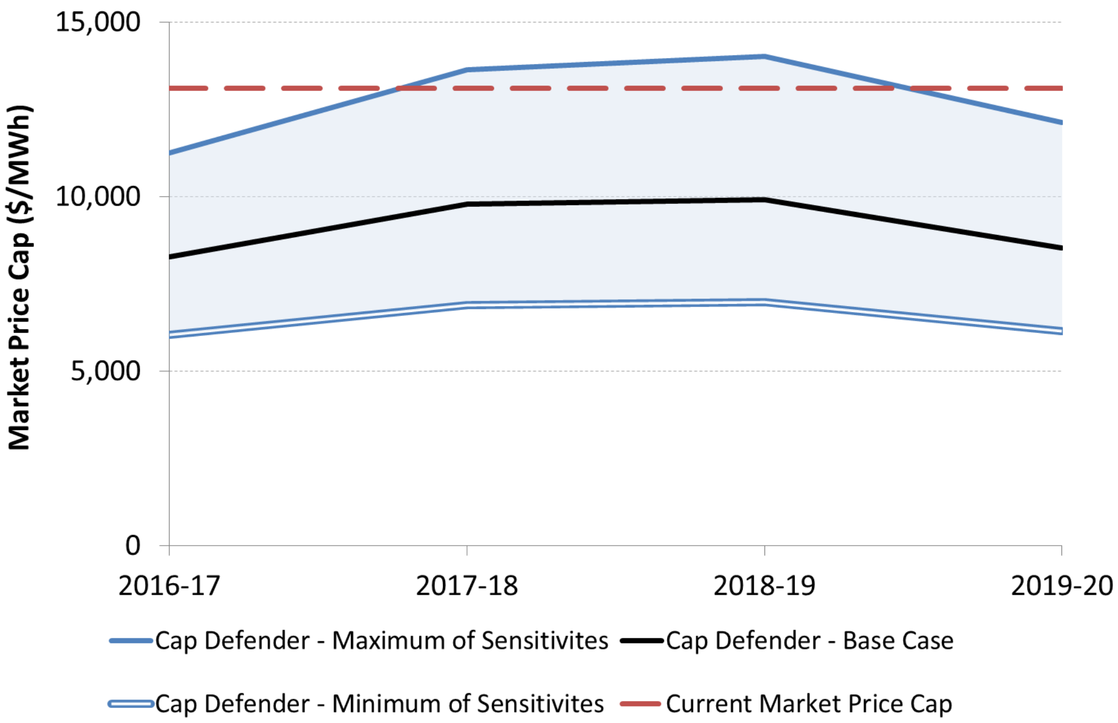
Drivers of differences between regions:
- Operation of energy-limited generation
- Interconnection
- Load factor

Stage 1: Regional load factors of demand net renewables (10% P.O.E)

	Queensland	New South Wales	Victoria	South Australia
2016-17	68%	57%	53%	30%
2017-18	67%	55%	51%	27%
2018-19	65%	53%	51%	24%
2019-20	65%	52%	50%	22%

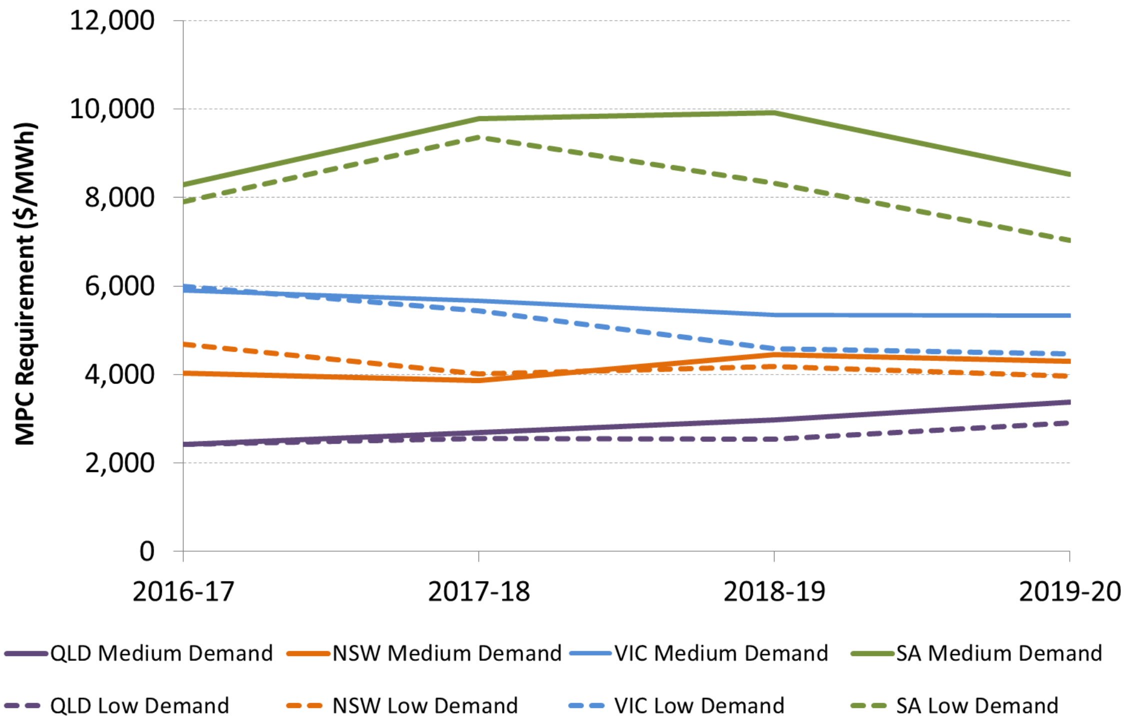
Stage 1: Modelling Features

- The MPC requirement in a region does not consider the inter-regional impact of that MPC on generation investment.
- Optimistic Modelling Features:
  - Reference node location: MLF = 1, no curtailment risk
  - Trading interval modelling
- Conservative Modelling Features:
  - Trading interval modelling
  - No consideration of contracts trading at a premium to their fair/expected value



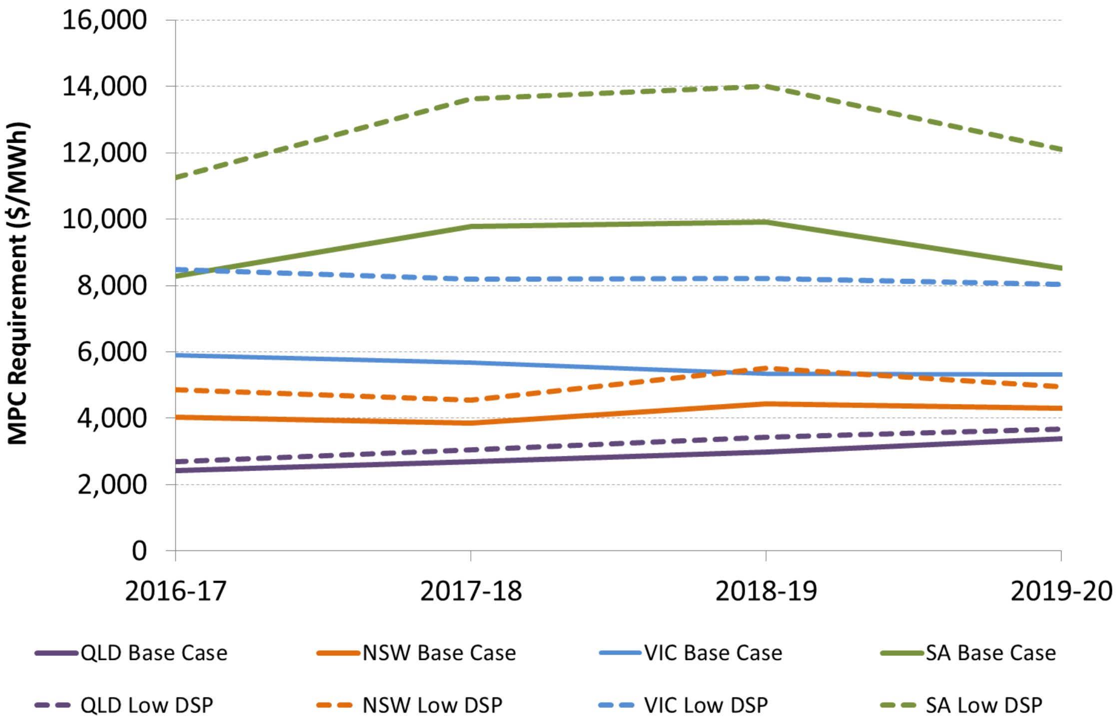
Stage 1: Cap defender, Range of sensitivity outcomes

Some sensitivities do drive MPC requirements that are significantly different from the Base Case outcome.



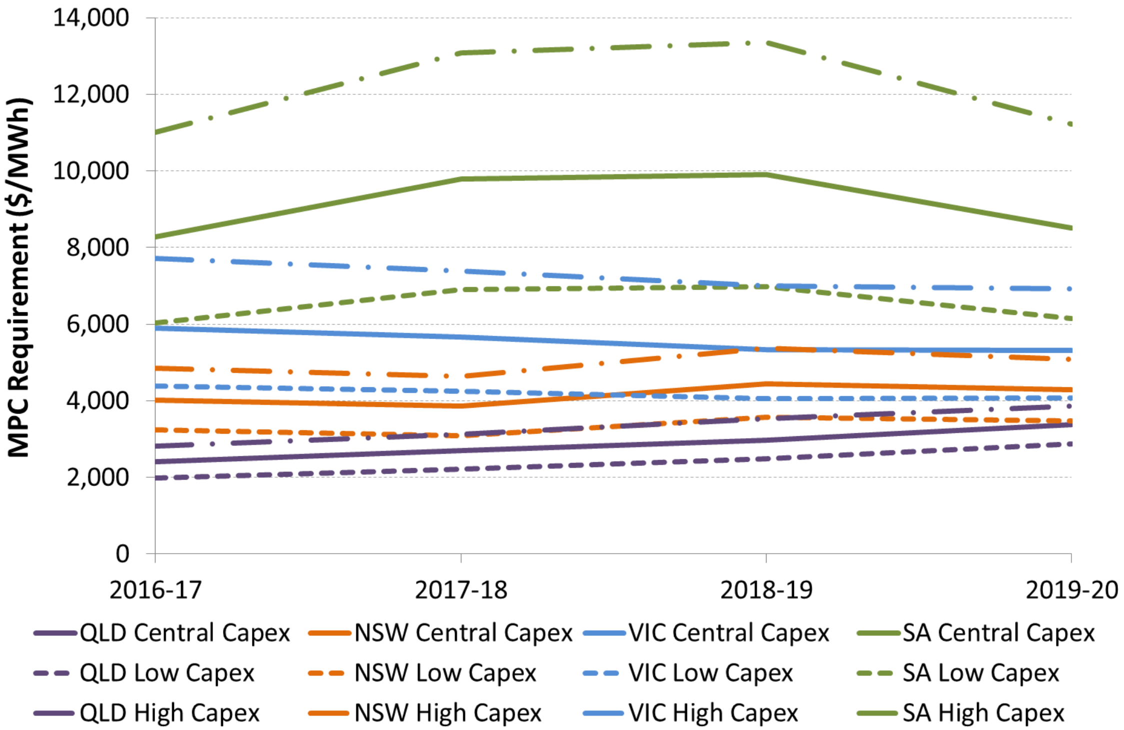
Stage 1: Cap defender, Low demand

- Impact of demand assumptions increases over study period.
- High-priced DSP and hydro capacity remains fixed so that there is proportionally less as demand increases.



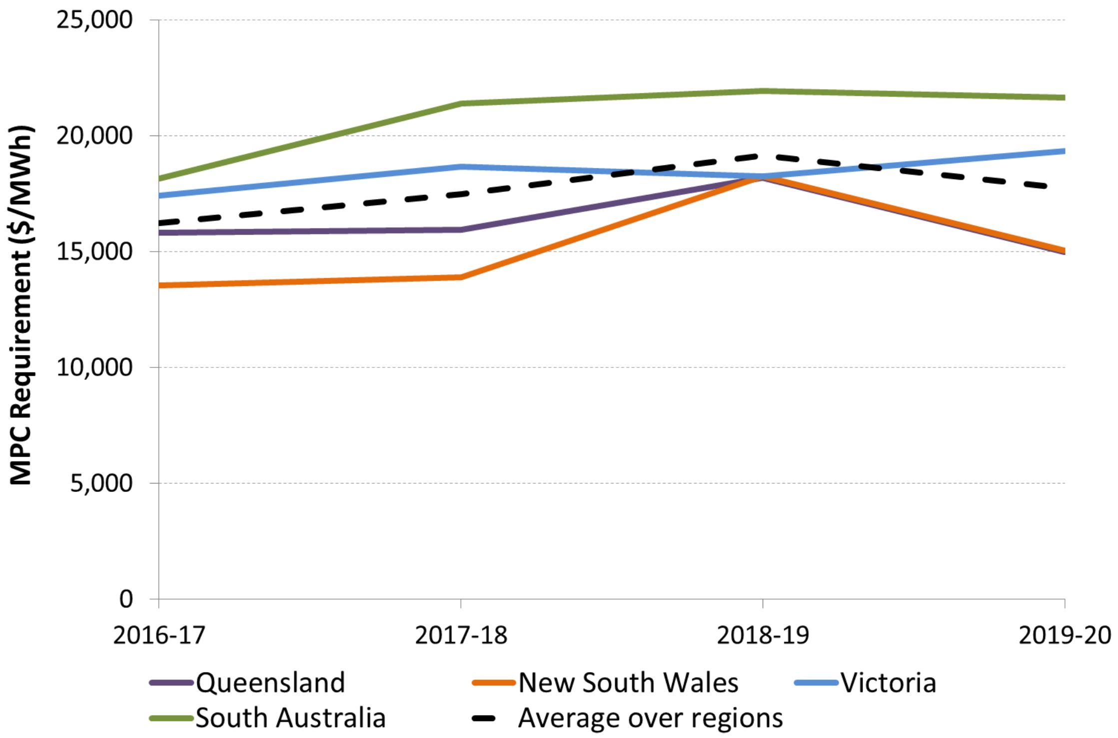
Stage 1: Cap defender, DSP sensitivity

A reduction in DSP (and an associated increase in the required level of installed capacity) reduces price volatility and therefore increases MPC requirement.



Stage 1: Cap defender, OCGT capex sensitivity

As capex increases, higher MPC requirement to recoup higher fixed costs.



Stage 1: Extreme peaker, Base case

- Relatively less regional disparity
- Higher MPC requirement

Stage 1 Summary

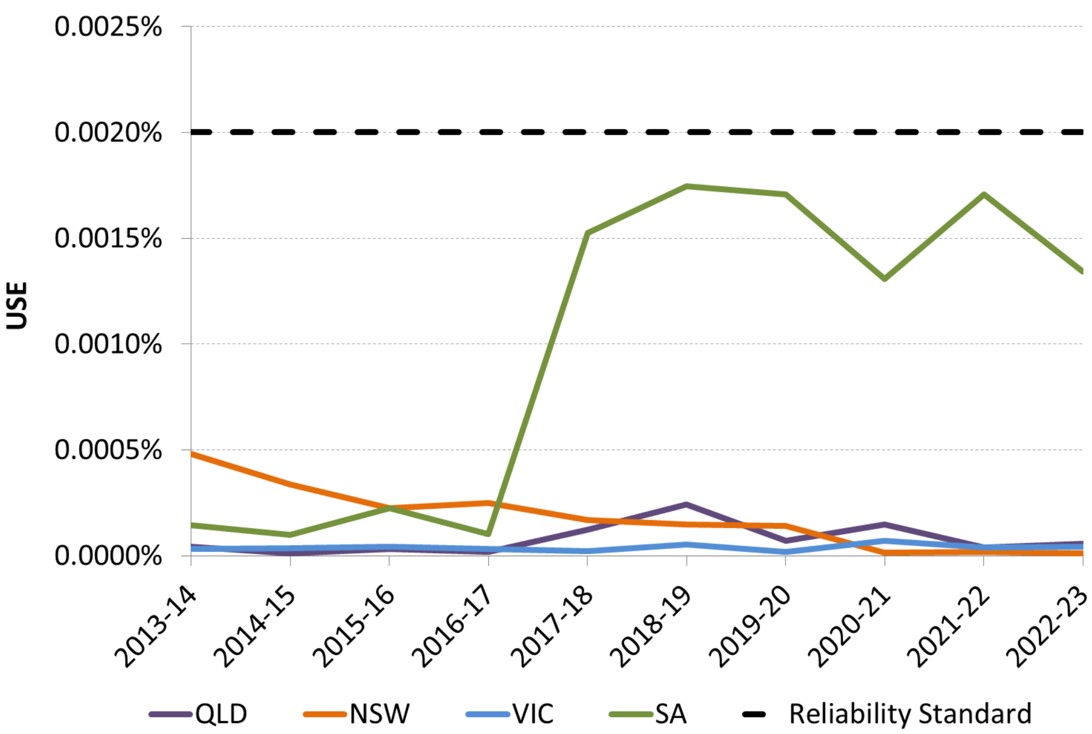
- The cap defender method replaces the extreme peaker approach which was applied in the previous review.
- Consideration of market factors significantly reduces the MPC requirement. The MPC requirement is below the current MPC in all regions in the Base Case.
- Substantial regional disparity is observed with South Australia requiring the highest MPC.
- The current MPC does fall within the range of outcomes observed in sensitivity analysis.

STAGE 2: RELIABILITY FORECAST

- Outline of the two approaches applied in Stage 2
  - Market driven development
  - No thermal development or withdrawal
- Present reliability outcomes in this modelling
- Consistency between Stage 1 and Stage 2 outcomes

Stage 2: Market Driven Development

- Objective: Forecast reliability in a profitability driven investment and mothballing scenario.
- Renewable generation developed to meet the LRET.
- Existing thermal generation withdrawn when pool revenue is insufficient to recover avoidable costs.
  - Thermal generation can return if revenue is sufficient in a later year.
- OCGT and CCGT generation developed when revenue is sufficient to recover annualised capital cost.
- The role and ownership of generation is not considered in this development.

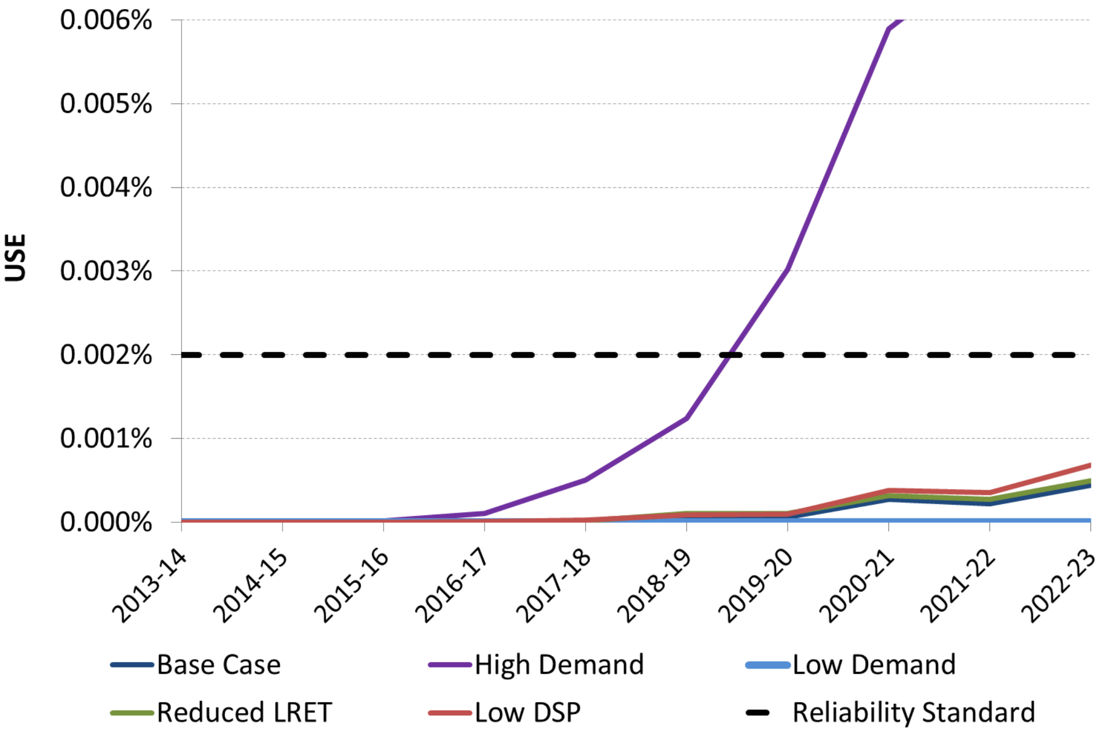


Stage 2 Market Development Outcomes

- The reliability standard is not exceeded in any region
- The highest level of USE occurs in South Australia

Stage 2: Fixed Planting

- Objective: Forecast the reliability delivered by existing generation.
- Renewable generation developed to meet the LRET.
- Existing thermal generation is maintained (with the exception of Mackay GT).
- No new entry thermal generation in permitted.
- Fixed planting scenarios in Stage 2:
  - The Base Case
  - High and Low Demand sensitivities
  - Reduced LRET sensitivity
  - Low DSP sensitivity



Stage 2 Fixed Planting Queensland Outcomes

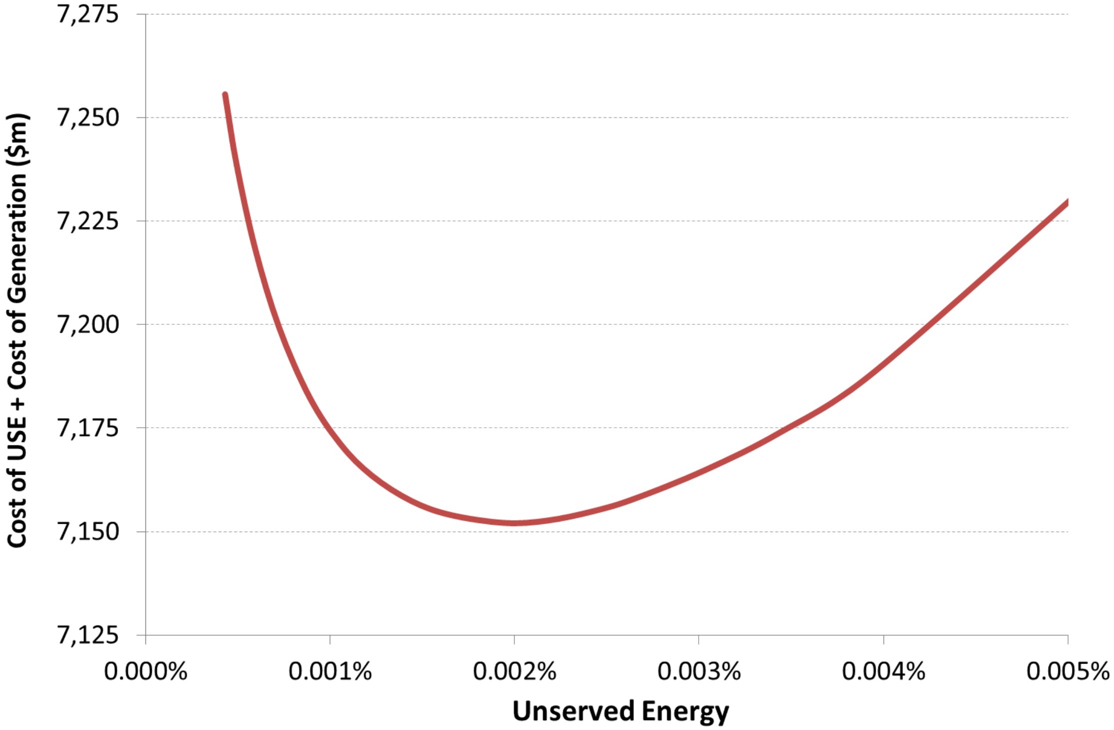
- No other region experiences material USE in any scenario
- Queensland exceeds the reliability standard in the high growth scenario

Stage 2 Summary

- The outcomes of the market driven development scenario are consistent with Stage 1 Results:
  - The current reliability settings are more than sufficient to achieve the Reliability Standard
- The fixed planting scenarios illustrate that given the current surplus of supply and the forecast slow demand growth that:
  - Additional thermal capacity is not required to achieve the Reliability Standard in NSW, VIC or SA
  - Additional thermal capacity is required in QLD under the high growth scenario

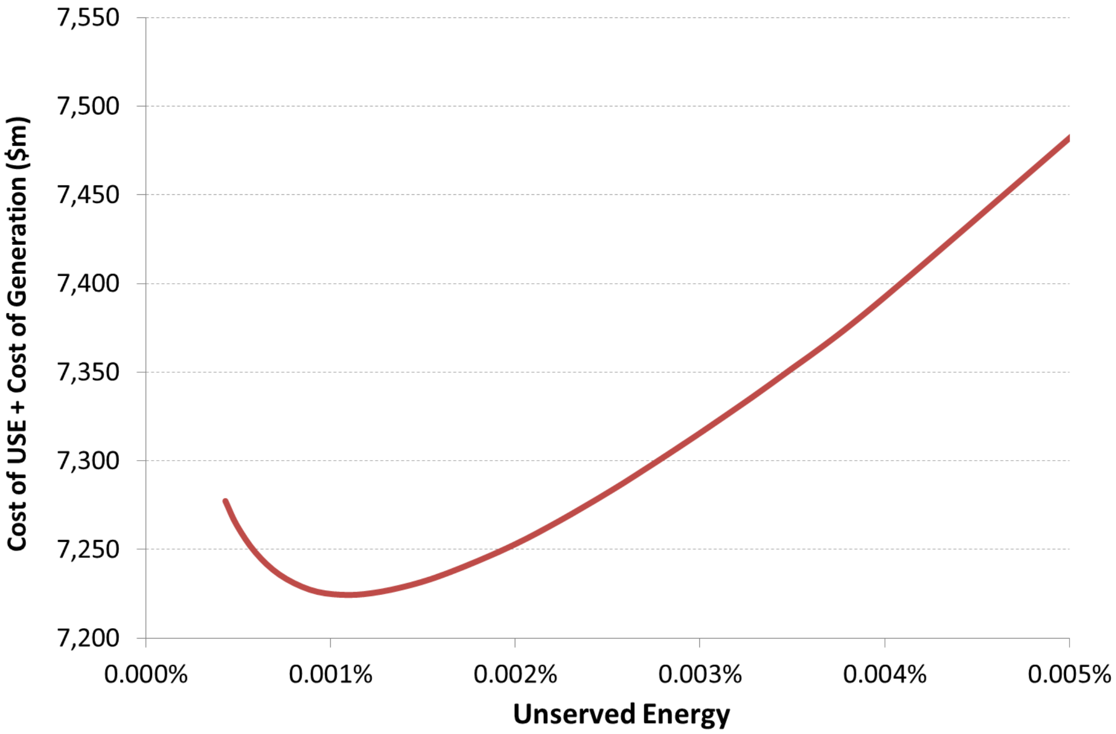
STAGE 3: RELIABILITY STANDARD

- Description of ROAM's methodology for economic assessment of the reliability standard
- Value of Customer Reliability (VCR) assumptions
- Modelling outcomes



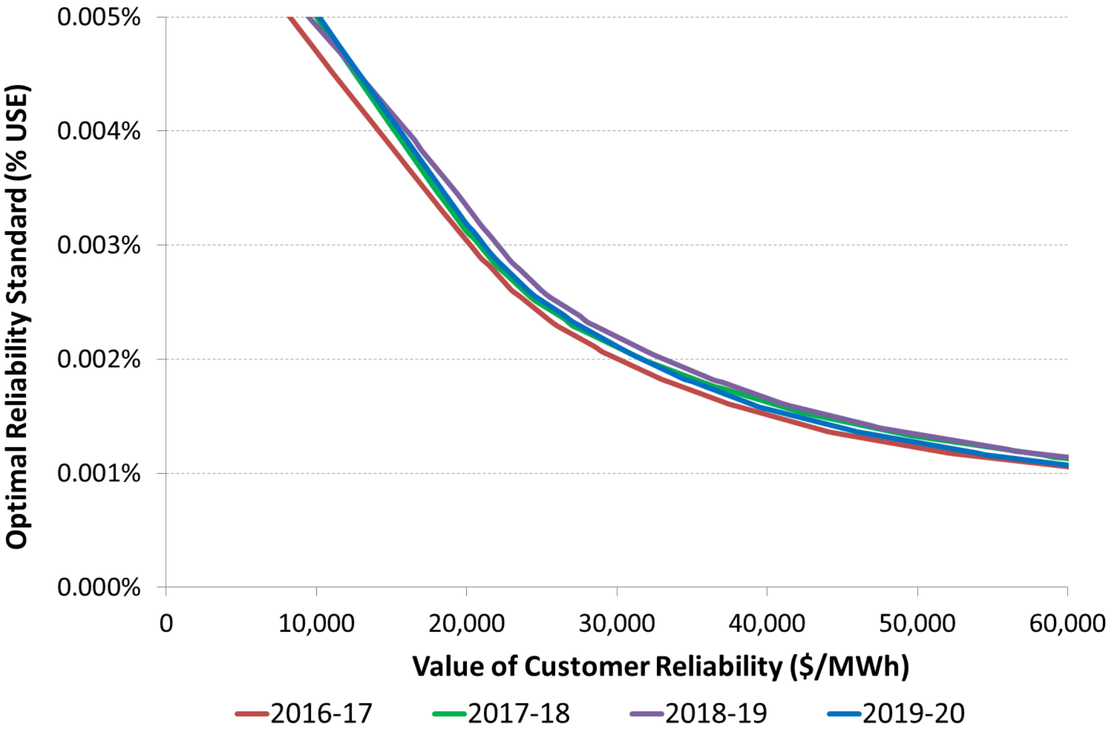
Stage 3: Total cost vs USE: VCR = $30,000/MWh (2016-17)

- For an assumed VCR of $30,000, economic cost is minimised where USE is 0.002%



Stage 3: Total cost vs USE: VCR = $55,000/MWh (2016-17)

- For an higher VCR, the optimal level of reliability increases.



Stage 3: VCR vs Reliability Standard Relationship

- Relationship is relatively constant over time

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Relationship between MPC and VCR

- In a purely theoretical representation of the NEM, the MPC and VCR should arguably be consistent.
- However, there a numerous additional factors that drive investment in the NEM. These are considered in the cap defender approach and result in a lower MPC requirement.

STAGE 4: MARKET FLOOR PRICE

- Considerations in setting the market floor price
- ROAM's Week Ahead Unit Commitment (WAUC) methodology for determining generation cycling
- Cycling cost assumptions
- Modelling outcomes relating to the economic drivers of the market floor price

Market Floor Price Considerations

- Economic efficiency considerations:
  - The market floor price must be set sufficiently low such that participants are incentivised to make efficient cycling decisions.
  - A market floor price that is too high does not allow generation to prioritise continued operation in periods of low demand.

- Market participant risk:
  - A market floor price that is significantly lower than that required to encourage economic unit cycling adds unnecessary risk for market participants.

Methodology for Market Floor Price Formula

- The objective is to determine the market floor price such that a generator would have preferred to incur cycling costs rather than operate at minimum load at a negative price.

$$\text{Min Load} \times \text{Hours off-line} \times (\text{SRMC} - \text{MFP}) > \text{Total Cycling Cost (\$)}$$

- The formula can be rearranged on this basis:

$$\text{MFP} < \text{SRMC} - \frac{\text{Total Cycling Cost (\$)}}{\text{Min Load} \times \text{Hours off-line}}$$

- For the MFP requirement to be a large negative number (such as $1,000/MWh), there must be an economic driver for units with high cycling costs (such as coal) to cycle for relatively short periods of time.

Week Ahead Unit Commitment and Assumed Cycling Costs

- ROAM applies a WAUC solver to optimise the operation of the NEM. This solver considers both the cost of generation and the cost of cycling.
- Results from WAUC studies are analysed to determine the cycling decisions made by generation and therefore to inform an analysis of the MFP.

Plant Type	Warm Start Cycling Cost ($/MW nameplate)	Hot Start Cycling Cost ($/MW nameplate)
CCGT	102	102
Supercritical coal	445	274
Large sub-critical coal	290	227
Small sub-critical coal	328	241

Market Floor Price Outcomes

- No short-term cycling of coal units was observed to be economically justifiable in the WAUC modelling. Therefore, the floor price required is not significantly negative.
- Warm start simulations with both Base Case cycling costs and a sensitivity with double cycling costs shown below.

	Market Floor Price ($/MWh)			
	2016-17	2017-18	2018-19	2019-20
Base Case	-2	-19	-29	-11
Double Cost	-27	-52	-35	-41

Stage 4 Summary

- The objective was to determine the Market Floor Price required to incentivise economically efficient cycling behaviour.
- The WAUC model used to forecast this cycling behaviour showed no incentive for coal generating units to cycle for short periods of time in the forecast period.
- Therefore, the modelling indicates that the existing Market Floor Price is far lower than the level which is required on this basis.
- This modelling is subject to the cycling cost assumptions illustrated previously.

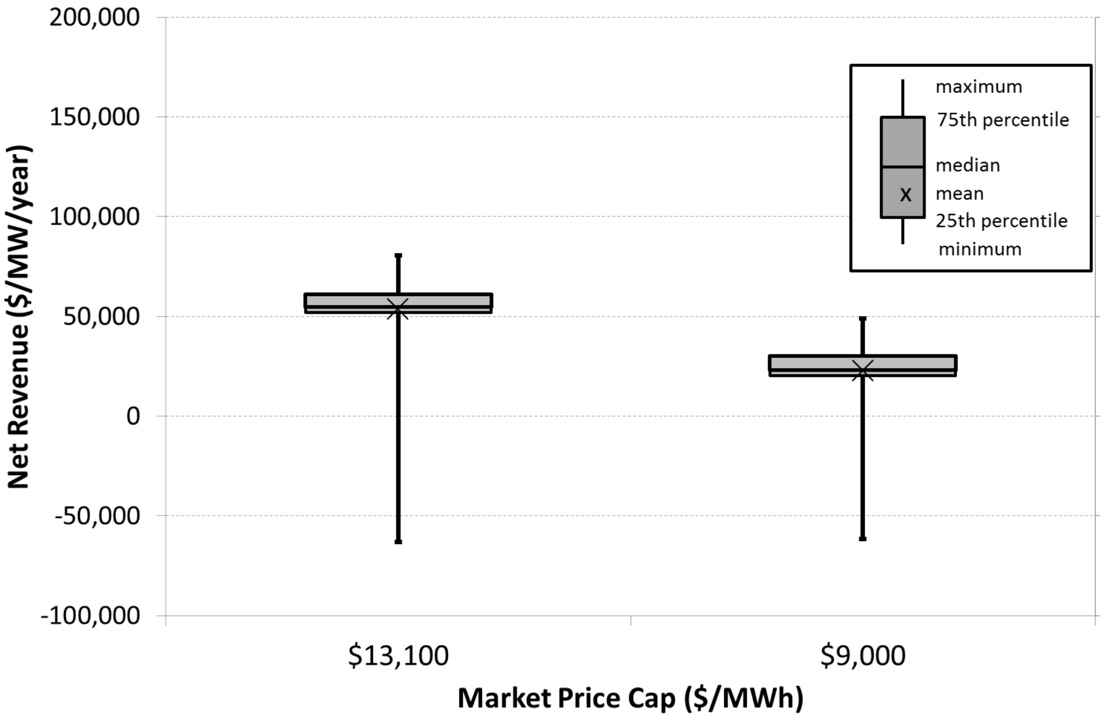
STAGE 5: NON-RELIABILITY IMPACTS OF THE RELIABILITY SETTINGS

- Effect on wholesale and contract markets
- Impact of the settings on the cost of energy for consumers
- The effect of the MPC on the behaviour of market participants:
    - Generation portfolio behaviour
    - Demand Side Participation
- The relationship between the MPC and settlements residues and therefore inter-regional trade

Forecast Modelling for Stage 5

- Two levels of reliability settings were considered:
  - The current MPC of $13,100 and CPT of $197,100
  - An alternative MPC of $9,000 and CPT of $135,000

- ROAM also considered two planting outcomes:
  - The 0.002% USE planting that was applied in Stage 1
  - A continuation of the current surplus of capacity with minimal retirement of baseload in NSW and VIC and a 250MW CCGT investment in QLD (2019-20)

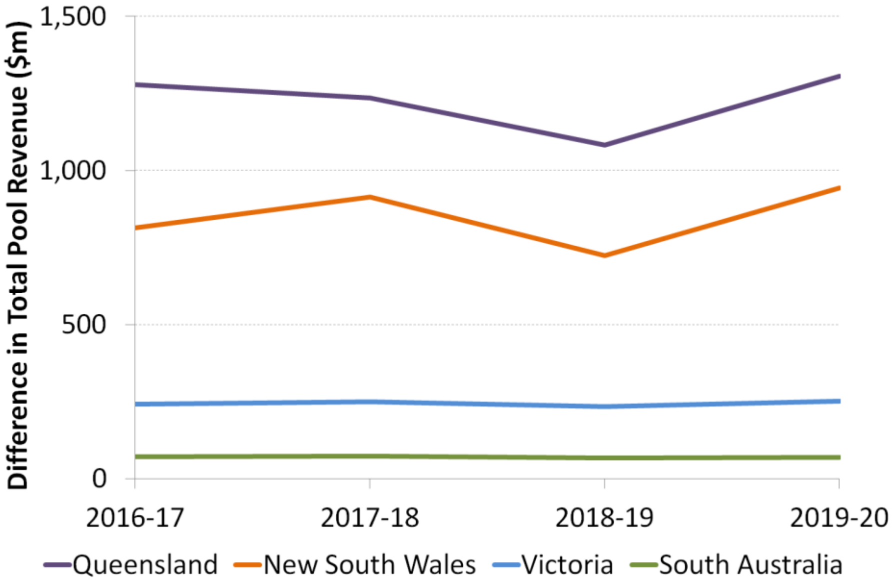


Volatility of New Entrant Returns – Victoria (0.002% USE Market)

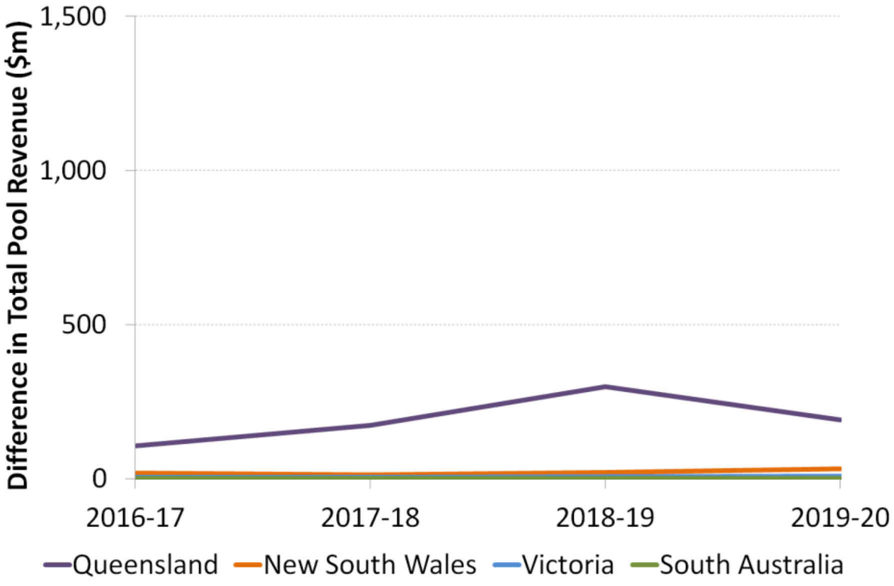
- A reduction in MPC reduces expected returns and volatility for new entrant generation.

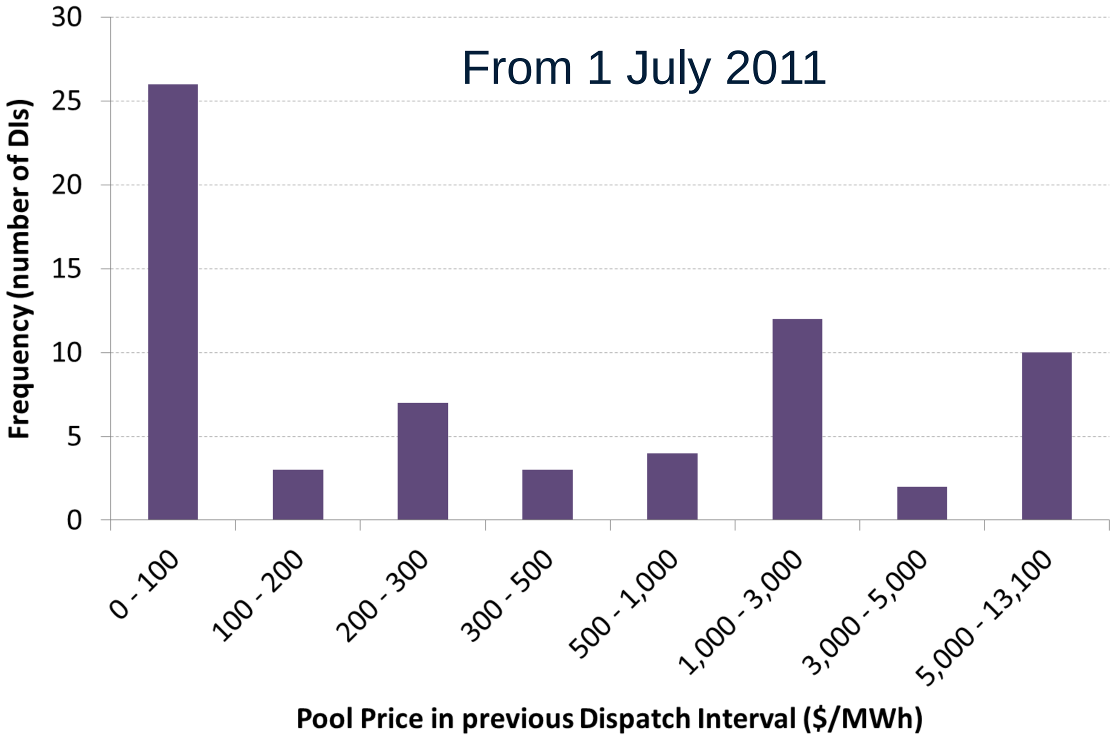
Impact of the Settings for Consumers

0.002% USE Market



Minimal Retirement Market





Historical Analysis of Dispatch Interval Price Volatility (QLD)

- Price spikes are short in duration
- Price spikes often directly follow periods of relatively low price

Impact of MPC on Portfolio Behaviour

Additional hours of prices ≥ $9,000/MWh in the $13,100/MWh market

0.002% USE Market

	QLD	NSW	VIC	SA
2016-17	4.2	3.5	1.1	1.1
2017-18	5	3.9	1.1	1.1
2018-19	3.8	3.1	0.9	0.9
2019-20	4.5	4.3	1.1	1.1

Minimal Retirement Market

	QLD	NSW	VIC	SA
2016-17	0.8	-	-	-
2017-18	1.2	-	-	-
2018-19	2.2	-	-	-
2019-20	1.3	-	-	-

Historical Analysis of inter-regional trade, IRSRs and Negative Settlements Residues

- A reduction in MPC leads to a material reduction in negative settlements residues in history.
- Reducing the MPC would help to mitigate a proportion of the basis risk which limits the liquidity of inter-regional trade.
- There is limited evidence that the MPC impacts the ability of IRSRs to mitigate basis risk.

TIMELINE & HOW TO COMMENT

- Next fortnight: ROAM's final report to the Reliability Panel will be published on the AEMC website.
    - No formal consultation.
    - The AEMC are happy to hear and consider comment.
- Early February: Reliability Panel's draft report published on AEMC website
    - Formal public consultation.

QUESTIONS?

Thank you for your attention.