MARKET REFORM

Attachment 1
Gas Market Parameters Review 2018
DRAFT Final Report

Report to the Australian Energy Market Operator

5 March 2018

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

EXECUTIVE SUMMARY

Introduction

The Australian Energy Market Operator (AEMO) has engaged Market Reform to conduct reviews of gas market parameters used in the Short-Term Trading Market (STTM) for gas and in the Victorian Declared Wholesale Gas Market (DWGM) to ensure that they continue to be fit for purpose.

This draft report presents Market Reform's findings and recommendations. The methodology used was presented to the Gas Wholesale Consultative Forum (GWCF) and was subject to industry consultation. A presentation was also made to GWCF of early simulation results.

The within scope gas market parameters and their current values in the STTM are the market price cap (MPC) of $400/GJ, an administered price cap (APC) of $40/GJ and a cumulative price threshold (CPT) of $440/GJ, while the corresponding values in the DWGM are the value of lost load (VoLL) of $800/GJ, an APC of $40/GJ and a CPT of $1,800/GJ.

The STTM parameters are currently required by the National Gas Rules to be reviewed at least once every five years. While there is no similar requirement for the DWGM, AEMO is seeking to conduct reviews concurrently. The period studied in this review is 2019 to 2024, with any revised parameters to apply from 2020, or if there is a strong case for more immediate change, from 2019.

Recommended Gas Market Parameters

We recommend no changes to the gas market parameters other than to reduce the CPT applied in the DWGM from $1800/GJ to $1400/GJ. The reasons for this change are:

- The tightening supply and demand conditions over the studied period mean that the current DWGM gas market parameters fail to provide adequate risk protection to market participants buying gas. The proposed reduction in the CPT value allows the revised parameters to provide adequate protection while minimising the impact on market efficiency.
- A CPT of $1400/GJ eliminates the potential for DWGM participants to be exposed to two VoLL events during a cumulative pricing period but it is sufficiently high that even allowing for moderately higher prevailing gas prices in the future it will still allow a single VoLL event to occur without APC being applied. Some risk of VoLL exposure promotes good hedging practices. A CPT value much lower than that proposed could mean that the threshold is breached by a single incidence of VoLL. In the DWGM the price in the period that breached CPT would be capped at APC, so in that case the market might never see VoLL applied.
- The revised gas market parameters for the DWGM are not materially different from the current parameters in terms of facilitating adequate revenue recovery for new investment.

The current STTM parameters were found to provide adequate protection to consumers in the STTM. Very few other parameters explored did. This arises in part because of a key difference between how administered pricing works in the STTM relative to the DWGM. If an STTM price reaches MPC and causes a breach of CPT, that price is not capped by APC as would be the case in the DWGM. Under the STTM procedures the application of administered pricing commences from the next gas day. The current CPT of $440/GJ means that it is possible for STTM participants to be exposed to MPC for two gas days – the first not breaching CPT, the second breaching it but not being capped. Higher levels of CPT could allow participants to be exposed to more days at MPC so are not acceptable. The current STTM parameters are sufficient to allow revenue recovery for new investment.

Comments received from retailers and energy users during this work included the suggestion that the VoLL in the DWGM should be lowered to the value of MPC in the STTM, primarily to mitigate risk and because there was a view that lowering VoLL would still support investment. However, mitigation of unmanageable risk is actually more the role of CPT. An exploration of a broader range of assumptions about the nature and incidence of CPT events than those used in the prior gas market parameter reviews showed that risks of under recovery of investment costs become more pronounced as prevailing gas prices rise. Caution is therefore required in consideration of lowering VoLL in the DWGM. The CPT changes proposed for the DWGM do modify the situation, however. The DWGM participants could be exposed to at most one day (in the case of the first schedule of the day) at an $800/GJ VoLL while the MPC continues to be limited to a maximum of two days exposure at a $400/GJ MPC.

A number of alternative parameters for each of the DWGM and STTM were identified that would have supported an increase in APC. No change is proposed. Such increases would not significantly impact investment cost recovery or market efficiency, though for a given CPT a higher APC will tend to increase consumer cost. An increase in APC was not suggested in any consultation feedback.

Market Situation

In forming these recommendations, we have endeavoured to account for the changing context of the industry during the period studied, including projected falls in production of gas in Victoria combined with increased demand for gas powered generation. Together these are projected to mean that from 2021 the DWGM may not always be able to meet peak DWGM consumption while also supplying gas to New South Wales and South Australia.

While mechanisms such as the Australian Domestic Gas Security Mechanism (ADGSM) and the Gas Supply Guarantee (GSG) have been implemented to provide assurance of supply for domestic gas demand and security of gas supply for the NEM, there will still be periods where the broader gas market in the eastern states is operating at, or near, its limits.

Of the three years focused on in this study – 2019, 2021 and 2024 – the tightest supply and demand situation occurs in 2021. It follows that the results for 2021 tend to constrain the acceptable gas market parameters.

Methodology

A range of gas market parameters were assessed based on their relative performance in maximising economic efficiency of the market while keeping risks acceptable to market participants buying gas. This assessment was based on simulations which combined market context, e.g. the DWGM under 2021 supply and demand conditions, with a scenario, e.g. a supply reduction at Longford. A subset of scenarios considered interactions between various combinations of the DWGM, STTM hubs and the NEM. While each of the DWGM and STTM hubs were simulated independently the trade conditions used accounted for conditions in other gas markets and the NEM. The set of scenarios (and the associated market contexts) are described in Appendix B.

The simulation tested a range of parameters across a sufficiently long sequence of days to reflect the periods leading up to an event and any subsequent administered pricing period. Supply and demand curves were used to reflect the market context and were adjusted to reflect both events that arise from a scenario and the imposition of administered price caps when triggered. Sensitivity analysis was performed for all simulations so as to provide data to test the robustness of the performance of gas market parameters with slight changes in market conditions.

By comparing simulation results for cases with administered price caps applied relative to identical cases without administered price caps applied it was possible to assess the loss in economic efficiency due to the application of different administered price caps. The different profitability of market participants in these two situations allows assessment of the impact on risk for a range of hypothetical typical buyers from the market, including direct market customers, small and medium retailers and gas powered generators (GPGs). For each hypothetical participant, a level of market exposure was assumed based on the nature of the participant with this linked to the degree the overall market was long or short. Based on standards established in prior gas market parameter reviews the acceptable level of risk was defined as not more than 500 days of lost profit relative to the participant's position absent an extreme event.

Parameters that were found to provide adequate protection to buyers while maintaining market efficiency were further tested against their ability to provide adequate revenue recovery for new investments. The assessment of new investment was based on the costs of an LNG facility similar to that at Dandenong in the DWGM. The final acceptable parameters were then compared and contrasted to decide the recommended values.

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1 INTRODUCTION

1.1 Background

The Australian Energy Market Operator (AEMO) has engaged Market Reform to conduct the 2018 review of a number of parameters used in the Short Term Trading Market (STTM) for gas and in the Victorian Declared Wholesale Gas Market (DWGM) to ensure that they continue to be fit for purpose. The market parameters to be reviewed are collectively referred to as the gas market parameters and are described in Table 1.

Table 1 – The current gas market parameters

STTM			
Parameter	**Purpose**	**Documented in**	**Value**
Market Price Cap (MPC)	The maximum market price to apply for a gas day.	National Gas Rules	$400/GJ
Administered Price Cap (APC)	A cap that replaces MPC during an administered price cap state so as to mitigate the risk of high prices.	National Gas Rules	$40/GJ
Cumulative Price Threshold (CPT)	The threshold for automatic imposition of an administered price cap state.	National Gas Rules	$440 /GJ (110% of MPC)
DWGM			
Parameter	**Purpose**	**Documented in**	**Value**
VoLL	The maximum market price.	National Gas Rules	$800/GJ
Administered Price Cap (APC)	A cap that replaces VoLL during an administered price cap state so as to mitigate the risk of high prices.	Wholesale Market Administered Pricing Procedures (Victoria)	$40/GJ
Cumulative Price Threshold (CPT)	The threshold for automatic imposition of an administered price cap state.	Wholesale Market Administered Pricing Procedures (Victoria)	$1,800/GJ

STTM market parameters are currently required to be reviewed at least once every five years in accordance with rule 492 of the National Gas Rules (NGR). Following this review, the requirement will be a four-yearly review. No similar requirement exists for a review of the parameters used in the DWGM. AEMO conducted its own review of the DWGM parameters in 2012 and is using the occasion of an STTM review have a third-party review the DWGM parameters also.

1.2 Consultation Process

This report is the final report in a piece of work that commenced in September 2017. The early phase of the work involved developing a methodology. A presentation on the proposed approach was made to the Gas Wholesale Consultative Forum (GWCF) on 3 November 2017. Subsequently the proposed approach was documented in the report Gas Market Parameters Review 2018, Consultation Report, Report to AEMO, 29 November 2017, hence forth referred to as the Consultation Report. AEMO submitted the Consultation Report to public consultation. The feedback on that consultation is documented in this report.

In conducting this work there were also discussions with the AEMC on the relationship of this work to concurrent reviews, including the Reliability Panel review of the NEM Parameters.

1.3 Market Situation

The Consultation Report described in some detail the context of the market during the review period. This is a period during which the eastern Australian gas industry may face material shortfalls in gas supply assuming full supply of demand for LNG for export. While mechanisms such as the Australian Domestic Gas Security Mechanism (ADGSM) and the Gas Supply Guarantee (GSG) have been implemented to provide assurance of supply for domestic gas demand and security of gas supply for the NEM, there will still be periods where the broader east coast gas market is operating at, or near, its limits. Projected falls in production of gas in Victoria combined with increased demand for gas powered generation are projected to mean that from 2021 the DWGM may not always be able meet peak DWGM consumption while also supplying gas to New South Wales and South Australia.

1.4 Advice Sought

AEMO is seeking advice on the appropriate settings of the gas market parameters.

In developing recommendations, AEMO has asked for the review to have regard to the following:

1. Recognise links between markets

The analysis of the gas market parameters must recognise interactions between the STTM, DWGM and NEM, recent developments in each of these markets and the convergence of the gas and electricity markets. In particular, consideration of interactions between the STTM and DWGM and between each of these markets and the NEM should recognise the activities and operations of participants across markets.

2. Recognise industry structure and future developments

Any modelling of market outcomes should represent the broad industry structure as it exists today and include foreseeable changes to industry and market design in the future. Any changes to industry structure and market design since the previous review should be taken into consideration. Modelling need not attempt to represent actual industry players, it should represent the different distributions of participant size and roles in the contract and spot markets.

The modelling needs to be cognisant of the Review of the Victorian Declared Wholesale Gas Market recently conducted by the AEMC

3. Data to be used

The determination of the gas market parameters should be based on available public and market data or be reasonable and logically based estimates of data values which are not otherwise public or available. Where historic or market data does not exist, the Consultant will have to adequately justify the use of alternative information.

4. Determination of MPC / VoLL

MPC or VoLL is to be determined with the primary focus on economic price signalling as a market clearing incentive. It is to be a value greater than the maximum short run price expected to arise in the market, recognising that the STTM prices both the gas commodity and the cost of transmission in its prices whereas DWGM prices only include gas commodity costs. The value of MPC/VoLL is to be set with the aim of maximising the opportunity for an efficient market to clear in the short run. This objective implies that longer term investment costs will be recovered over time, but does not restrict short run prices to be constrained by long run average cost.

In the STTM the value of MPC should be common to all hubs and across the ex ante market price, contingency gas price and the ex post market price. In the DWGM the value of VoLL should be common to all schedules.

In considering the short run cost of demand side response in each market, the appropriate measure should be the greater of the cost incurred for a rare temporary supply interruption and the cost of responding to a long-term loss of reliability due to supply side under-investment.

Whilst the setting of MPC/VoLL has fundamental implications for overall risk in the market and is a primary driver of that risk, the determination of its value is to focus on achieving economic price signals rather than to limit risk. Risk is addressed by the application of an administered price cap, and accordingly will be addressed when determining that price cap.

Market Reform is required to determine the appropriate settings of MPC and VoLL.

5. Determination of APC and CPT parameters

The purpose of the administered price cap (APC) is as a last resort to address unmanageable risk in the market by limiting the impact of extreme and prolonged events. Accordingly, the APC is a balance between providing limitation of overall risk whilst maintaining appropriate incentives on individuals for prudent risk management and minimising distortion of incentives for appropriate investment.

APC will be triggered by the cumulative price threshold (CPT) or triggered as a result of events that occur on a given day, primarily force majeure type conditions.

The intent of CPT is a means of addressing unmanageable risk and distortions arising from prolonged exposure to very high prices. CPT allows for a high MPC/VoLL that meets the objectives of ensuring voluntary market clearing and at the same time allows management of risk due to high price.

Market Reform is required to determine the appropriate settings of APC and CPT.

1.5 Report Outline

This rest of this report is structured as follows:

- Section 2 describes the roles and bounds on the gas market parameters.
- Section 3 presents a summary of the methodology and approach.
- Section 4 summarises and comments on consultation feedback.
- Section 5 describes the data and key assumptions used in implementing the approach.
- Section 6 presents the study findings
- Section 7 presents our recommendations.
- Appendix A provides a list of abbreviations.
- Appendix B describes the scenarios used.
- Appendix C provides summary data on the market outcomes in each scenario.
- Appendix D presents summaries of risk exposure levels for the different hypothetical participants.

2 ROLE AND BOUNDS OF GAS MARKET PARAMETERS

2.1 Introduction

It is important to appreciate the relationship between the maximum price in a market – such as VoLL in the DWGM and MPC in the STTM and administered pricing arrangements. This section provides an overview of the roles of the various gas market parameters and the important considerations in setting their values.

2.2 The Maximum Market Price (MPC/VoLL)

VoLL in the DWGM and MPC in the STTM are the maximum market prices in those markets. The maximum market price represents the price at which the market – as a matter of policy – is prepared to accept that it is not willing to pay more to supply demand. It should be set at a level high enough:

- To allow the market to clear in the short run, whether this be through demand response, redirecting supply from one use to another, or for additional high cost supply to come into the market on a short-term basis; and
- To encourage investment in capacity over time to support the ability for the market to clear.

It is common to try and justify the maximum market price based on some economic consideration of the "optimal" amount of peaking capacity in a long-run equilibrium. That is, over the long term the investment and operating costs of the gas system are perfectly aligned with the value of delivered gas. However, a long-run equilibrium view assumes perfect planning and will tend to imply lower prices in situations where the market is in disequilibrium – as most real markets are most of the time. In effect, a maximum market price based on an optimal long run equilibrium may actually cap prices at a level too low to allow a market to respond to situations arising from imperfections in forecasting, planning or investment.

It is appropriate to review the maximum market price from time to time to assure that it is high enough to accomplish its principal objectives but not so high as to cause other problems that are not best dealt with by other means. It should be a stable market parameter that is not changed, and particularly not lowered, without a compelling argument that the current value is causing problems that are not best dealt with some other way. In particular, the maximum market price should not be lowered primarily because an inherently uncertain engineering/economic calculation suggests that a lower value might support a hypothetical long-run market equilibrium.

The view taken in this report is that the maximum market price should be high enough as not to interfere with the operation of markets.

The risks of extended periods of high prices should be managed with policies such as the administered price cap (APC) and cumulative price threshold (CPT), and other problems – such as market power for example - should be attacked directly by modifications in the market design or regulatory arrangements.

2.3 The Cumulative Price Threshold (CPT)

A cumulative price threshold (CPT) serves to limit the total amount of revenue suppliers in a market should be able to earn over a cumulative price period before an Administered Price Cap is imposed. The normal logic is to set CPT at level such that investors in peaking capacity can recover enough revenue to justify the investment prior to APC being applied. The cumulative price period is essentially seven days in both the DWGM and the STTM and the review of that value is outside the scope of this review. In theory if there were multiple CPT events a year then it would not be necessary for owners of peaking capacity to recover all of their costs in one cumulative price period. However, given that no CPT event has ever occurred in either the DWGM or STTM we will assume that investment costs must be recovered during a single cumulative price period.

It is important to note that the workings of CPT in the DWGM and the STTM are not the same:

- In the DWGM, if the price for the current pricing period causes CPT to be breached then an administered pricing period commences from the start of the current pricing period. This means that APC applies to the price determined the current pricing period and may reduce that price.

- The situation is different in the STTM. If the price for the current day breaches CPT then the administered pricing period commences from the next gas day. This means that APC does not apply to the price for the current gas day.

2.4 The Administered Price Cap

Once the CPT triggers APC then it can be assumed that those who have made investments to protect themselves or others against the risk of high prices have recovered an adequate return on their investment. APC is intended to be a price cap that – to a great extent – allows trade based on short run costs to continue while limiting profits on peaking capacity. This acts to limit the financial risk of consumers. The imposition of APC may require some interventions to ensure that supply and demand clear when APC is lower than the natural price that the market would otherwise clear at.

2.5 The Bounds on Parameter Settings

Here we summarise the logical bounds on the gas market parameters to be considered in this review.

- The maximum market price (VoLL or MPC) should be set at a level no less than that which the market could be expected to clear at without requiring involuntary curtailment.
- The maximum market price (VoLL or MPC) should not be an impediment to efficient investment, but should not be so tightly defined by that criteria as to restrict investment in capacity or to mitigate deficiencies in planning or forecasting.[1]
- CPT should be set to a level that would allow reasonable opportunity to recover peak capacity investment costs over the cumulative pricing period (and allowing for revenues earned under normal market operation and subsequently under APC).
- APC should not be set so low as to remove the need for prudent risk management by the demand side.
- APC should not be set so low as to exacerbate issues by having supply withdrawn from the gas market or creating bigger issues in other markets (e.g. due to APC being too low for GPGs to be able to source gas).

In addition, the gas market parameters applied in the STTM and in the DWGM should avoid, where possible, inefficient outcomes between those markets or with the NEM and the broader gas market.

[1] In formulating investment decisions, the value of price caps is important as it influences the expectation over the long term of the avoided costs achieved through making an investment. As price caps become more restrictive they can lower the expectation of avoided costs and hence make investment less attractive, giving rise to shortages in supply.

3 METHODOLOGY

3.1 Introduction

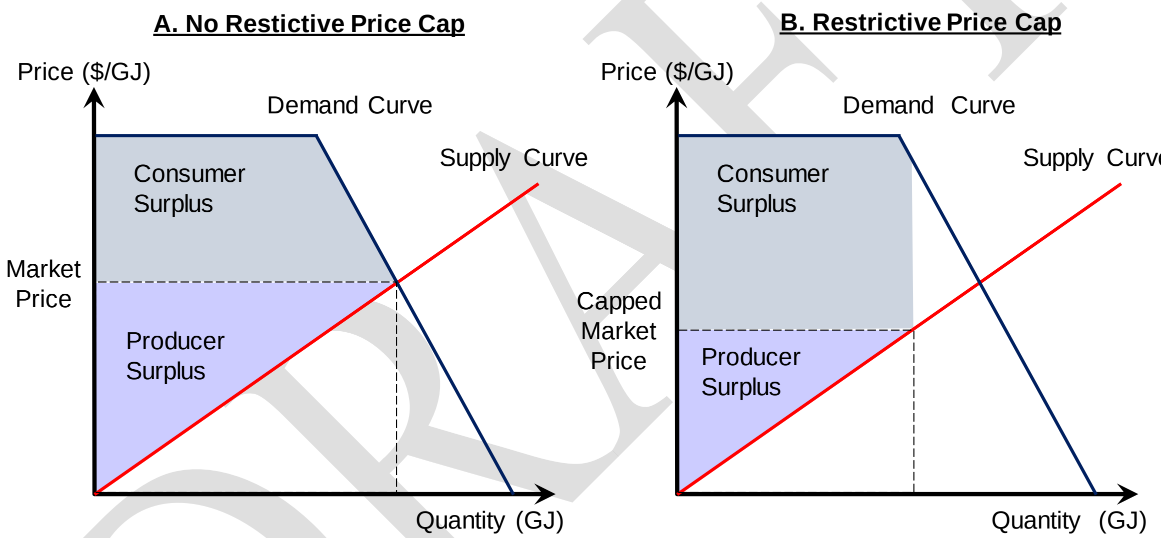
This section provides an overview of the problem to be addressed and the methodology used to study a parameter setting. A parameter setting includes a value for VoLL or MPC, as applicable, a value for the CPT and a value for the APC. More detail and discussion of the methodology can be found in the Consultation Report.

3.2 Efficiency vs Market Risk

The core objective is to explore the trade-off between market efficiency and market risk. The primary measure of market efficiency is the sum of consumer and producer surplus.

Figure 1 illustrates the concept of market efficiency and the impact that price caps can have on it.

Figure 1 – Market efficiency, consumer and producer surplus, and the impact of price caps



Consumer surplus is the amount by which the total benefit consumers receive from gas exceeds what they must pay for it. Producer surplus reflects the total amount by which payments to suppliers exceed their costs.[2] Case A in Figure 1 shows a situation where the market clears without being restricted by a price cap. The market price is set at the point where the supply and demand curves cross. This is the point at which the sum of consumer surplus and producer surplus is maximised.

Case B illustrates the impact of capping the market price for the case where the market wants to clear at a point above the price cap. The diagrams show suppliers withdrawing from the market due to the price caps. Suppliers have little incentive to supply gas which costs more to deliver than the capped market price allows or on which they cannot earn a profit[3], so the total quantity of gas made available has been restricted. While the consumers actually supplied benefit from a lower price, the reduced gas supply means that the sum of consumer and producer surplus is reduced. The efficiency of the market is reduced. Less restrictive applications of price caps will alleviate this problem and improve total economic surplus.

On the other hand, less restrictive gas market parameters increase the risk exposure of participants in the market to the extent they are exposed to the market price. Exposed participants are required to

[2] Once involuntary curtailment occurs APC will apply anyway. Consequently, this assessment is limited to situations where involuntary curtailment is not required.

[3] Under administered pricing the gas markets do offer cost-based compensation for suppliers scheduled with costs higher than APC. However, suppliers are not guaranteed to have their costs compensated fully and may prefer to move the gas to other markets or to other days (where they can get a profit). Suppliers also may not want to reveal their costs. In this study we assume that where supply can be withdrawn without causing involuntary curtailment it is withdrawn from the market.

buy expensive gas to either fulfil their obligations to retail gas consumers, or support their own industrial or commercial use of gas.

The measure of market risk of a firm (or participant) used in this study is the number of days it would take a firm of different sizes to recover the total lost profit from an event. It is defined as the ratio of the profit lost and the average daily profit, as defined by the total annual profit of the participant divided by 500 days, or:

$$\text{Days Lost Profit} = \frac{\text{Profit Lost}}{\text{Average Daily Profit}}$$

Each participant is normalised to consume an average of 1 GJ per day. For each participant type a representative but broad range of cost structures are considered. For gas retailers the average price and typical gas retail margin for a range of customer profiles are used to determine the average daily profit. The proportion of gas purchased under contract and the cost of contracted gas are also a factor in retailer profitability. For industrial users, the average daily profit is estimated over a wide range of gas intensities and final product margins.[4] Integrated participants are businesses who produce gas and conduct business in related markets. The average daily profit of these participants depends on similar factors for retailers but also the extent to which contractual commitments or physical outages limit their hedging in gas markets. For each participant type the profits are estimated based on the simulations of scenarios discussed below, allowing the Profit Lost to be estimated and hence the Days Lost Profit under each scenario.

The definition of the average daily profit as the total annual profit divided by 500 days[5] (rather than 365 days) is measure used in prior reviews and maintained for consistency. This is deemed to be the point at which the potential for the participant to become insolvent arises.

3.3 The Grid of Gas Market Parameters

The methodology was applied to the grid of gas market parameters shown in Table 2. Specifically, each scenario/context was simulated with the application of each combination of one of the MPC/VoLL values, one of the APC values and one of the CPT values.

[4] In the Consultation Report we proposed to determine values for industrial users based on ABS statistics. Those statistics would give a measure of the intensity of use of gas by industry and hence the potential lost profits due to the loss of gas. In practice, while the ABS statistics guided the selection of the range of gas intensity, we considered a wide range of values to account for atypical or future entrants to the market.

[5] The 500 days foregone gross operating profit is approximately equal to 10% of annual operating costs for a typical retailer. This would be manageable for some larger established participants or non-retailers who do not intensively use gas but perhaps not for smaller new entrant participants. It is a compromise value that has been used as a yardstick in previous analysis, e.g. DWGM CPT Review 2013 –Final Report, AEMO, 2013.

Table 2 – The Grid of Gas Market Parameters Studied

Parameter	Current Value	Grid Points
Market Price Cap (MPC) Value of Lost Load (VoLL)	STTM $400/GJ DWGM $800/GJ	$400/GJ, $600/GJ, $800/GJ, $1000/GJ
Administered Price Cap (APC)	STTM $40/GJ DWGM $40/GJ	$40/GJ, $60/GJ, $80/GJ
Cumulative Price Threshold (CPT)	STTM $440/GJ DWGM $1800/GJ	$600/GJ, $1000/GJ, $1800/GJ $440/GJ (STTM only) $1400/GJ[6], $2500/GJ (DWGM only)

The lowest CPT value was only applied to the STTM, reflecting the current value, while the highest CPT value was only applied to the DWGM. This simplification was applied for computational efficiency. Combinations with CPT less than VoLL or MPC were not considered.

3.4 Assessing Gas Market Parameters

To assess gas market parameters, prior studies have exclusively focused on an outcome-based approach, which entails scenarios that are defined by specific outcome, like five days of application of APC, without considering the cause or the market machinations behind the scenario. By contrast the approach proposed for this review explicitly simulates periods in the future and extreme events that might occur. While more intensive, this modelling approach has the following advantages:

- It forces recognition that extreme events occur in different market contexts when the intrinsic supply and demand situations of a market may differ. This gives visibility of how the relative market efficiency and risk exposures change across the study period. Prior studies implicitly assume a static system throughout the study period,
- Given the infrequency of extreme events, it is impossible to tell if an outcome-based result reflects a credible or unrealistic event. Describing scenarios explicitly makes it possible to understand how realistic an extreme outcome is, and whether or not a particular type of extreme event is likely to generate participant risk. In particular, our approach requires analysis of which events are plausible in terms of the scope of the administered pricing mechanism, and which would not trigger other interventions.
- It allows more complex scenarios that involve interaction between gas markets and the electricity market to be explored.

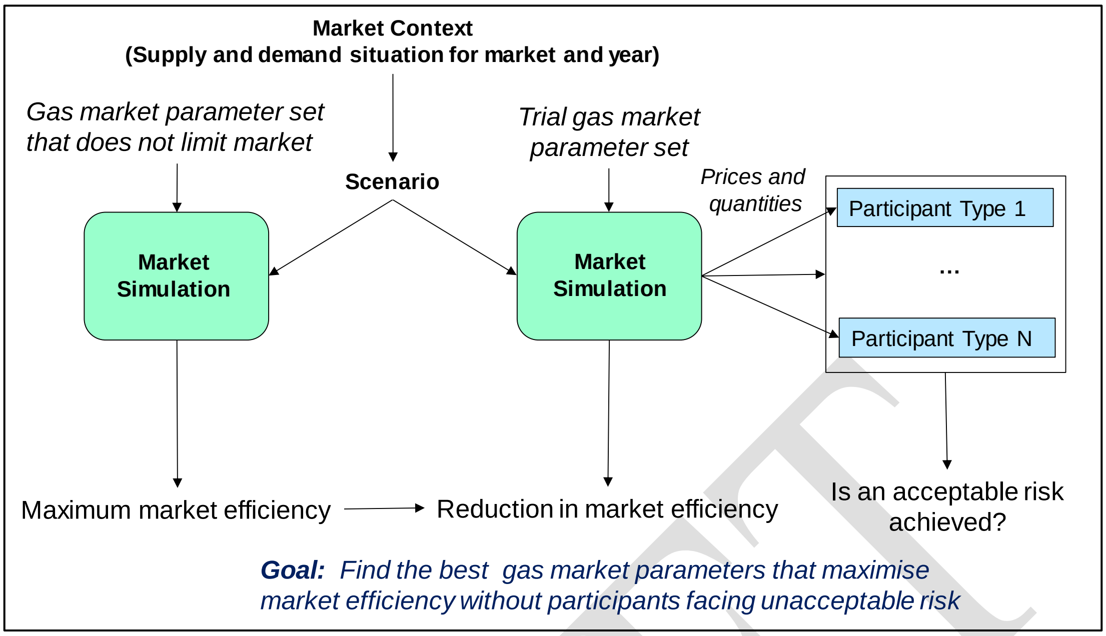
Applying this new approach, the performance of our grid of gas market parameters was assessed by simulating the application of those parameters across a range of situations. In each case the level of relative market efficiency and the degree to which risk exposures for a range of participant types was assessed. By varying the key setting in the scenarios, the sensitivity of each parameter setting can be assessed.

A strongly performing set of gas market parameters would consistently produce higher market efficiency in different situations while maintaining an acceptable risk exposure for all represented participant types. If a set of gas market parameters were to perform very well in some cases but very poorly if the scenario was slightly change under a sensitivity analysis then that would make that parameter setting less attractive. If the current gas market parameters were found to be in the strongly performing set of possibilities that would suggest no need to change them. However, if the current gas market parameters perform noticeably less well than others than that would suggest grounds for change.

Figure 2 provides an overview of the solution methodology for the parameter assessment problem.

[6] CPT of $1400/GJ was considered only in conjunction with VoLL of $800/GJ and APC of $40/GJ as part of a process to tune the parameter recommendation. This parameter selection is detailed in Section 6.2.2.2

Figure 2 – Overview of the Methodology



The key concepts in Figure 2 are:

- A market context describes a specific market, in a specific year with some specific supply and demand conditions. For example, this could be the DWGM in 2021 with the supply and demand figures as forecast by the Victorian Gas Planning Report.
- A scenario represents a specific event that happens in that a market – such as production problem or some the impact that a broader gas market issue has on the market under study. The scenarios are described in Appendix B.
- The gas market parameters used are sourced from the grid of gas market parameters discussed in Section 3.3, though it is used in two ways:
  - A set of parameters is used that does not limit the market. This set will have a range of values of VoLL/MPC but no administered price cap applied. This will correspond to the maximum market efficiency case, though the risks for participants may not be acceptable.
  - Each candidate gas market parameter set within the grid of gas market parameters, including different levels of CPT and APC, are applied independently to simulate the effect of those parameters.
- By simulating the market context across the event represented in the scenario, and for enough time to work through the flow-on effects of the cumulative pricing period, we can assess the market efficiency and participant risk exposures for the different parameter sets.
- For a given VoLL/MPC the set of gas market parameters that does not limit market efficiency was used as a reference point to determine the loss in market efficiency for each parameter set with the same VoLL/MPC but with APC and CPT imposed.
- For each occurrence of APC, two variations of participant behaviour were considered. One variation has a "truncated variation" with market response modified to reflect the lack of willingness to offer into a capped market when cost is above the cap. The second variation is a "no-response" variation in which supply and demand curves are unchanged by the imposition of the APC.
- Given the parameters, and the resulting prices and quantities, we can assess the risk exposure for a range of hypothetical representative participants. This assessment is relative to an estimate of their profits derived by simulating the market context without the scenario occurring (not shown).

- The goal is to find those parameter settings which perform best in terms of minimising the reduction in market efficiency while maintaining acceptable risk.

3.5 Assessment of Implications for Investment

CPT settings should not deny efficient cost recovery. Our analysis of this is based on the use of LNG storage as a gas source that can be located where required. Data for the Dandenong LNG plant has been used in prior reviews and is used again in this review. We also assume that the only opportunities for LNG cost recovery arise during CPT events. Given a set VoLL/MPC level, the amount of revenue required to be earned during a CPT event to achieve the reasonable recovery of LNG costs implies a lower financial constraint on the gas market parameters that will allow cost recovery.

We adopted an approach similar to that employed in other reviews. Our approach was as follow:

- Using LNG investment costs, required rates of return and an assumed annual event frequency, we can estimate the annualised cost of capacity built that must be recovered from profits during a CPT event.
- Given the fixed and variable cost structure, the profit requirement can be transformed into a revenue requirement.
- Given the operational characteristics of the Dandenong plant we can calculate the output of the plant across individual periods. The results will vary with inputs so we conduct some sensitivity analysis around those factors that could influence the potential to recover costs.
- The revenue generated is a function of the output of the plant and pricing throughout the event. The level of CPT required to achieve cost recovery is partially dependent on the levels of VoLL and APC.

By assessing the extent of revenue recovery for a range of parameters it is possible to determine sets of alternative gas market parameters that would support investment cost recovery. This provides information on whether potential gas market parameters determined from the simulation are acceptable with respect to supporting investment.

4 CONSULTATION FEEDBACK

4.1 Feedback Received

The Consultation Report described the goals and bounds on this work, the methodology and an initial set of proposed scenarios. Two responses were received in the consultation. These responses supported AEMO's position of reviewing the DWGM and STTM together. There was common preference expressed for aligning parameters between markets. There was recognition in one response that while the electricity market is quite different some logical consistency between the parameters would be beneficial.

Feedback received following the GWCF workshop on February 2018 elaborated more on the issue of aligning markets. The view was expressed that VoLL in the DWGM should be set to match the current value of APC in the STTM. Arguments for this included:

- The risks associated with the value of VoLL discourages small participants with limited supply portfolios from entering the market due to a low level of hedge ability.
- A lower price cap would lower the risk premiums resulting in lower prices to consumers.
- It was also suggested that DWGM prices have not been particularly high in recent years so lowering VoLL would not impair the market.
- It was suggested that alignment of gas markets is a direction being pursued as part of east coast gas market reforms, which is understood to refer to AEMC reviews of east coast and DWGM arrangements.

4.2 Commentary on Feedback Received

As already described in Section 2.2, the roles of VoLL and MPC are not primarily to limit risk. That is the role of CPT and APC. VoLL and MPC should be set at a point high enough to allow the market to clear. They can achieve that with different values.

The methodology used in setting parameters is focused on managing risks for a diverse array of participants including small participants. It determines a level of risk through a methodology, the core features of which have been used across a number of parameter reviews. This methodology accounts for and addresses risk issues associated with small participants. That said, it is not the role of market price caps to limit the need for participants to hedge. An unhedged participant is a risk to its customers and a risk to the market. This is not to say that there may be limitations in the ability to secure a hedge, but the correct way to address that is by addressing the source of the problem rather than changing the market design to transfer the risk from retailers to suppliers.

While the DWGM has not experienced a price at VoLL since 2008, the events under discussion are by their nature infrequent. The future forecasts indicate tighter supply conditions. More gas storage capacity could help the situation. Investment in gas storage has occurred before in the DWGM and it may be a useful contribution to the supply mix in the future. Such facilities need flexibility to price gas so as to trade-off the value of releasing gas with the value of storing gas. The level of VoLL has a strong bearing on the value of such facilities.

The current VoLL setting of $800/GJ was set in the late 1990's at the commencement of what is now the DWGM. The current STTM MPC value was set to $400/GJ at the time that the STTM was established a decade later. The methodologies for setting these parameters had changed between those points in time. The study that gave rise to the MPC setting[7] concluded that $400/GJ was sufficient for investment though a value of up to $800/GJ would meet the requirements. It was noted that the $400/GJ value produced a risk of arbitrage between the STTM and the DWGM during multiple day gas disruptions. It was concluded that a value of $800/GJ could be applied in the STTM if there was a concern about arbitrage between the STTM and DWGM. It should be noted that the DWGM parameter settings were not in the scope of that review.

[7] STTM Market Settings Analysis, Report to VENCorp, MMA, 2009.

The issue of aligning MPC and VoLL was raised in the 2012 review.[8] In the light of other reviews occurring at that time, AEMO focused solely on whether the current parameters were set appropriately in the context of the market design. AEMO observed that there are significant differences between the markets. In particular:

- The STTM is designed to facilitate balance variations in daily gas demand between shippers and gas users. The DWGM, by contrast, is a more dynamic gas market for trading gas.
- The STTM operates as a day-ahead market while the DWGM operates as an intraday market.
- While AEMO operates the gas network and manages linepack in the DWGM there is no single operator for the STTM, with pipeline owners and network owners controlling their own networks – and linepack - in isolation. That aspect of the STTM makes trading gas between STTM facilities more complicated and less robust than trading gas within the DWGM.

In that review no changes were made to MPC or VoLL.

In this review we further note that there are differences between the DWGM and the STTM as to how CPT is applied. In the DWGM if a price causes the cumulative prices to breach the CPT then the administered pricing period commences from the start of the period to which that price applies. This means that the price that breaches CPT is capped. This is not the case in the STTM. Instead when CPT is breached for a gas day the administered pricing period commences only on the following gas day. The consequence of this is that in the STTM if a price of MPC causes a breach of CPT then that price will apply. In the DWGM if a price of VoLL causes a breach of CPT then APC will be applied.

In feedback received there were references to current reviews, which include the AEMC's East Coast Wholesale Gas Market and Pipeline Frameworks Review[9], and the AEMC's Review of the Victorian Declared Wholesale Gas Market[10]. These reviews have not at the time of writing lead to any actual rule changes so it would not be appropriate to make assumptions about the precise outcomes of those processes. But it is relevant to note that the nature of changes described in those reviews is not specifically to align the design of the markets. Indeed, they seem to propose quite different designs for the STTM and the DWGM. The STTM demand hubs would become hubs to trade pipeline imbalances, much like the Wallumbilla hub, while the DWGM would have changed pricing processes, and probably, scheduling processes. Alignment of price caps is not explored in recommendations, though Section 4.1.4 of the review of the DWGM does mention that the values of VoLL and CPT might need to be reconsidered in the context of a changed design and that such matters would be considered as part of any rule change. The key message is that those reviews are considering different designs to those for which this current review is being conducted.

Later sections will report on the sets of parameters that provide acceptable risk protection while highlighting their trade-offs with market efficiency. The current VoLL has been used in the DWGM for almost 20 years. The markets are heading into a period of tighter supply and demand and a market response to those conditions is best achieved by maximising the ability of the market to respond efficiently to those conditions. It was observed in Section 2.2 that an optimal long run equilibrium may actually cap prices at a level too low to allow a market to respond to situations arising from imperfections in forecasting, planning or investment. While there may be attraction to retailers in lower price caps to lower their unhedged risk, their consumers are still exposed to the risk of non-supply if the price cap is too low to allow the market to clear in extreme conditions. The gas market parameter settings of CPT and APC are designed to moderate the effects of VoLL or MPC values and to provide an upper bound on retailer risk exposure that can inform their hedging strategies.

To the extent that there are any issues in the availability of hedge instruments it is more appropriate to address those issues at source. A significant feature of the AEMC's reviews described above is that they are endeavouring to tackle the issue of hedge liquidity and achieving firmer access to gas transportation. It is reform in that direction which is a more appropriate direction for addressing concerns about difficulty of hedging.

[8] STTM and DWGM Parameter Review - Final Report, AEMO, December 2012.

[9] "Stage 2 Final Report, East Coast Wholesale Gas Markets and Pipeline Frameworks Review", AEMC, 23 May 2016.

[10] "Final Report, Review of the Victorian Declared Wholesale Gas Market", AEMC, 30 June 2017.

5 DATA SOURCES

5.1 Introduction

In this section we identify the data that used in this study. The principle documents referenced are:

- Gas Statement of Opportunities, (GSOO), AEMO, March 2017 and September 2017 update.
- Victorian Gas Planning Report (VGPR), AEMO, March 2017
- National Gas Forecasting Report (NGFR), AEMO, December 2016
- DWGM – CPT Review Final Report (DCPTR), AEMO, September 2013
- AEMO website: www.aemo.com.au
- ABS, Australian Bureau of Statistics website, www.abs.gov.au

5.2 Supply and Demand Data

5.2.1 Demand Forecasts (excluding GPG Demand)

Demand forecasts for each state, excluding GPG demand, were based on Table 14 in the NGFR. The demand in the DWGM and STTM hubs was assumed to change relative to 2017 data in proportion to the rate of change of these state level figures. Both 1 in 2 (i.e. average) and 1 in 20 (i.e. peak) demand day data was used.

5.2.2 GPG Demand

Base GPG price responsiveness was based on an analysis of NEM GPG demand data and NEM prices for the period 1 October 2016 to 30 September 2017. Capacity and heat-rate data was sourced from Tables 12 to 16 of Fuel Resource, New Entry and Generation Costs in the NEM, ACIL Tasman, Prepared for the Inter-Regional Planning Committee April 2009.[11]

Growth in GPG generation over time could be inferred from the difference between NGFR Table 13 which forecasts total demand, and NGFR Table 14 which forecasts demand excluding GPG demand. As the NGFR provides data by year to 2021 and then only for 2026 and 2036, the data was interpolated linearly between 2021 and 2026.

5.2.3 Gas Supply Changes

For the DWGM the primary source of information was Table 15 of the VGPR. This provides data for Victorian gas fields through to 2021. Eastern Gas Pipeline flows were removed from that data. It was assumed that projected estimates of the prospective gas available in the future would be available. Data beyond 2021 to 2024 was extrapolated. The extrapolation was subjective but conservatively optimistic. It made use of annual and maximum demand data for 2021 and 2026 from the NGFR, VGPR annual and daily data to 2021 and GSOO data. The final values used are shown in Table 3.

Table 3 – Assumed Daily Production by DWGM Gas Fields by Year (TJ/day)

DWGM supply source	2019	2020	2021	2022	2023	2024
Gippsland	715.1	750.7	624.7	606.4	718.7	690.4
Port Campbell	82.2	46.6	38.4	30.1	21.9	13.7

For Iona and Moomba (which can supply gas from further north) throughput is assumed to be proportional to demand.

5.2.4 Historic Market Bid and Offer Data

Gas market bid and offer curves were derived from historic data for the period 1 October 2016 to 30 September 2017 available from the AEMO website. For the DWGM bids and offers for the 6 AM

[11] https://www.aemo.com.au/media/Files/Other/planning/419-0035%20pdf.pdf.

schedules were used. For the STTM hubs the ex ante bid data, MOS stacks and contingency gas offers were used.

Bids and offers were adjusted for future years and scenarios as follows:

- Non-price responsive demand was adjusted based on demand applicable to the scenario.
- Storage through put was scaled with demand.
- Contract levels were adjusted based on the available supply and bids and offers were shifted relative to those new contract positions.

The levels of non-GPG price responsive gas demand was assumed to be static.

5.3 Pipeline and Facility Capacity

Because the simulation does not model pipelines and storage capacity explicitly, restrictions that would normally appear in such a model must be incorporated in the supply and demand curves.

For the STTM hubs we applied the pipeline capacities declared for 1 October 2017 as the maximum facility capacity at each STTM hub. These values are shown in in Table 4. This capacity will supply GPG in the hub (Swanbank in Brisbane) and any GPG backhaul from the hub. Any GPG consumption outside the hub could reduce the capacity to the hub on a given day.

***Table 4 – Maximum Pipeline Capacities for STTM Hubs*.**

Pipeline	STTM Hub	Capacity (TJ/day)
Moomba Adelaide Pipeline (MAP)	Adelaide	274.5
SEAGAS Pipeline	Adelaide	216.0
Roma to Brisbane Pipeline (RBP)	Brisbane	189.3
Eastern Gas Pipeline (EGP)	Sydney	335.0
Moomba Sydney Pipeline (MSP)	Sydney	326.0
Newcastle Gas Storage (NGS)	Sydney	120.0
Rosalind Park Production Facility (ROS)	Sydney	11.4

DWGM pipeline capacities between Longford, Iona, Melbourne and interconnected transmission pipelines were sourced from Appendix A of the VGPR. National Gas Bulletin Board data was also used.

Often more gas is bid or offered than can physically be supplied. Some refinements to data to correct for differences between facility potential output and maximum quantities offered or cleared were therefore made in consultation with AEMO and based on data for the period 1 October 2016 to 30 September 2017.

In general plant and pipeline capacities are assumed to be constant over time, apart from announced expansion.

5.4 Participant Profitability Data

The profitability calculations for each participant type are based on the data in Table 5. Participant data has not been selected to represent any specific current participants. A variety of participant characteristics have been assumed to cover the possibility of new or different types of participants, or participants of existing type with different operating models.

Table 5 - Participant Profitability Data

Metric	**Retailers**	**Retailers – Tight Market**	**Industrial Participants**	**Integrated Participants**
Gas Price Data				
Average Spot Price	$7/GJ	$7/GJ	$7/GJ	$7/GJ
Gas Hedging Data				
Proportion of peak demand hedged	10%-80%	10%-80%	10%-80%	10%-100%
Proportion of gas demand hedged	5%-85%	5%-85%	5%-85%	5%-90%
Contract Premium	5%	6%-10%	7%	5%
Commercial Data				
Fraction of demand that is residential.	20%-90%	20%-70%	0%	20%-90%
Fraction of demand that is commercial/industrial.	80%-10%	80%-30%	100%	80%-10%
Gas Cost Fraction - Residential	29%	29%	0%	29%
Gas Cost Fraction – Commercial	69%	69%	100%	69%
Gas Cost Fraction – Participant	Function of customer profile (see below)	Function of customer profile (see below)	10%-40%	Function of customer profile (see below)
Profit Margin	7%	Function of cost retail pricing and cost structure	5%-20%	Function of retail pricing and cost structure

The range of values considered are shown in the table for a range of participant types:

- Retailers, though we have separated the special case of a tight market where hedging is more expensive.
- Industrial Participants, who buy from the wholesale gas market; and
- Integrated Participants, who both supply and consume gas (and who may also operate in the related markets).

The following sections explain the terms used in Table 5 and detail the rationale for the values chosen in each section. Profitability data was based the range of customer profiles described in DCPTR. Information on industrial users is based on data from ABS.

5.4.1 Gas Price Data

Determining the normal profitable of a participant requires information on the average spot price of gas and the average contract price. An average spot price $7/GJ was assumed across the study period.

5.4.2 Gas Hedging Data

To determine hedging performance in each scenario, the relevant metric is the level of hedging as a percentage of the peak demand/gas purchase. For retailers and industrial participants, the range analysed is from 10%-80%. For integrated participants we extend this range to the case where production capacity covers all contracts written. In each case the range chosen is to demonstrate a wide range of participant impacts.

The overall profitability of a participant depends in part on the proportion of gas demand hedged throughout the year. We consider a range of value from 5%-85% for all participants with 5%-90% for integrated participants.

Gas that is purchased on contract may attract a risk premium. We have adopted an approach applicable to the most vulnerable in the market who may struggle to obtain contracted gas and/or pay a risk premium when they do. For each participant, the level of the risk premium is based on the retail margin of 7% as noted in DCPTR). For retailers and integrated businesses, we have adopted a contract risk premium of 5% above the spot price, but less than the 7% we expect retailers themselves to achieve when selling to end users. Retailers operating in a tight market are subjected to 1%-5% increases in risk premium. For industrial users we have adopted a higher basic premium of 7% to account for higher transaction costs associated with industrial customers who may also have more demanding consumption profiles. Finally, in the absence of definitive data, we have allowed for contract premiums to increase by between 1% and 5% in response to the predicted tightening of gas market.

5.4.3 Commercial Data

For a particular scenario, the customer profile of a participant will influence participant profitability and exposure to risk. For retailers and integrated participants, a wide range of proportions are considered to account for consumer focussed participants through to commercial focussed participants.

The DCPTR review assumed the cost of gas represented 29% of the total gas contract price for a typical residential gas contract, and we have adopted that value. This reflects higher marketing and other costs in dealing with smaller users. The share of gas costs for commercial contracts is much higher at 69%, reflecting lower transaction costs for larger customers. The Gas Cost Fraction – Participant is a measure of the share of total costs gas comprises for each business. For retailers and integrated participants, this is an average of the gas cost proportions of residential and commercial customers, weighted according to the share of each in their customer portfolio.

Industrial users are their own end-users and do not on-sell gas. Instead they produce a range of products for which gas is an input. The proportion of gas used by industry can be calculated as the ratio of industry energy consumption ($) to industry total revenue ($) as presented by the ABS. The average gas use intensity by industry is typically very low, however we consider 10%-40% to reflect individual firms significantly exceeding sector average gas penetration.

Finally, we consider retail margins. For retail participants, other than in a tight market, we used the 7% value used in the DCPTR. Given the cost information, this implies the revenue associated with one GJ of gas given a particular customer mix. While participants with the same customer mix also will have the same revenue amount, it is necessary to calculate the retail margin based on individual cost structures. For industrial users, the ABS provide information on profit margins by industry categories. These typically range from 10%-40%. The latter figure was for the mining industry so in keeping with the requirement to focus on business' most susceptible to risk we considered the modified range of 5%-20%.

5.5 Investment Cost Data

For the purpose of determining the applicable revenue sufficiency-based CPT bound described in Section 3.5, the most efficient new investment option is considered to be an LNG facility such as that in Dandenong. Table 6 states costs for establishing an LNG facility (such as that in Dandenong in the DWSG) as established in 2013 alongside the values adopted in this report

Table 6– LNG Investment & Operating Expense Assumptions[12]

Assumption	2013 Input Value	Adopted Value (2018)
Capital Cost	192,000/tonne	210,000/tonne
Fixed Costs	$0/GJ	$0/GJ
Variable Costs	$0.50/GJ	$0.55/GJ
Expected Life of Facility	30 years	30 Years
WACC	7%	6.67%
Average Utilisation in Event	50%	50%

Table 7 details the composition of the weighted average cost of capital (WACC) presented in Table 6. This value was not challenged by anyone in the consultation.

Table 7 – Weighted Average Cost of Capital[13]

	Estimated Values
Average nominal risk free rate	3.50%
Inflation	2.00%
Debt margin	2.00%
Market risk premium	7.50%
Debt funding	40.00%
Equity funding	60.00%
Corporate tax rate	30.00%
Effective tax rate for equity	30.00%
Effective tax rate for debt	30.00%
Equity beta	1.00
Cost of equity (nominal post-tax)	11.0%
Cost of equity (real post-tax)	8.8%
Cost of debt (nominal pre-tax)	5.5%
Cost of debt (real pre-tax)	3.4%
Post-tax Nominal WACC	8.80%
Post-tax real WACC	6.67%

[12] Data taken from Table 4-2: LNG Cost Assumptions, DWGM CPT Review 2013 –Final Report, AEMO, 2013.
[13] Adapted from modelling data used in the IPART Review of Regulated Retail Prices in their August 2015 model.

6 STUDY FINDINGS

6.1 Introduction

In this section we present the study findings that inform our conclusions and recommendations.

Each combination of market context, such as a particular market/hub in a particular year, combines with a scenario and a particular set of pricing parameters to define a case. Relevant subsets of the case results are aggregated to produce the range of results presented in this section.

Section 6.2 presents the simulation results, which give information on both the market efficiency and financial exposure of retailers and industrial users across different years and market contexts for each set of gas market parameters.

Section 6.3 presents results and sensitivities around the impact of different gas market parameters on investment. That analysis services to indicate a lower bound on the acceptable gas market parameters. However, as the analysis assumes a specific technology and is based on relatively simple assumptions, this lower limit should not be viewed only as a guide, rather than a hard limit.

Section 6.5 draws out the range of acceptable gas market parameters, in the sense of being acceptable with respect to investment and risk exposure and highlights those that minimise loss of market efficiency.

Section □ concludes the analysis of the set of acceptable gas market parameters.

6.2 Simulation Results

6.2.1 Scenario Results

In this section we summarise the behaviours of the scenarios simulated. Additional detail is provided in Appendix C.

The scenarios used in this study are relatively extreme by design. Accordingly, the pricing outcomes are generally outside the range experienced in current day to day market operation. Most scenarios involve a number of coincident individual issues, one of which is the general level of demand. As a result, prices leading into an event vary from slightly heightened levels of $8/GJ through to $25/GJ. The price impact of subsequent events in the scenarios vary in intensity and longevity between scenarios. The intensity of the price impact in each scenario can be assessed using the average and maximum prices attained, relative to VoLL/MPC across the scenario.

Figure 3 – Average and Maximum Uncapped Price by Scenario as a Percentage of VoLL/MPC (DWGM)

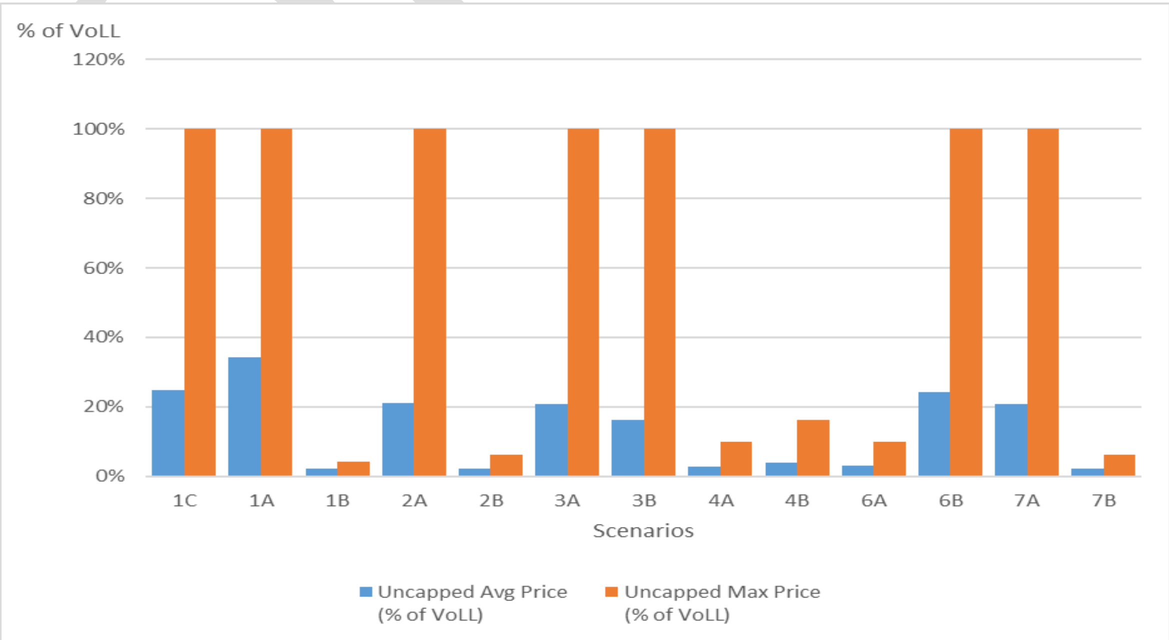


Figure 4 - Average and Maximum Uncapped Price by Scenario as a Percentage of VoLL/MPC (STTM)

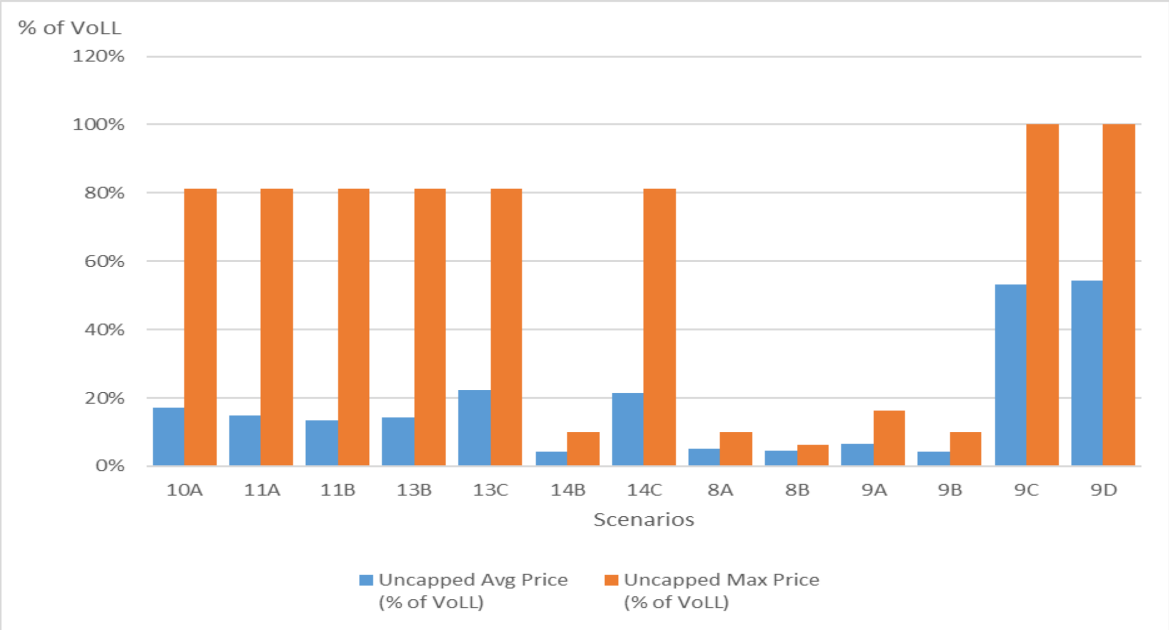


Figure 3 and Figure 4 show the average and maximum uncapped prices attained for each scenario in the simulation as a percentage of VoLL/MPC for the DWGM and STTM. In most DWGM scenarios the event causes the price to reach VoLL, although this depends on market context. For example, scenario 1 variations occurring in 2019 and 2021 result in the attainment of VoLL but in 2024 the market manages to meet supply without attaining VoLL.

Scenarios with higher prices tend to relate to 2019 and 2021 while those with lower prices tend to relate to 2024. These outcomes align with the general supply and demand trends.

In the cases simulated, the attainment of VoLL is typically sustained for a sufficient number of periods to breach the CPT. Once triggered, the APC limits prices to a lower upper limit than would otherwise apply until the administered pricing period ends. For each scenario, **Error! Reference source not found.** shows the average number of periods for which the CPT is breached and the applicable APC limits prices, providing a measure of the typical longevity of pricing implications of the event. Figure 6 shows the same for the STTM

Figure 5 – Average Number of Days CPT Breach and APC Limits by Scenario (DWGM)

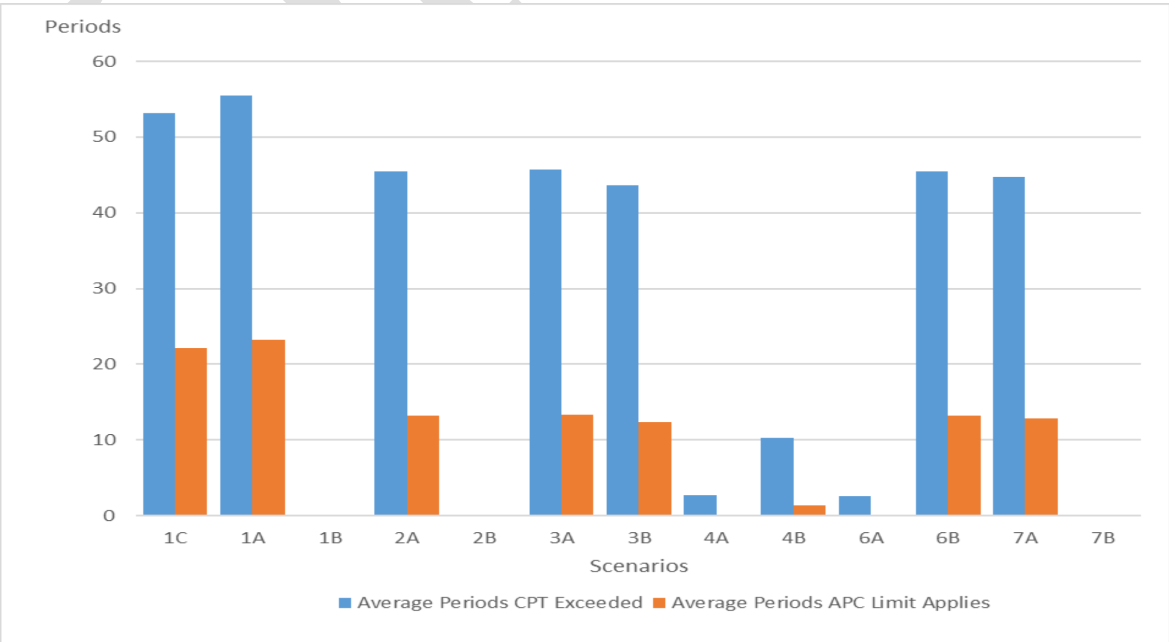
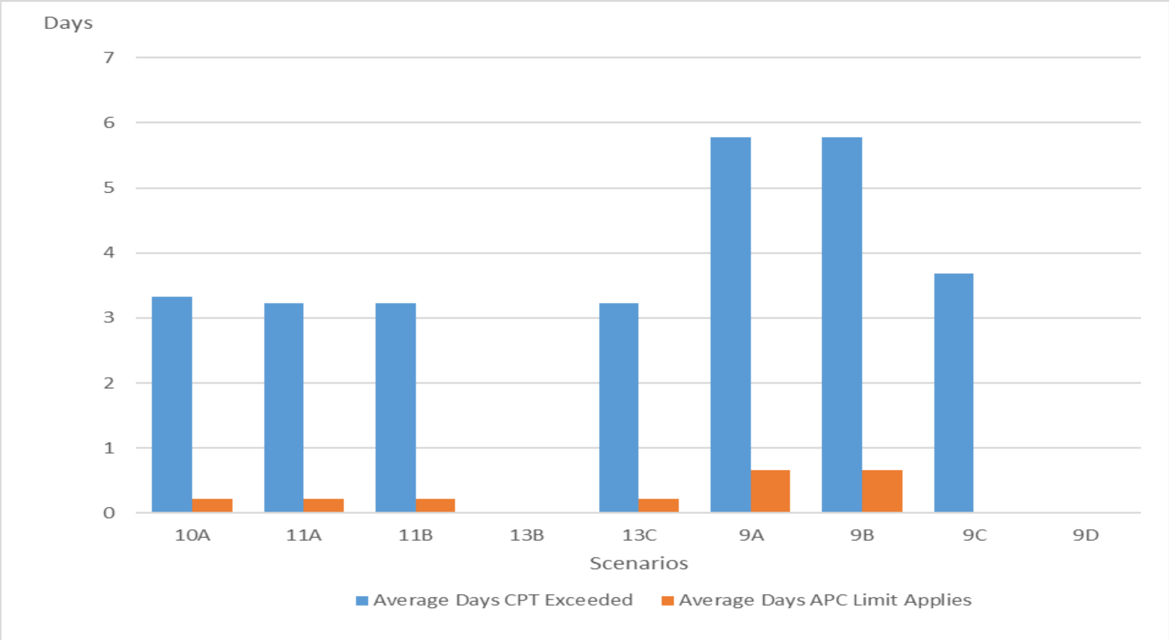


Figure 6 - Average Number of Days CPT Breach and APC Limits by Scenario (STTM)



It is apparent in the graphs presented above that a number of scenarios did not result in conditions extreme enough for prices to reach VoLL/MPC or to breach CPT. These cases fall into two broad groups.

- The first group includes scenarios 4, 9 and 10. These scenarios include gas powered generators (GPG), either within the DWGM or STTM hub or backhauling from an STTM hub. To ensure that GPG behaviour was reasonably realistic we used historic NEM prices, operational data and heat rates to form demand curves for gas. The operational of these generators did increase prices but only to the levels that was economic for the generators. A daily average NEM price of around $600/MWh corresponds to a maximum value of gas of between $40/GJ and $60/GJ for most GPGs. If gas prices go above these levels then the level of GPG generation reduced. While prices in the NEM can go much higher they would normally do so for much shorter durations requiring lower volumes of gas and hence having less impact on the gas market outcomes. In these scenarios the behavior of the GPGs prevented the gas prices spiking and while gas prices were increased they were not sufficient to breach CPT.
- The second group is represented by scenario 8, an STTM case. The Technical or Operational Conditions of the STTM procedures place limits on how much supply to the STTM can be restricted before AEMO can activate an Administered Market State which would have APC applied. To avoid this situation, we limited the restrictions on supply to the Sydney STTM Hub to be no more than a 5% restriction. With that limit, the simulation found sufficient other supply options to satisfy demand without prices reaching MPC or breaching CPT. While the simulation tool presents a simplified view of reality, most particularly in not modelling pressures, these scenarios give some insight into factors that can moderate prices even in scenarios that are extreme on paper. Even without these cases being extreme there were sufficient other interesting scenarios to support the analysis.

A set of cases are solved for each scenario with different values of VoLL/MPC but without applying CPT. These cases give a base level of total quantity supplied, including to serve exports and GPG, which can be taken as the most efficient market outcome. For other cases, under which CPT is applied the lower prices may restrict supply and lower overall level of quantity supplied. If, in either case, the reduction in supply is so severe that the market cannot satisfy uncontrollable demand, involuntary curtailment would result and the case is excluded from our analysis on the basis that the subsequent administered pricing period was not driven by the parameters under investigation.

The extent of the reduction depends on the quantity of offers above the APC and whether participants withdraw supply. Suppliers may be compensated for costs above the level of APC but for a number of reasons they may wish to truncate their offers at prices above APC. We assume that suppliers will withdraw supply as long as this does not lead to curtailment. In the DWGM, for example, the deductions ranged from 30TJ through to 250TJ.

The market efficiency loss is defined as the lost consumer surplus as a result of implementing the gas market parameters. Where the amount of gas cleared by the market does not change, there is no efficiency loss. Instead there will be a wealth transfer between supply and demand participants where prices have changed. If supply is truncated above APC then some demand bids that were previously accepted will no longer be supplied.

Figure 7 and Figure 8 show the average and maximum efficiency losses in each scenario in which the total quantity cleared by the market is reduced.

Figure 7 - Average and Maximum Efficiency Loss in Scenarios with Altered Volume (DWGM)

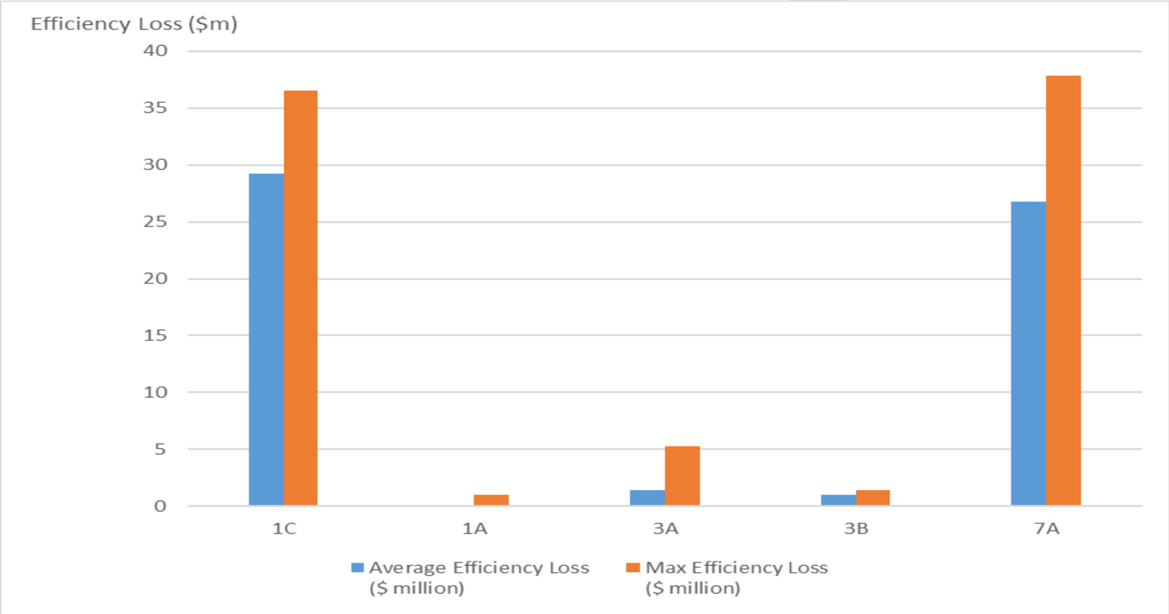
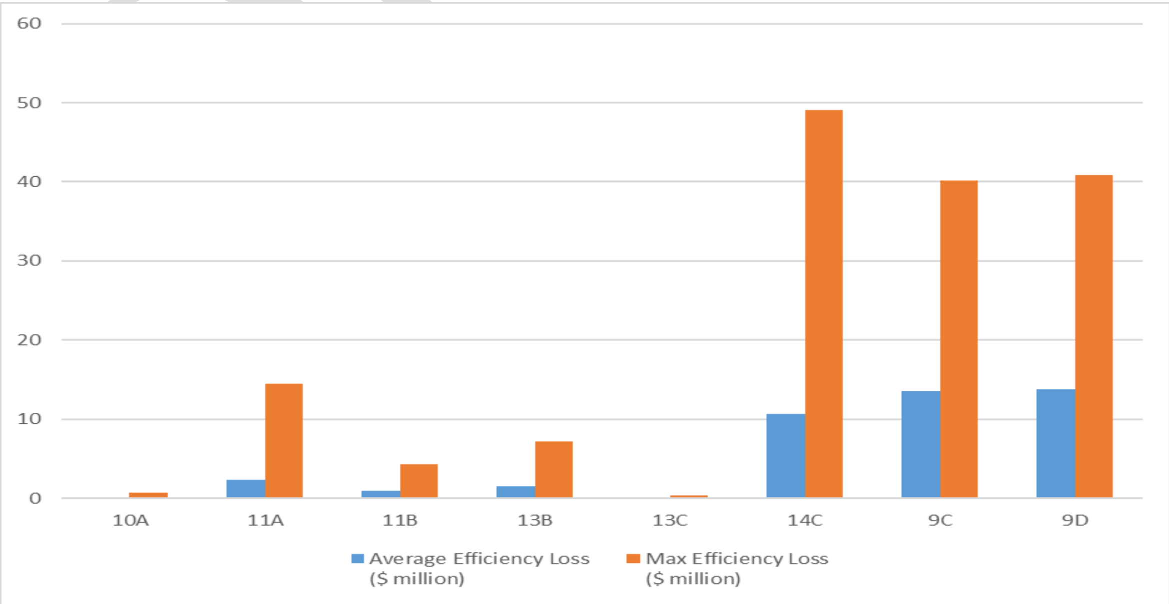


Figure 8 - Average and Maximum Efficiency Loss in Scenarios with Altered Volume (STTM)



In the DWGM and STTM the level of efficiency loss incurred depends on the level of reduction in the quantity cleared. In the DWGM, these reductions represent the loss of consumer surplus associated with uncleared bids for GPG units, and reduced exports. In the STTM hubs with no in-hub GPG units these are reflective of unfulfilled export bids. Depending on the market context there may be significant variation in the quantity of bids affected, and this drives the large variation in the expected losses under each scenario. Efficiency losses are therefore not solely a function of event severity.

The application of administered pricing reduces the risk exposure of consumers, which we measure by the risk exceedance percentage. We define Risk Exceedance as the proportion of case/participant combinations within a scenario with exposure to risks greater than 500 days gross operating profit for combinations of gas market parameters where CPT and APC are applied and APC is activated. Figure 9 shows the average and maximum level of risk exceedance in the DWGM by scenario. Cases run with gas market parameters that do breach limits do not contribute to these results. Figure 10 shows the corresponding results for the STTM.

Figure 9 – Average and Maximum Risk Exceedance by Scenario (DWGM)

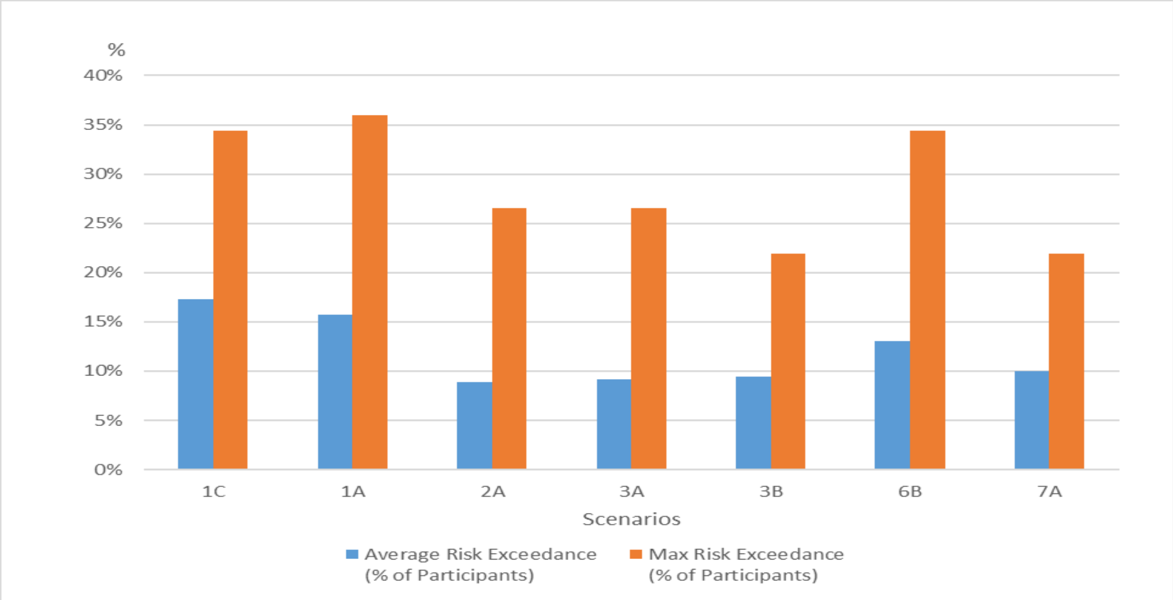
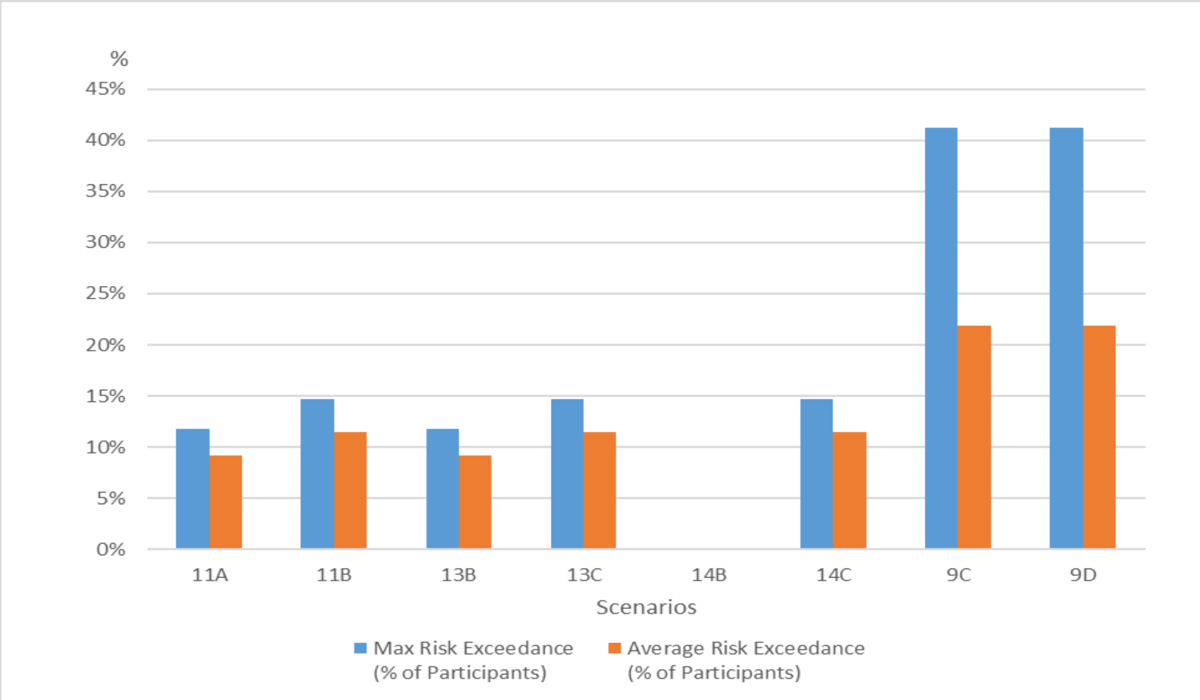


Figure 10 - Average and Maximum Risk Exceedance by Scenario (STTM)



The gas market parameter sets that give rise to non-zero maximum risk exceedance are not appropriate settings for the market to adopt as they indicate excessive risk to participants in one or more cases.

6.2.2 Market Results

In this section results by market and year are used to identify gas market parameter sets for each market that are acceptable throughout the study period. For each market this involves the following steps:

- Calculate the effective exposure for each hypothetical participant. The effective exposure is the percentage of a participant's total cost structure that is exposed to spot gas prices.
- Using historical 2016/17 gas market data, determine whether the participant would be protected by current gas market parameters in the current market context. To maintain consistency of protection, those not protected are removed from future consideration.
- Given a participant's effective exposure, determine its days of lost profit based on simulation results for different markets and simulated years. Identify situations where the 500 days of lost operating profit criteria is breached.
- Determine the parameter sets for each market and year studied that are compatible with the maximum 500 day lost operating profit criteria.
- Determine the subset of parameter settings suitable for all years studied.

6.2.2.1 DWGM Results

For each participant we assess the days profit at risk using the current market parameters in the current market context using average annual gas prices to assess normal profitability. Each participant is also associated with a level of effective exposure. In the DWGM, participants with greater than 61% of their total cost structure exposed to spot market gas prices are not protected by current gas market parameters in the current market context. Participants in this category typically have a combination of very low hedging levels and gas as a large proportion of their cost base.

The maximum effective exposure is a proxy for the level of protection that a future set of parameters should provide. Anything above that would imply an increase in the scope of risk management afforded by the parameters, while anything below would imply a reduction in the same. The same limits on exposure were used as were used to set the current parameters. The maximum effective exposure of any studied participant in the DWGM is 55% so all representative participants are considered protected by current parameters, and therefore none were removed from consideration in future years.

Table 8 shows the gas market parameter combinations for which no remaining participant is exposed to greater than 500 days lost operating profit in any of the scenarios contemplated by the simulation. While they have different levels of efficiency loss, the subsequent analysis indicates that the range of variation between them is not that great.

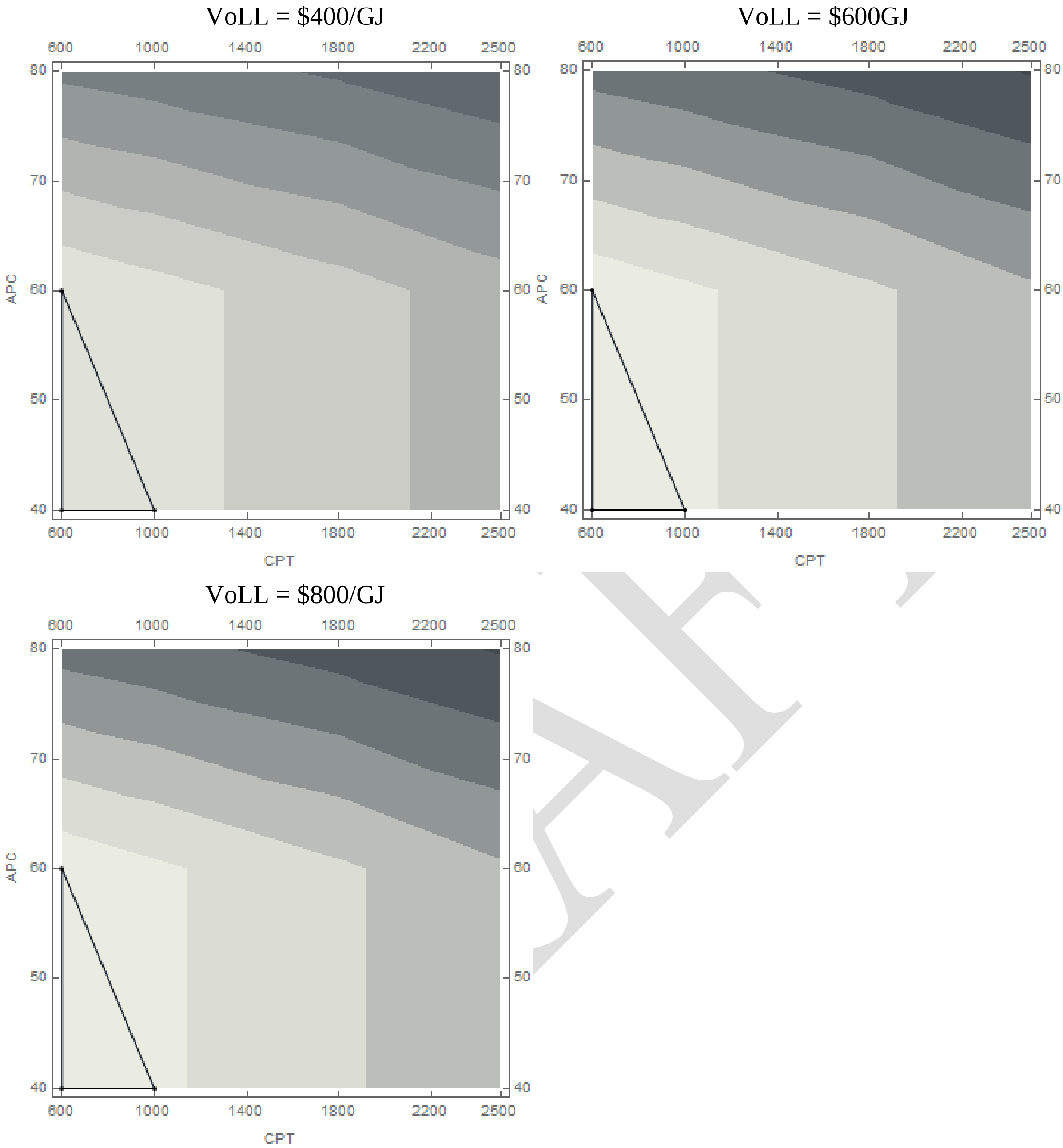
Table 8 - Acceptable Parameter Combinations Identified by Simulation by Year (DWGM)

Years Parameters Acceptable			Gas Market Parameters		
2019	2021	2024	VoLL ($/GJ)	CPT ($/GJ)	APC ($/GJ)
✓	✓	✓	400	600	40
✓	✓	✓	400	600	60
		✓	400	600	80
✓	✓	✓	400	1000	40
		✓	400	1000	60
		✓	400	1000	80
✓	✓	✓	600	1000	40
		✓	600	1000	60
		✓	600	1000	80
✓	✓	✓	800	1000	40
	✓	✓	800	1000	60
		✓	800	1000	80

The supply and demand conditions tighten towards 2021 and improve by 2024. While these conditions are not the sole driver of the results, there is a broader range of acceptable parameters for 2024 than for earlier years. Each of the three simulated years identified VoLL candidate values of $400/GJ, $600/GJ and $800/GJ. Taking these individually we can assess the preferred combinations of CPT and APC associated with each VoLL option in each year.

In Figure 11, and in similar figures that follow, each band represents an additional $1 million change in expected efficiency losses relative to the performance of the parameter set with no CPT applied. Darker shades represent lower efficiency losses and higher market efficiency. The region highlighted by the triangle represents the parameter combinations that are acceptable from the perspective of participant risk based on the parameter grid used. Note the actual efficiency loss recorded in each scenario varies significantly as shown in above in Figure 7. To keep the charts consistent there are ranges in which CPT is less than the VoLL value of $800/GJ, even though that would be a nonsensical set of parameters.

Figure 11 – DWGM Market Efficiency Loss and Risk Exceedance 2019 ($1 million steps)



The triangle in each of the three charts shown in Figure 11 contains all the parameter sets that provide satisfactory risk protection. The right most boundary of the triangle defines the most efficient parameters. For a given VoLL it is clear that a higher CPT and/or APC will increase market efficiency while a lower value will decrease market efficiency.

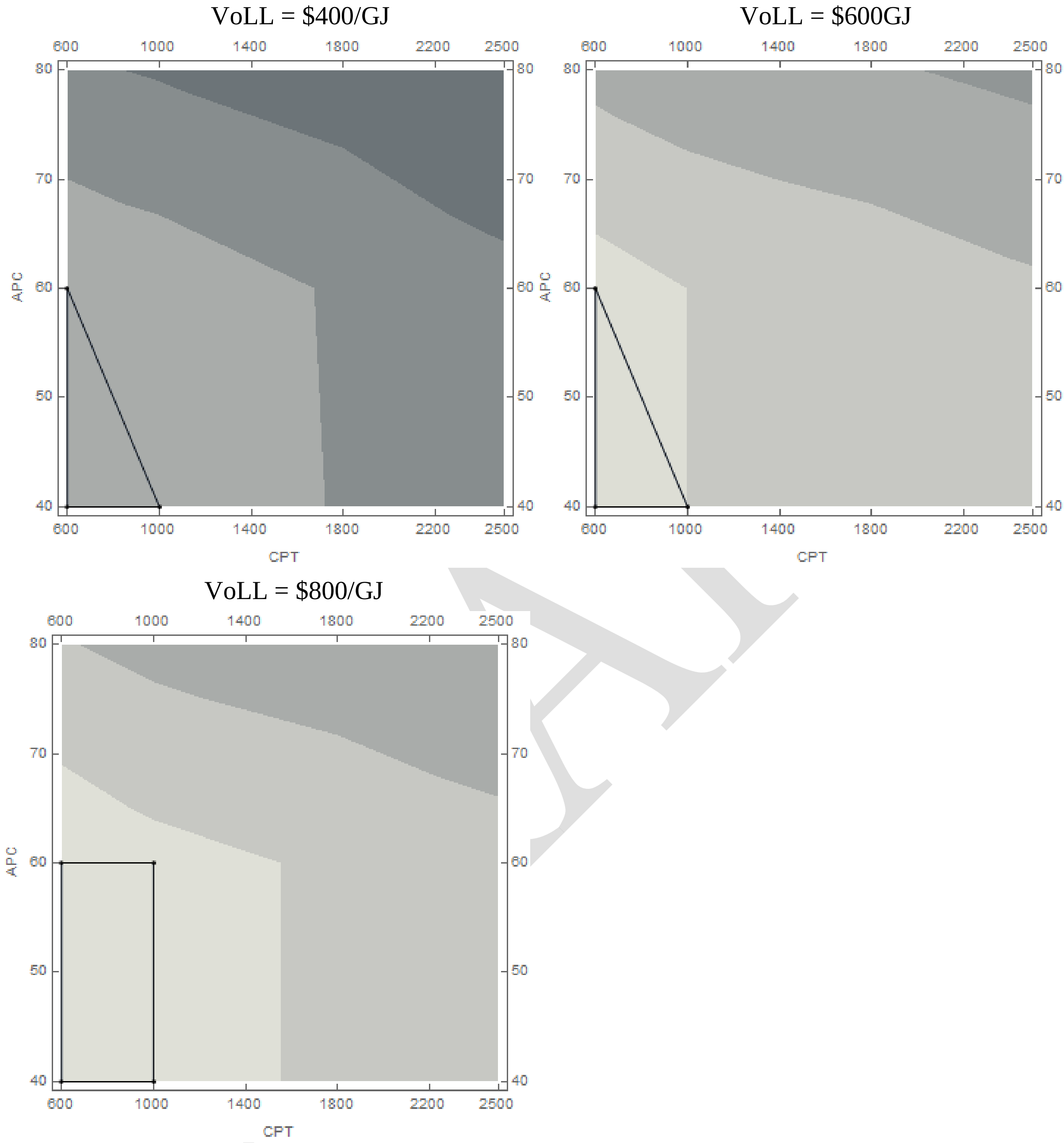
As VoLL increases, market efficiency can actually decrease for a given level of CPT/APC. With a fixed CPT, increasing VoLL increases the likelihood of the CPT being breached with the subsequent imposition of APC causing efficiency losses.

For 2019, the current DWGM market parameters lie outside the acceptable region as they were not found to provide acceptable risk protection. With VoLL of $800/GJ, CPT of $1800/GJ and APC of $40/GJ there was a violation of the 500 days of lost operating profit rule in 4.17% of cases simulated.

Based on the parameter grid, the efficiency maximising setting for each value of VoLL in 2019 involves CPT = $1000/GJ and APC = $40/GJ. An increase in the APC to $60/GJ would require a decrease in the CPT to $600/GJ, a level that would be non-sensical with a VoLL of $600/GJ or $800/GJ, and in any case would not be as efficient.

Figure 12 shows corresponding results for 2021. The variation in market efficiency loss between years is the result of different scenario mixes applying in different years, and is not indicative of lower efficiency losses in those years.

Figure 12 – DWGM Market Efficiency Loss and Risk Exceedance 2021 ($1 million steps)



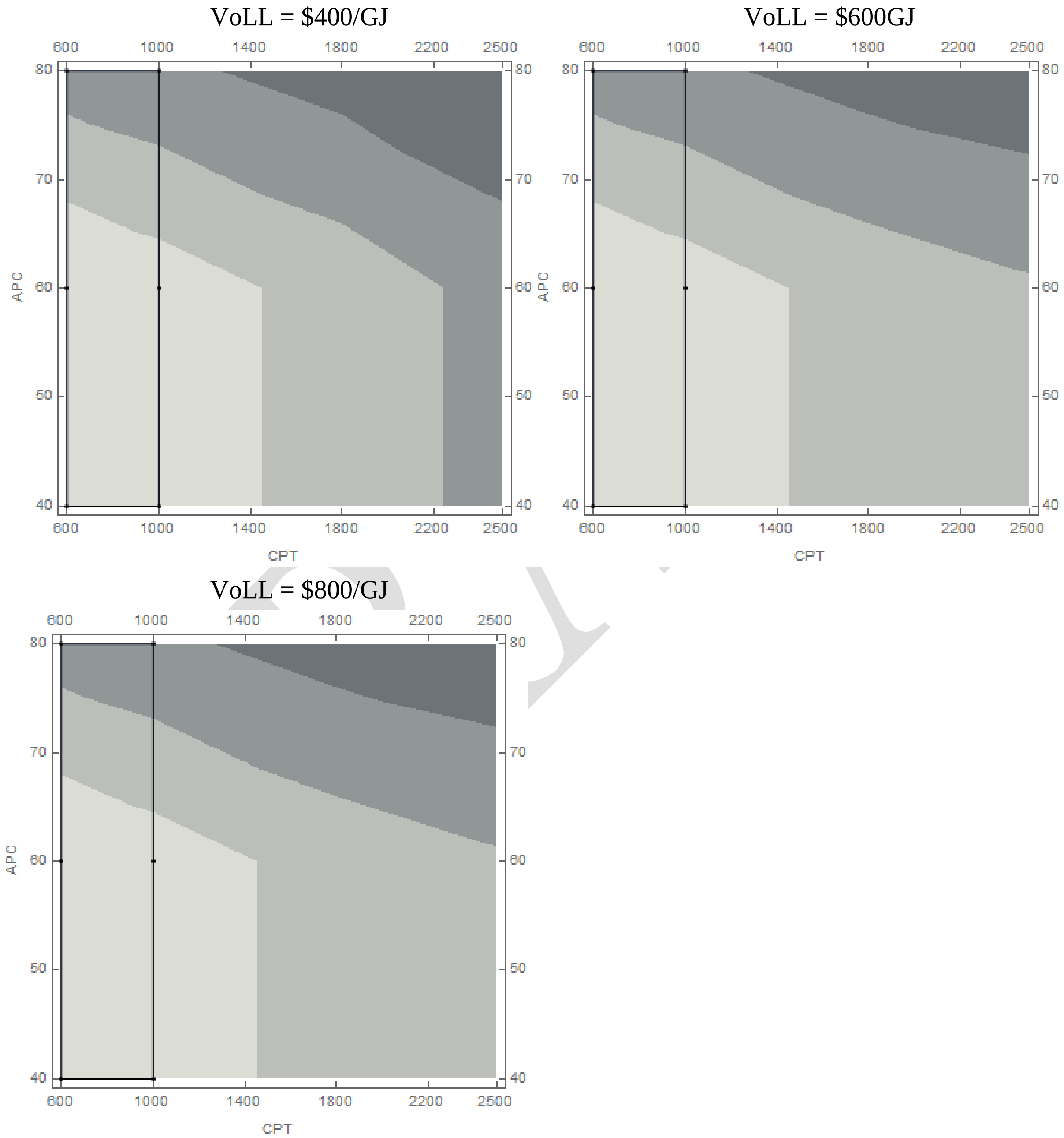
For 2021, the acceptable range of parameters is slightly expanded when VoLL = $800. The higher VoLL would normally be indicative of higher participant risk. In this case, however, the interaction with CPT is such that a higher VoLL can in some circumstances reduce the number of VoLL periods and in doing so provide increased protection to participants.

As before, the current DWGM market parameters lie outside the acceptable region as they were not found to provide acceptable risk protection. With VoLL of $800/GJ, CPT of $1800/GJ and APC of $40/GJ there was a violation of the 500 days of lost operating profit rule in 1.30% of cases simulated.

Based on the parameter grid, the efficiency maximising setting for each value of VoLL in 2021 vary from CPT = $1000/GJ and APC = $40/GJ when VoLL = $400/GJ or $600/GJ, and CPT = $1000/GJ and APC = $60/GJ when VoLL = $800/GJ. In the latter case, it is important to note that in general the level of efficiency loss is the same for an APC of $40/GJ within the bands shown, so efficiency alone would not be a major consideration in increasing the level of APC.

Figure 13 presents results for 2024. The results reflect generally more favourable market conditions. As before, though, the current DWGM market parameters lie outside the acceptable region as they were not found to provide acceptable risk protection. With VoLL of $800/GJ, CPT of $1800/GJ and APC of $40/GJ there was a violation of the 500 days of lost operating profit rule in 2.08% of cases simulated (noting that the scenarios represented in 2024 are a different subset to those used in 2019 and 2021).

Figure 13 – DWGM Market Efficiency Loss and Risk 2024 ($1 million steps)



Based on the parameter grid, the efficiency maximising setting for each value of VoLL in 2024 is CPT = $1000/GJ and APC = $80/GJ. As before, the level of efficiency loss makes little difference as APC is increased to $60/GJ, but beyond this value, efficiency losses do decrease as APC is increased. This result is a function of the specification of the demand curve in each case. In general, we would expect a more graduated increase in efficiency as APC is increased. The higher the value of APC, the fewer demand side bids will be excluded if suppliers withhold capacity.

Collectively, the simulation results for those gas market parameters studied show that whichever VoLL level is selected, the maximum efficiency obtained from the options defined by the initial parameter grid, while respecting the acceptable risk region in each year, is provided by CPT = $1000/GJ, and APC = $40/GJ.

6.2.2.2 An Additional Grid Point for the DWGM

Having completed an initial review of the parameters for the DWGM it become apparent that there was scope for an additional grid point. The current DWGM gas market parameters were found to be outside the acceptable range for the protection of market participants buying gas. This suggested that a CPT value of $1800/GJ was too high. Our grid included a CPT of $1000/GJ which was acceptable. However, there is relatively little headroom between a VoLL at $800/GJ and a CPT of only $1000/GJ or even $1200/GJ. The cumulative pricing period covers 35 pricing intervals and it is quite easy for the cumulative price to reach $400/GJ over that time, preventing a single period of VoLL being applied in the market before APC is applied.

To address this limitation, we explored results in the DWGM for VoLL = $800/GJ, CPT = $1400/GJ and APC =$40/GJ. These parameters were found to provide acceptable risk protection for market participants across all years studied. It was also a higher efficiency solution.

6.2.2.3 STTM Results

This section reports on the STTM results. Considering the performance at all hubs, those participants with greater than 30% of their total cost structure exposed to spot market gas prices are not protected by current gas market parameters in the current market context in the STTM. Among the representative participants used in the study, 23 out of a total of 64 have effective exposure levels greater than 30%. As these participants are not protected by current parameters in the current market context, they are removed from consideration in future years.

Table 9 shows the STTM parameter combinations for which no participant is exposed to greater than 500 days lost operating profit in any of the scenarios contemplated by the simulation. As with the DWGM, the efficiency loss variation is not that great between parameters.

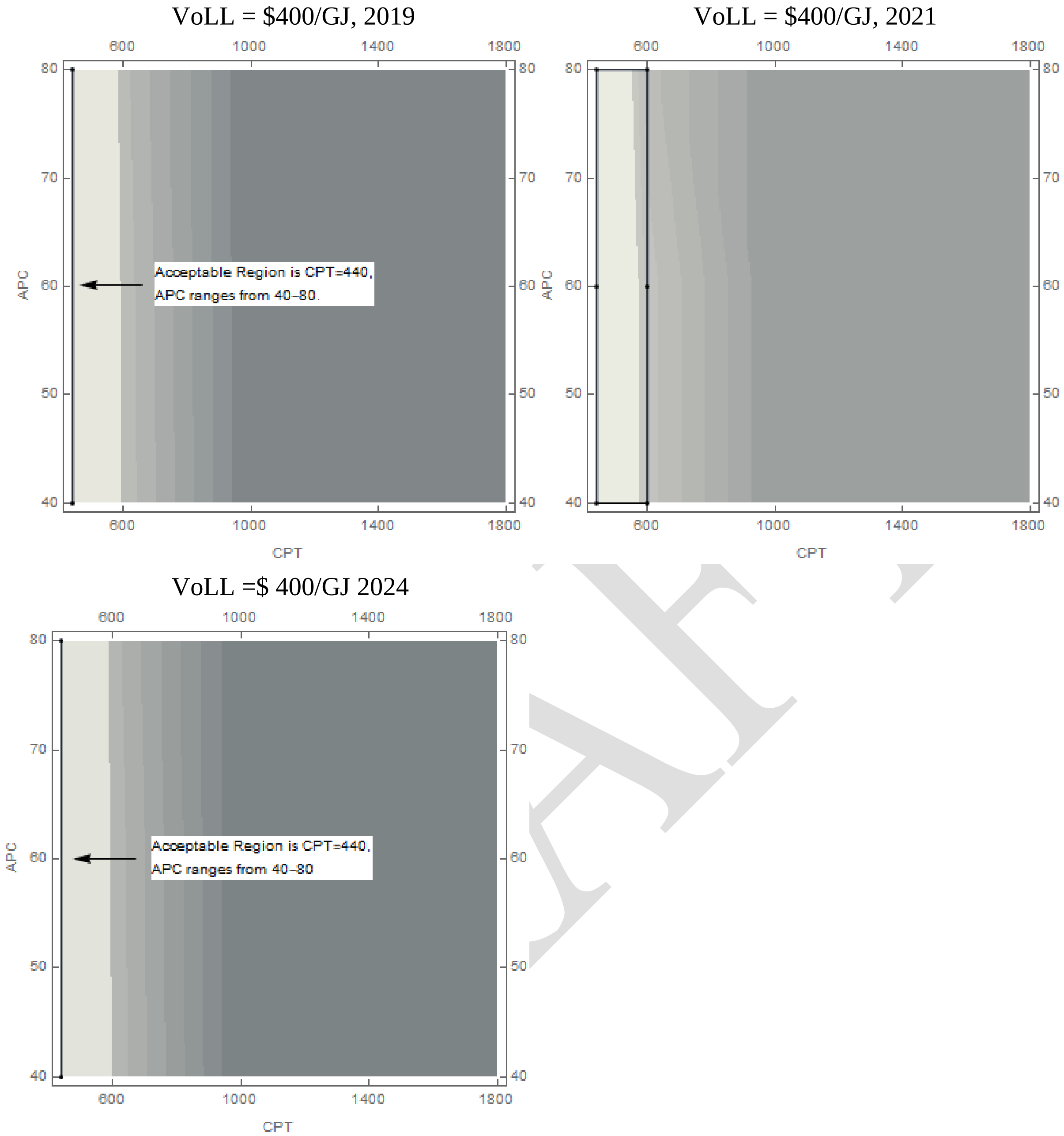
Table 9 - Acceptable Parameter Combinations Identified by Simulation by Year (STTM)

Years Parameters Acceptable			Gas Market Parameters		
2019	2021	2024	MPC ($/GJ)	CPT ($/GJ)	APC ($/GJ)
✓	✓	✓	400	440	40
✓	✓	✓	400	440	60
✓	✓	✓	400	440	80
	✓		400	600	40

The behaviour of the acceptable set of parameters across years is somewhat more stable than for the DWGM. Although the STTM comprises a number of different hubs with different combinations of hubs and scenarios being used in different years, the method by which the CPT is invoked in the STTM tends to align results by allowing a single MPC in almost all cases in which the CPT is breached. The results indicate that the current parameters are still acceptable in all hubs. They also indicate that the specific context of each hub makes it difficult within the set of simulations performed to find other parameters that perform adequately for all STTM hubs.

Figure 14 shows the performance of the parameters with respect to market efficiency across all three years and hubs.

Figure 14 – STTM Market Efficiency Loss and Risk 2019 – 2021 ($1 million steps)



The relationship between parameter sets and market efficiency is stable across each studied year. In each year, increasing the CPT increases efficiency, pointing to the desirability of a higher CPT from the perspective of efficiency. As the CPT grows, the chance of a CPT breach is reduced, and the number of periods of MPC is increased. The results show there is a low efficiency gain to be achieved by increasing APC in all years. This is a noticeable difference relative to the DWGM and is primarily due to GPG units in the DWGM. These bids occupy the price range of $60/GJ to $80/GJ and when uncleared these bids cause efficiency losses.

From the perspective of risk, the choices are very limited. The only acceptable parameters across all years have MPC = $400/GJ and CPT = $440/GJ. There does remain some flexibility in the APC, which can range from $40/GJ to $80/GJ, though with little impact on efficiency.

6.2.3 Participant Results

In this section we summarise the behaviours of the scenarios simulated. As already noted there was a strong correlation between the days lost profit for each participant and the level of effective exposure. The relationship is not exact however as it is sensitive to the overall profitability of the participants.

We have simulated results for a plausible range of gross margins surrounding industry standards but where a participant operates at much lower level than the range of industry standards simulated, then that participant will not be covered by the recommended parameters.

In both the DWGM and STTM, the trajectory of maximum days lost profit for each type of participant increases from 2019 to 2021 before dropping in 2024. The increased risk posed in 2019 and 2021 is reflected in the market context but also the exposure of each participant to gas prices, and the increased cost in securing contracts when the market is tight. As a result, retailers and integrated participants are more susceptible to exceeding 500 days lost profit, as they generally have a greater proportion of their cost structure exposed to gas. Industrial gas users were generally less exposed, although some were exposed to risk as a result of assumed low rates of contracting. In the STTM trends are less apparent, in part due to the elimination of participants that are not currently protected.

Appendix D provides details of participant specifications alongside risk outcomes for the current and preferred parameter sets for each market based as determined by simulation on the parameter grid

6.2.4 Sensitivity Testing of Gas Market Parameter Results

Sensitivity tests were conducted by re-running cases with a ± 3% variation in supply or a ±1% variation in demand. These changes mean that the conditions of a scenario are slightly changed, giving rising to different pricing outcomes, different efficiency outcomes and different levels of days of lost profit. The aim was to verify the robustness of our findings for these slightly altered scenarios relative to the original scenario. Sensitivity tests were analysed for all scenarios across a selection of relevant gas market parameters.

It was found that efficiency loss was reasonably sensitive to small changes. This is not unreasonable as adding demand or reducing supply in a tight situation can have a disproportionate effect on efficiency. The levels of risk exceedance did not increase for acceptable parameter sets but did increase slightly for parameter sets outside the boundary of acceptability. We concluded that that our findings with respect to the acceptability of gas market parameters with respect to risk protection were robust under sensitivity testing.

6.3 Assessment of Implications for Investment

As described in Section 3.5 the relationship between the gas market parameters and investment cost recovery was based on an LNG facility with the cost structure of the Dandong LNG facility.

Table 10 presents the input data and results for the required profit per GJ. With the cost data of Section 3.5 we derive in an annual cost per tonne of capacity of $16,365/GJ, which implies a profit required of $300.29/GJ for a single CPT event per year and $150.14/GJ for two CPT events per year.

Table 10– Calculation of Annual Profit Required per GJ.

Input	**Value**
Capital Cost / tonne	$210,000
WACC	6.67%
Life Time	30
Annualised Cost/tonne	$16,365.66
GJ/tonne	54.5
Results	**Value**
Profit Required/GJ – 1 event per year	$300.29
Profit Required/GJ – 2 events per year	$150.14

AEMO assumed two CPT events per year in the 2013 DWGM parameter review. While that would be viewed as unusual in normal circumstances, a supply shortfall situation in the future which were to produce more VoLL/MPC events could conceivably give rise to that frequency of events. However, to provide some contrast we also consider a single event per year as well.

Given this a target revenue we explored the conditions under which that profit could be recovered as a function of different VoLL/MPC, CPT and APC values, while also considering a number of other inputs. Specifically:

- We consider two levels of prevailing or "usual price" prior to the event, $6/GJ and $7/GJ. Under both the STTM and DWGM rules for accumulating prices over time, the higher price will mean that cumulative price will exceed $40 at the time that a gas price rises to $400/GJ a CPT of $440/GJ will immediately trigger APC without the market ever clearing at the $400/GJ price. Were the price $6/GJ leading up to the event that the $400/GJ would be applied before CPT was triggered.
- We consider the contrast between the "LNG level" being 100% of capacity for a single CPT "event" per year relative to the facility being at 50% of capacity for each of two CPT events per year. The former case would imply that the storage facility is providing capacity only intended to be used when a high-priced event occurs, but a higher revenue must be earned during that event. The 50% case corresponds to a mid-range level of a facility that is operating in the market, but which only needs to recover half the required revenue per event. The facility will earn at a higher rate in the latter case because a higher proportion of its output will be sold before CPT is breached relative to a single event per year.

The LNG facility is assumed to start vaporizing gas as fast as it can from its initial storage when the price first spikes. It earns that price for the remainder of the day, being approximately half the day in the case of the DWGM and the full day in the case of the STTM.[14] It continues to operate at this level after the application of APC until the end of the CPT period (or storage is exhausted).

The variable cost per GJ of vaporization was $0.55/GJ and the daily limit on injection was 38% of the maximum storage capacity. A margin on the sale price of 10% was assumed.

Table 11 presents revenue adequacy figures for the DWGM while Table 12 presents similar figures for the STTM.[15] The columns corresponding to the current parameters is highlighted. The results differ due to different time frames of the market and CPT trigger conditions. The percentages indicate the level of investment revenue shortfall, if any. The parameters shown tend to recover investment costs under at least favourable conditions. More restrictive parameters that are not shown tend to perform poorly.

[14] The logic for this is that the DWGM market runs close to real-time during the gas day and an event could occur anytime during that gas day, meaning an LNG facility on average might only run for half the day on the first day of an event. In the STTM the market runs a day-ahead of real time so it is much more likely that an event would be apparent by the start of the gas day, allowing the LNG facility to run all day on the first day of an event.

[15] In some case the level of revenue shortfall is the same across different parameter sets. These sets have the same VoLL and APC values and the results are the same as the proportion of time that VoLL and APC apply are the same.

Table 11– Revenue Adequacy for Parameters and Scenarios for the DWGM

			Gas Market Parameter Settings ($/GJ)							
		VoLL	400	400	600	600	600	800	800	800
		CPT	440	1800	800	1000	1000	1000	1400	1800
		APC	40	40	40	40	60	40	40	40
Usual Price	Events	LNG Level	A	B	C	D	E	F	G	**H**
$7/GJ	1	100%	-86%	-34%	-86%	-36%	-31%	-86%	-19%	-19%
$7/GJ	2	50%	-86%	0%	-86%	0%	0%	-86%	0%	0%
$6/GJ	1	100%	-86%	0%	0%	0%	0%	0%	0%	0%
$6/GJ	2	50%	-86%	0%	0%	0%	0%	0%	0%	0%

Table 12– Revenue Adequacy for Parameters and Scenarios for the STTM

			Gas Market Parameter Settings ($/GJ)							
		MPC	400	400	400	600	600	600	800	800
		CPT	440	600	1000	800	1000	2500	1000	1800
		APC	40	40	40	40	80	40	40	40
Usual Price	Events	LNG Level	**I**	J	K	L	M	N	O	P
$7/GJ	1	100%	-36%	0%	0%	0%	0%	0%	0%	0%
$7/GJ	2	50%	0%	0%	0%	0%	0%	0%	0%	0%
$6/GJ	1	100%	0%	0%	0%	0%	0%	0%	0%	0%
$6/GJ	2	50%	0%	0%	0%	0%	0%	0%	0%	0%

In each of the tables the bottom row is the nearest current equivalent of results that would match AEMO's results from their 2013 review. While the STTM parameters would not have supported investment in the DWGM, the other parameters shown would all have been acceptable. The analysis shows that as the usual price rises it actually became harder to recover cost. This is because there is less headroom before breaching CPT. It is also apparent that for a given CPT value a lower VoLL or MPC can produce better returns as a longer period would pass before CPT was breached.

The results for the DWGM show that provided the usual prices are low enough that VoLL would be applied for one pricing period prior to breaching CPT that profitability of a new investment can be achieved at a lower VoLL and even with a lower CPT, as shown in cases D and E. However, as the usual price rises it becomes harder to recover revenues with a reduced VoLL as shown in case F.

The results for the STTM indicate that the current STTM settings could become challenging if the usual prices are higher and the number of events is less. All of the other STTM parameter options shown would impose less risks for investors under the assumptions applied. The better performance of the STTM is due to APC only applying from the gas day following a breach of CPT rather than capping the price on the day CPT is breached. The level of revenue under-recovery does rise, however, if the LNG facility fails to run for the full gas day on which MPC is first reached.

6.4 Inter-market Linkages

A requirement of this study was to recognise the interactions between the STTM, DWGM and NEM. This was achieved through exploring a number of scenarios that allowed interaction between the

DWGM and the STTM gas hubs, while also representing drives in the NEM. As such the results of our core analysis factor in the results of those interactions.

There are practical limitations between the interactions of the gas markets. They are less able to interact in timeframes shorter than that in which gas can be moved, so most interactions will be with respect to sourcing gas during longer term events. The situation is similar between the gas markets and the NEM. While the NEM prices can respond suddenly the ability to source gas to meet that demand in the timeframe of the NEM is very limited. This is why our scenarios focused on longer term events. It was found that price responsiveness between gas and electricity markets would tend to moderate the impact of GPGs. If they drive up gas demand then gas prices rise and without a corresponding increase in electricity prices will limit the running of the GPGs.

The level of APC in gas markets is an important consideration for GPGs. The relationship between the NEM and gas markets is driven to a large degree by the price differential between gas and electricity relative to the heat rate of a GPG, though with the limitation that electricity prices and schedules change in real-time while scheduling gas can take many hours. This means the GPGs tend to be scheduled based on expectations of average prices over time in the NEM. The current $40/GJ APC, adjusted by generator heat rate, would correspond to an average daily NEM price of $400/MWh to $600/MWh. While a lower APC would increase generator profitability if they could secure gas, it may also mean that gas is not made available. A higher APC of $60/GJ would reduce this risk but would increase the exposure of other market participants buying in the gas market.

There are a number of acceptable parameter ranges with increased APC, particularly for the STTM. While APC could be increased in the STTM we have not observed a strong efficiency gain in doing this, primarily due to the lack of generation bids. The grid points explored for the DWGM have variations in the APC values but do not suggest a strong candidate with an increased APC for lower valued VoLL but $40/GJ is still favoured for the current VoLL.

There were also no specific concerns expressed about the level of APC in the consultation responses, other than a request that the processes and methodology for setting the parameters in the NEM and the gas market be better aligned. This is understood to be more related to the differences in practice of periodic reviews of gas market parameters relative to automatic updates of parameters like VoLL in the NEM.

6.5 Acceptable Parameter Ranges

The results from Section 6.2 indicate that:

- The current STTM parameters continue to be an acceptable option across the entire study period.
- Alternative STTM parameters that work for all years either would accommodate an increase in APC from $40 to $60 or $80.
- The current DWGM parameters do not provide adequate protection in future years. It fails the 500 days of lost profit condition in 1.48% of our cases.
- The DWGM parameters from our original grid that best maintain efficiency while protecting participant exposure across all years have VoLL of 800/GJ with a reduced CPT of $1000/GJ and APC of $40/GJ. Other options that satisfy protect participant exposure are a reduced VoLL of $600/GJ with a CPT of $1000/GJ and an APC of $40/GJ, or a reduced VoLL to $400/GJ with CPT of either $1000/GJ or $600/GJ and an APC of either $40/GJ or $60/GJ.
- An additional grid point was introduced for the point VoLL = $800/GJ, CPT = $1400/GJ and APC =$40/GJ. This setting is effectively the current parameters but with CPT reduced by $400/GJ. This setting was found to provide adequate protection across all years while maximising market efficiency.

The results of Section 6.3 indicate that

- Relative to the current STTM parameters there would only be improvement in investment cost recovery by imposing higher CPT or APC values.

- The current DWGM parameters are relatively robust over a range of investment assumptions but these get challenged as the parameters become more conservative.

We also note that one of the key features of the period under study is that there is a possibility that the DWGM will no longer be able to satisfy its own load requirements while also supporting the STTM hubs. It follows that the DWGM and the southern STTM hubs will be more sensitive to restrictions on investment in the DWGM than would be the case for the STTM hubs in isolation.

The STTM parameters common to all hubs and years from Section 6.2 are only:

- $400/GJ, $440, $40/GJ (I in Table 12)

While some increases in APC were possible in some years, an increase to $80/GJ would still under recover investment by at least 27% (for the current parameters it is 36%) in situations where average prices are higher and cost recovery must occur in a single CPT event. The loss of efficiency is almost invariant to the level of APC in the STTM, we conclude that the only STTM parameter set worthy of consideration is the current parameter set.

For the DWGM, the simulation options involve either VoLL = $400, $600 or $800. We do not recommend consideration of a $400/GJ VoLL price as our analysis of investment impacts showed that to keep an APC of $40/GJ would require a CPT value of at least $1800/GJ. While this value would support investment, it would also result in excessive participant risk. Furthermore, while a VoLL of $400/GJ could support a CPT of $1000 with an APC of $60/GJ, and this would provide cost recovery when prices are low leading into an event, investment scenarios with high prices leading into an event show cost recovery shortfalls of at least 14%. A higher CPT value of $1800/GJ would support investment but would result in excessive participant risk.

Higher VoLL values of $600/GJ and $800/GJ also support CPT of $1000/GJ with an APC of $40/GJ and perform reasonably well from an investment perspective. The CPT value of $1400/GJ also performs well for risk while providing good investment recovery and efficiency results. The following options are carried forward for further consideration:

- $600/GJ, $1000, $40/GJ (D in Table 11)
- $800/GJ, $1000, $40/GJ (F in Table 11)
- $800/GJ, $1400, $40/GJ (G in Table 11)

6.6 Conclusions

The current DWGM gas market parameters fail to provide adequate risk protection to market participants buying gas. We favour lowering CPT in the DWGM to $1400/GJ as this will provide adequate protection to participants while also minimising reductions in market efficiency. This reduction in CPT will not appreciably change the ability of new investors to recover costs relative to the current DWGM settings. Lowering CPT further is rejected primarily because of the reduced head room between the value of CPT and VoLL. With normal gas prices being higher than in past years it is conceivable that the cumulative price could exceed $400/GJ over 35 pricing periods, meaning that a VoLL event could immediately be capped at APC by a $1000/GJ or $1200/GJ CPT.

For the STTM, we found that only the current parameters performed well enough to be considered. This arises in part because of the difference between how administered pricing works in the STTM relative to the DWGM. The current CPT of $440/GJ means that it is possible for STTM participants to be exposed to MPC for two gas days – the first not breaching CPT, the second breaching it but not being capped as APC would apply from the next gas day. Higher levels of CPT could allow participants to be exposed to more days at MPC so are not acceptable. The current STTM parameters are sufficient to allow revenue recovery for new investment.

Comments received from some energy buys/users during this work included the suggestion that the VoLL in the DWGM should be lowered to the value of MPC in the STTM, primarily to mitigate risk and because there was a view that lowering VoLL would still support investment. However, mitigation of unmanageable risk is actually more the role of CPT. An exploration of a broader range of assumptions about the nature and incidence of CPT events than those used in the prior gas market parameter reviews showed that risks of under recovery of investment costs become more pronounced as average levels of gas prices rise. Caution is therefore required in consideration of lowering VoLL in the DWGM. The CPT changes proposed for the DWGM do modify the situation, however. The DWGM participants could be exposed to at most to one day (in the case of the first schedule of the day) at an $800/GJ VoLL while the STTM participants continues to be limited to a maximum of two days exposure at a $400/GJ MPC.

A number of alternative parameters for each of the DWGM and STTM were identified that would have supported an increase in APC. No change is proposed. Such increases would not significantly impact investment cost recovery or market efficiency, though for a given CPT a higher APC will tend to increase consumer cost. An increase in APC was not suggested in any consultation feedback.

7 RECOMMENDATIONS

We recommend no changes to the gas market parameters other than to reduce the CPT applied in the DWGM from $1800/GJ to $1400/GJ. The reasons for this change are:

- The tightening supply and demand conditions over the studied period mean that the current DWGM gas market parameters fail to provide adequate risk protection to market participants buying gas. The proposed reduction in the CPT value allows the revised parameters to provide adequate protection while minimising the impact on market efficiency.
- A CPT of $1400/GJ eliminates the potential for DWGM participants to be exposed to two VoLL events during a cumulative pricing period but it is sufficiently high that even allowing for moderately higher prevailing gas prices in the future it will still allow a single VoLL event to occur without APC being applied. Some risk of VoLL exposure promotes good hedging practices. A CPT value much lower than that proposed could mean that the threshold is breach by a single incidence of VoLL. In the DWGM the price in the period that breached CPT would be capped at APC, so in that case the market might never see VoLL applied.

The revised gas market parameters for the DWGM are not materially different from the current parameters in terms of facilitating adequate revenue recovery for new investment.

The current STTM parameters were found to provide adequate protection to consumers in the STTM. Very few other parameters explored did. This arises in part because of a key difference between how administered pricing works in the STTM relative to the DWGM. If an STTM price reaches MPC and causes a breach of CPT, that price is not capped by APC as would be the case in the DWGM. Under the STTM procedures the application of administered pricing commences from the next gas day. The current CPT of $440/GJ means that it is possible for STTM participants to be exposed to MPC for two gas days – the first not breaching CPT, the second breaching it but not being capped. Higher levels of CPT could allow participants to be exposed to more days at MPC so are not acceptable. The current STTM parameters are sufficient to allow revenue recovery for new investment.

APPENDIX A – ABBREVIATIONS

TERM	DEFINITION
ABS	Australian Bureau of Statistics
ADGSM	Australian Domestic Gas Security Mechanism
ADL	The Adelaide STTM hub
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AMDQ	Authorised Maximum Daily Quantity (DWGM)
APC	Administered Price Cap
BRI	The Brisbane STTM hub
CPT	Cumulative Price Threshold
DCPTR	DWGM CPT Review Final Report, AEMO, September 2013
DTS	Declared Transmission System (DWGM)
DWGM	Declared Wholesale Gas Market
GJ	Gigajoule
GPG	Gas Powered Generation
GSG	Gas Supply Guarantee
GSOO	Gas Statement of Opportunities
GWCF	Gas Wholesale Consultative Forum
LNG	Liquefied Natural Gas
MOS	Market Operator Service (STTM)
MPC	Market Price Cap (STTM)
MSV	Market Schedule Variations (STTM)
NBB	National Gas Bulletin Board
NEM	National Electricity Market
NGERAC	National Gas Emergency Response Advisory Committee
NGR	National Gas Rules
NGFR	National Gas Forecasting Report
PJ	Petajoule (1,000,000 GJ)
ROLR	Retailer of Last Resort
STTM	Short Term Trading Market
SYD	The Sydney STTM hub.
TJ	Terajoule (1,000 GJ)
VGPR	Victorian Gas Planning Report (DWGM)
VoLL	Value of Lost Load (DWGM)

APPENDIX B – DESCRIPTION OF SCENARIOS

The following table describes the scenarios modelled. Some of these have been modified slightly from the versions in the Consultation Report. This usually reflects adjustments required to prevent the event becoming so extreme as to trigger an administered price state for other reasons. The years of focus are the tight supply year 2021 and years at the start and end of the horizon – 2019 and 2024. We have specifically included some scenarios based on 2019 to test the need for an earlier implementation of new market parameters. Some scenarios – 5, 15 and 16 – which were originally proposed in the Consultation Report ended up being very similar to other scenarios in practice and were abandoned as the results would be effectively be duplicates of other cases. In developing scenario 12 it was found it would not have created significant risks for the market so this scenario was also abandoned.

Scenario	Market Context	Event	Detail
1A	DWGM 2021	Gippsland supply interruption	A 50% reduction in Longford production on a high winter demand day with output restored at midnight on the fifth day of the event. NEM prices are at average winter values.
1B	DWGM 2024		
2A	DWGM 2021	Compressor failure near Melbourne	Pipeline compressor failure near Melbourne on a high flow day from Iona, occurring early on a high demand day preventing management of pressure around Melbourne with impact on interconnected transmission pipelines. Output restored at midnight on the third day of the event. NEM prices are at average winter values.
2B	DWGM 2024		
3A	DWGM 2021	Moomba supply interruption with a high rate of flow to SA and NSW.	High rate of gas export from DWGM to support ADL and SYD for three days after a Moomba supply interruption. Event occurs during average winter demand period. NEM prices are at high levels (circa $300/MWh) reflecting the supply interruption.
3B	DWGM 2024		
4A	DWGM 2019	High forecast GPG demand	High expected GPG demand coincident with high winter demand. The scenario has average NEM winter prices rising to $660/MWh long enough to trigger CPT in the NEM. This would produce extra high demand going into the day. Increased flow of gas to SA to manage increased GPG demand there.
4B	DWGM 2021		
5	DWGM	High unforecast GPG demand.	This scenario was planned as a case with high unforecast gas demand in the DWGM though the scenario was dropped in favour of scenario 4 as the unexpected nature of the event had an insignificant impact on the solution given that the models had limited ability to account for congestion in the DWGM.

Scenario	Market Context	Event	Detail
6A	DWGM 2019	Extremely high demand	Demand in excess of 1:20 year scenario – e.g. due to extremely cold weather. The cold weather lasts into the third day. NEM prices are at a high level (that could lead to CPT in the NEM). This is a situation where demand may also exceed normal contract / hedge limits.
6B	DWGM 2021		
7A	DWGM 2021	High demand day requiring LNG while gas storage is low.	Peak winter week but with inflated LNG prices and low gas storage levels due to high demand earlier in the winter and/or as a consequence of previous events. Demand increases unexpectedly during first day causing LNG to be used. Demand drops back to average winter demand at end of third day. NEM prices are high encouraging GPG demand.
7B	DWGM 2024		
8A	SYD 2021	Reduced supply to hub due to upstream reduction in production.	MSP capacity to supply SYD reduced by 5% at time of high winter demand but known at time that ex ante market ran. Capacity reduced for three days. The 5% reduction is not enough to trigger APC for technical operating reasons.
8B	SYD 2024		
9A	ADL 2019	Reduced supply to hub due to high GPG demand outside of the hub during ex ante market	GPG's constrain pipelines in the ex ante market due to purchasing high volumes of backhaul gas arising from high electricity demand. At peak GPG consumption, the SEAGas and MAP pipelines may be reduced by as much as 60%
9B	ADL 2024		
10A	BRI 2021	Reduced supply to hub due to unexpected high GPG demand outside of the hub after ex ante market has run.	GPG's buy high volume of back haul gas in ex ante market due to high electricity demand for three consecutive days during winter (though season not that important). NEM prices rise to a level that has generation near the Brisbane hub operating at maximum after the ex ante market has run. Generation stops running on the third day.
10B	BRI 2024		
11A	SYD 2019	Contingency gas scenario	Moomba supply interruption leading to contingency gas required on the day of the event.
11B	SYD 2021		
12	ADL		This scenario was abandoned. It related to a high cost of replacement MOS gas but the STTM hedges the MOS provider against such high costs so was not that interesting.
13A	DWGM 2021	DWGM supplying gas to SYD and ADL while electricity prices are high. *Interlinked markets scenario*	Gas supply issues north of Moomba places increased demand on gas that would normally serve the STTM or DWGM. High winter demand, with NEM electricity prices in the $300/MWh range. Event is expected prior to the ex ante market running, and lasts for three days. High levels of export from the DWGM to the STTM are required.
13B	SYD 2021		
13C	ADL 2021		

Scenario	Market Context	Event	Detail
14A	DWGM 2021	High GPG demand in or around key markets. *Interlinked markets scenario*	High electricity prices for a sustained period required long term running of gas powered generation at higher utilisation than normal. This causes strong linkage between the DWGM and the ADL and SYD STTM hubs. High winter demand, with electricity prices at levels likely to trigger APC in the NEM. Starts prior to the ex ante market bid submissions and lasts for three days. There is a high demand for DWGM exports to the STTM.
14B	ADL 2021		
14C	SYD 2021		
15, 16	DWGM, SYD, ADL	High dependency of STTM hubs on DWGM due to high gas prices (15) and high electricity prices (16)	These scenarios were abandoned as they effectively duplicated results of other similar cases.

APPENDIX C – SCENARIO RESULT SUMMARY

This appendix presents high level summary results for each scenario. The following terminology is used:

- Base Scenario Average Price ($/GJ) reflects the average price in the market between the start and end of an event for the base scenario, i.e. where no event occurs.
- Uncapped Average Price (% of VoLL) is the average gas price in the market for a case with the current VoLL/MPC values and no application of CPT between the start and end of an event when the event has occurred, expressed as a percentage of VoLL
- Average CPT Active Period is the average number of periods from the commencement of the event for which the cumulative price exceeds the CPT.
- Average APC Active Period is the average number of periods from the commencement of the event for which the price is capped at APC.

Scenario	Market Context	Base Scenario Average Price ($/GJ)	Uncapped Average Price (% of VoLL)	Uncapped Maximum Price (% of VoLL)	Average CPT Active Periods	Average APC Active Periods
1A	DWGM 2021	$9.72	34%	100%	55.50	23.25
1B	DWGM 2024	$9.00	2%	4%	0.00	0.00
1C	DWGM 2019	$9.00	25%	100%	53.17	22.08
2A	DWGM 2021	$9.72	21%	100%	45.50	13.25
2B	DWGM 2024	$9.00	2%	6%	0.00	0.00
3A	DWGM 2021	$13.00	21%	100%	45.67	13.33
3B	DWGM 2024	$13.00	16%	100%	43.67	12.33
4A	DWGM 2019	$9.72	3%	10%	2.75	0.00
4B	DWGM 2021	$12.14	4%	16%	10.33	1.33
6A	DWGM 2019	$9.00	3%	10%	2.58	0.00
6B	DWGM 2021	$8.42	24%	100%	45.50	13.25
7A	DWGM 2021	$10.00	21%	100%	44.67	12.83
7B	DWGM 2024	$10.00	2%	6%	0.00	0.00

Scenario	Market Context	Base Scenario Average Price ($/GJ)	Uncapped Average Price (% of VoLL)	Uncapped Maximum Price (% of VoLL)	Average CPT Active Periods	Average APC Active Periods
8A	SYD 2021	$25.00	5%	10%	0.00	0.00
8B	SYD 2024	$25.00	5%	6%	0.00	0.00
9A	ADL 2019	$8.00	6%	16%	0.00	0.00
9B	ADL 2024	$8.00	4%	10%	0.00	0.00
9C	ADL 2019	$8.00	53%	100%	5.78	0.67
9D	ADL 2024	$8.00	54%	100%	5.78	0.67
10A	BRI 2021	$6.75	17%	81%	1.44	0.11
11A	SYD 2019	$25.00	15%	81%	3.44	0.33
11B	SYD 2021	$17.00	14%	81%	3.33	0.22
13A	DWGM 2021	See 3A				
13B	SYD 2021	$17.00	14%	81%	3.22	0.22
13C	ADL 2021	$8.00	22%	81%	3.22	0.22
14A	DWGM 2021	See 4A				
14B	ADL 2021	$8.00	4%	10%	0.00	0.00
14C	SYD 2021	$11.00	21%	81%	3.22	0.22

APPENDIX D – PARTICIPANT RESULTS

This appendix presents high level summary results for each participant. The following terminology is used:

- Gross Margin (%) reflects the retail margin assumed for each retailer/integrated supplier and the final product margin achieved by industrial users.
- Gas Fraction of Cost (%) is the proportion of participant total costs assumed to be related to gas.
- Effective Exposure (%) combines the participants assumed gas hedging with the gas fraction of costs to define the percentage of their cost structure that is exposed to gas prices after hedging is taken into account.
- Maximum Days Lost Profit (days) is the maximum days lost profit over all scenarios for all years (2019, 2021 and 2024). Data is supplied for the current parameters and the recommended parameters in the DWGM. In the STTM the current parameters are also the recommended parameters so the results are the same. Results are only shown for those participants currently protected.

Participant	Gross Margin (%)	Gas Fraction of Cost (%)	Effective Exposure (%)	DWGM – Max Days Lost Profit		STTM – Max Days Lost Profit
				Current Parameters	Recommended Parameters	Current and Recommended Parameters (as the same)
Retailers – Current Market Context						
R1	7%	33%	7%	58.80	54.08	135.18
R2	7%	41%	21%	212.53	169.52	410.18
R3	7%	49%	37%	414.55	305.67	
R4	7%	61%	55%	613.59	443.99	
R5	9%	33%	17%	145.94	115.96	290.37
R6	8%	41%	31%	299.20	219.40	
R7	8%	49%	44%	473.75	339.50	
R8	3%	61%	12%	106.46	106.46	242.14
R9	10%	33%	25%	207.68	151.97	390.55
R10	9%	41%	37%	344.10	245.95	
R11	4%	49%	10%	103.21	103.21	219.40

Participant	Gross Margin (%)	Gas Fraction of Cost (%)	Effective Exposure (%)	DWGM – Max Days Lost Profit		STTM – Max Days Lost Profit
				Current Parameters	Recommended Parameters	Current and Recommended Parameters (as the same)
R12	5%	61%	31%	368.53	311.83	
R13	11%	33%	30%	240.37	171.44	444.32
R14	5%	41%	8%	75.91	75.91	179.38
R15	6%	49%	25%	296.75	241.19	
R16	6%	61%	46%	533.44	399.19	
Retailers – Tight Market Context						
RT1	5%	41%	8%	81.11	80.83	191.04
RT2	7%	41%	21%	224.94	179.23	433.69
RT3	8%	41%	31%	307.65	225.46	
RT4	9%	41%	37%	347.77	248.53	
RT5	7%	41%	21%	218.57	174.24	421.62
RT6	8%	41%	31%	304.78	223.40	
RT7	9%	41%	37%	346.29	247.49	
RT8	4%	41%	8%	110.73	108.64	256.96
RT9	6%	61%	46%	543.29	406.56	
RT10	7%	61%	55%	618.64	447.64	
RT11	2%	61%	12%	192.85	192.85	435.76
RT12	3%	61%	31%	519.84	439.59	
RT13	7%	61%	55%	616.11	445.80	
RT14	2%	61%	12%	152.15	152.15	344.54

Participant	Gross Margin (%)	Gas Fraction of Cost (%)	Effective Exposure (%)	DWGM – Max Days Lost Profit		STTM – Max Days Lost Profit
				Current Parameters	Recommended Parameters	Current and Recommended Parameters (as the same)
RT15	4%	61%	31%	446.67	377.81	
RT16	6%	61%	46%	586.59	438.95	
Commercial/Industrial Participants						
C1	5%	20%	4%	0.00	0.00	0.00
C2	5%	30%	15%	0.00	0.00	0.00
C3	5%	40%	30%	206.65	131.16	356.55
C4	5%	50%	45%	417.62	265.07	
C5	10%	20%	4%	0.00	0.00	0.00
C6	10%	30%	15%	0.00	0.00	0.00
C7	10%	40%	30%	97.89	62.13	168.89
C8	10%	50%	45%	197.82	125.56	341.32
C9	15%	20%	4%	0.00	0.00	0.00
C10	15%	30%	15%	0.00	0.00	0.00
C11	15%	40%	30%	61.63	39.12	106.34
C12	15%	50%	45%	124.55	79.06	214.90
C13	20%	20%	4%	0.00	0.00	0.00
C14	20%	30%	15%	0.00	0.00	0.00
C15	20%	40%	30%	43.51	27.61	75.06
C16	20%	50%	45%	87.92	55.80	151.70

Participant	Gross Margin (%)	Gas Fraction of Cost (%)	Effective Exposure (%)	DWGM – Max Days Lost Profit		STTM – Max Days Lost Profit
				Current Parameters	Recommended Parameters	Current and Recommended Parameters (as the same)
Integrated Participants						
I1	15%	33%	0%	7.51	7.51	43.22
I2	13%	41%	2%	12.27	12.27	54.05
I3	12%	49%	5%	16.01	16.01	61.83
I4	11%	61%	9%	19.63	19.63	70.09
I5	14%	33%	8%	34.35	33.71	77.36
I6	12%	41%	12%	56.70	54.32	120.39
I7	11%	49%	17%	85.10	82.19	177.49
I8	10%	61%	24%	120.04	115.56	241.51
I9	13%	33%	17%	95.44	75.99	193.17
I10	11%	41%	23%	150.98	119.03	296.21
I11	9%	49%	29%	226.16	175.33	427.03
I12	9%	61%	40%	318.59	246.72	
I13	12%	33%	25%	176.03	128.85	337.52
I14	10%	41%	33%	271.61	197.83	
I15	8%	49%	42%	405.54	293.15	
I16	7%	61%	55%	575.97	416.76	