Australian Energy Market Commission

Effect of 5 Minute Settlement on the Financial Market

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EnergyEdge

Contents

1 Executive Summary

The Australian Energy Market Commission is reviewing a rule change proposal from Sun Metals that would involve a move from 30 minute settlement to 5 minute settlement. Energy Edge has been engaged to review the effect of the proposed rule change on the financial markets, to assess whether market participants would continue to be able to access appropriate financial market contracts to manage spot price risk exposure through financial hedging.

This review has shown that the main financial product that will be impacted by the proposed rule change would be half hourly settled caps ("Caps"). We have come to the conclusion that the market would move from trading 30 minute financial caps to 5 minute caps to align with the financial risk profile of the bulk of the wholesale market participants.

Caps are a vital financial product used by buyers such as retailers to manage retail load flex and extreme price events and help sellers such as gas fired generators to underwrite new generation capacity and long term fuel arrangements. Caps account for between 10 – 20% of traded volume across the regions. Caps are predominantly sold by fast start and ramping generators who look to gain income certainty from the sale of the cap, and then generate at times of high prices to physically support the payout required under the financial cap product.

Due to the physical ramp rate and technical capability of most fast start plant (i.e. hydro, gas fired peaking plant), those assets are not able to effectively respond to unexpected 5 minute price spikes from rest or from minimum load and a reasonable proportion of their annual earnings is reliant on the averaging of such pricing over the current 30 minute settlement period. Under the proposed rule change, our modelling suggests that these generators would capture a reduced amount of value from the spot market due to their inability to respond as quickly as needed.

This reduced physical ability to capture high spot market pricing is likely to result in those generators reducing the volume of caps that they are willing to sell. Our modelling suggests that across the market approximately 625MW of flat cap equivalent (23% of underlying cap volume) is likely to be withdrawn from the market, impacting retailers' ability to manage their financial market price and volume risk.

The complication for these existing peaking generators is that they are likely to have reduced earnings from the spot physical market combined with reduced earnings from the sale of a lower volume of caps. This would likely result in either reduced profitability, or an increase in their risk profile through the sale of a higher volume of caps than they could physically support, in an attempt to maintain income levels. Our view is that either option could result in financial stress for these assets.

We have reviewed some alternative hedging and operational strategies to determine whether there may be other arrangements that may go some of the way towards bridging the shortfall of caps that would be available in the market. These include the increased use of weather derivatives, some other assets potentially selling caps or existing sellers of caps offering the product at higher prices to offset their increased risk profile post the rule change.

It should be noted that full market modelling of the impact of the 5-minute settlement has been excluded from the scope of works and the primary analysis has been based on historical results which include market responses based on 30 minute settlement. The operational strategies that may be implemented by such generators to mitigate reduced earnings is a very complex optimisation modelling exercise. Despite the fact Energy Edge has not completed this quantitative analysis, we anticipate that revised operational strategies to adjust to a 5 minute settlement market would have a marginal increase in earnings which would likely result in a lower total earnings outcome compared to a 30 minute market for the majority of existing peaking generator asset types.

While this report focuses primarily on the incumbent buyers and seller of existing financial contracts, Energy Edge acknowledges that the introduction of 5 minute settlement market would likely promote alternative technologies (i.e. very fast start plant) and that it is possible that the financial market would eventually regain a new equilibrium. The modelling of the impact and timing of this type of transition is beyond the scope of the report.

2 Introduction

The Australian Energy Market Commission (AEMC) is tasked with setting, reviewing and amending the rules for the national electricity, gas and retail markets as well as providing advice to governments on market developments. As part of this role, the AEMC is required to allow market participants to raise a Request for Rule Changes. The AEMC must investigate the option raised and follow the Rule Change Procedure to determine if the Rule Change should be implemented.

The AEMC is currently assessing a rule change request submitted by Sun Metals in December 2015 to align the dispatch and settlement intervals in the National Electricity Market (NEM) in order to improve market efficiency.

The proposal seeks to make it compulsory for all generators, scheduled loads and market inter-connectors to settle on a 5-minute frequency with demand side participants, including retailers and large consumers, given the option to select either 5-minute or 30-minute settlement.

The AEMC is required to assess all rule change requests put forward, and are guided by the National Electricity Objective (NEO) in determining whether the rule change request is likely to contribute to the achievement of the NEO.

In assessing the rule change request, the AEMC has to consider all potential issues that may affect market participants because of the potential change. In the context of this rule change request, the AEMC is considering the issues raised by the rule change request, including:

- That 30-minute settlement accentuates strategic late rebidding, where generators have been observed to withdraw generation capacity in order to influence price outcomes; and
- 30-minute settlement impedes market entry for fast response generation and demand side response.

The AEMC has engaged Energy Edge to investigate the potential impacts on the electricity financial contract markets in response to the proposed 5-minute settlement rule change. This analysis assesses the potential impact on the ability of market participants to access appropriate financial market contracts to manage spot price risk exposure through financial hedging. Consideration has been given to the potential impact on liquidity and costs associated with retailers hedging the spot market exposure for end users. Further details of the scope of this report can be found in section 7.

3 Summary of Financial Instruments

3.1 Outline of the financial market

The regulatory structure of the NEM is classified as a 'gross pool', which means that market participants are compelled to engage in a centrally cleared wholesale market to both sell and purchase their power. Consequently, NEM market participants (generators, retailers) inherit a natural financial position subject to the high levels of price volatility which characterise electricity spot markets.

The electricity financial market was originally established to allow the physical market participants (i.e. those participants with exposure to spot prices such as generators, retailers and market loads) to manage risks associated with spot price variability, by trading in financial products that reduced their exposure to electricity spot pricing. Since that time the financial market participants have expanded to include those trading for profit and/or looking to increase their exposure to electricity spot prices and financial institutions undertaking client service based business models in the electricity market.

Likewise, the range of products offered has increased although despite their complexity, they all reference the underlying spot price in some way. The more basic and commonly used products "plain vanilla financial products" are explored below, together with some of the more sophisticated, but less used financial products. It is important to appreciate that the plain vanilla financial products, i.e. Swaps/Futures and Caps, are the key building blocks necessary for physical market participants and financial institutions alike to be able to issue the more sophisticated structured products and client services that allow all market participants to more precisely engineer the risk and return profiles of their electricity portfolio. Inadequate turnover and liquidity levels in these plain vanilla financial products cascades into a reduced ability for parties to offer structured financial products and client services in the energy markets sector.

The purpose of this section of the report is to identify the products traded and their characteristics and whether they would be affected by a change to the settlement timing or the optionality of such a change on the demand side. It should be noted that some of these products are traded on the ASX (exchange-traded), whilst others are traded between parties under legal agreements, e.g. ISDA and PPA's, in the over-the-counter (OTC) market.

A listing of key financial derivative products, their characteristics and uses is included in section 3.4 of this report.

3.2 How participants use derivatives to manage risk

Within this paper, the main focus of the impact of 5 minute settlements on the financial products will be in relation to their use by the physical market participants (i.e. generators and retailers). Whilst it is acknowledged that these physical market participants are a subset of those trading in the financial market, and that the non-physical market traders play an important role in adding liquidity to the financial market, the scope of this paper is primarily on the impacts that a change to settlement periods would have on the physical market participants.

In understanding the reason for utilising the various financial products, it is important to understand the underlying exposure that physical market participants face. This section briefly describes what exposure each of the market participants face, and how they typically engage in the financial market to manage their natural risks.

3.2.1 Generators

Generators are paid the spot price for their generation, and therefore their revenue is exposed to the variability in spot pricing. In most cases, generators look to reduce that variability to allow for more stable revenue streams. The extent to which they do this is driven by their risk appetite and strategic goals. They are able to reduce their revenue variability by entering financial contracts with other market participants that provide them with either a fixed price per MWh or some form of fixed payment e.g. option premium.

Generators may also want some certainty around forward pricing in addition to spot pricing, and may enter option contracts that reference forward prices. These types of products are explored in more detail below, but the general intention of entering them is to reduce revenue variability (and/or reduce downside risk) to provide more certainty around revenue streams.

The secondary market supports numerous derivative instrument products, each with idiosyncratic characteristics suitable to manage distinct facets of a participant's financial risk. A key attribute of each product is the payoff profile which expresses how the contingent cash payments or receipts (payoffs) depend on market outcomes. As each product has a different payoff profile, each generator's hedge portfolio will contain a different risk profile and distribution. However, the intent of using hedge products is invariably to reduce the risk of revenue variability and if managed well, gross margin variability. The extent to which the generation volumes are covered by hedges (the right volume and the right instrument selection) leads to improved certainty in future gross margin outcomes, despite uncertain and volatile pool prices.

The expected effect of this on their revenue/gross margin distribution is shown in the figure below for a Generating business with a notional capacity of 500 MW over a year.

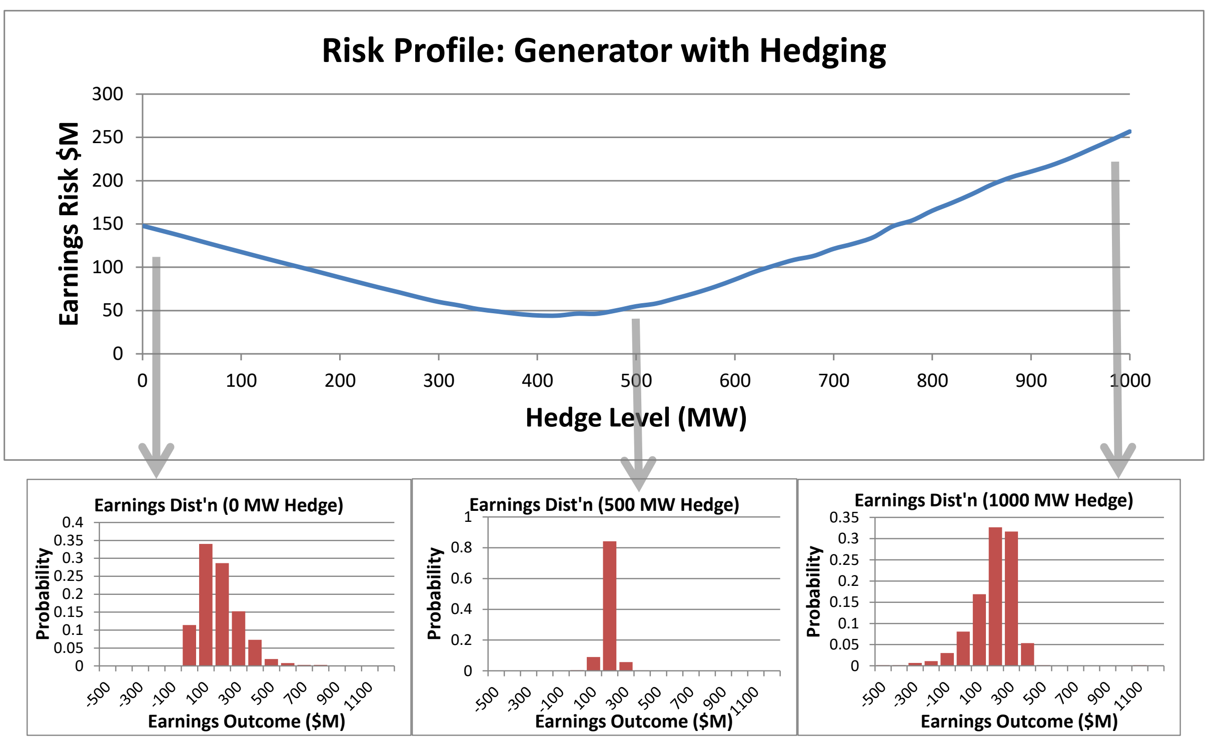


Figure 1: Effectiveness of hedge levels to deliver a generator improved financial risk profiles. As the hedge level rises the financial risk on the spot market diminishes to an optimal point, whereupon adding more hedges leads to a deteriorating risk position.

The payoffs from the financial instruments do not perfectly offset the earnings from the physical power station. There are volume mismatches from, for example, forced outages, 5/30 issues, slow responses, bidding and rebidding, changed generation profiles and so on.

Various aspects of this report address if a change to 5-minute settlement will significantly exacerbate the imperfect hedging risk, Residual Risk, for participants using derivatives to manage financial risks from physical exposures.

3.2.2 Retailers

Retailers pay the spot price for the amount of energy that their customers use, and therefore their cost is exposed to the variability in spot pricing. The majority of their revenue from customers is generally a fixed price per MWh so in order to manage their margins, retailers typically look to (selectively) reduce their exposure to spot pricing to allow them to lock in more stable, known gross margins.

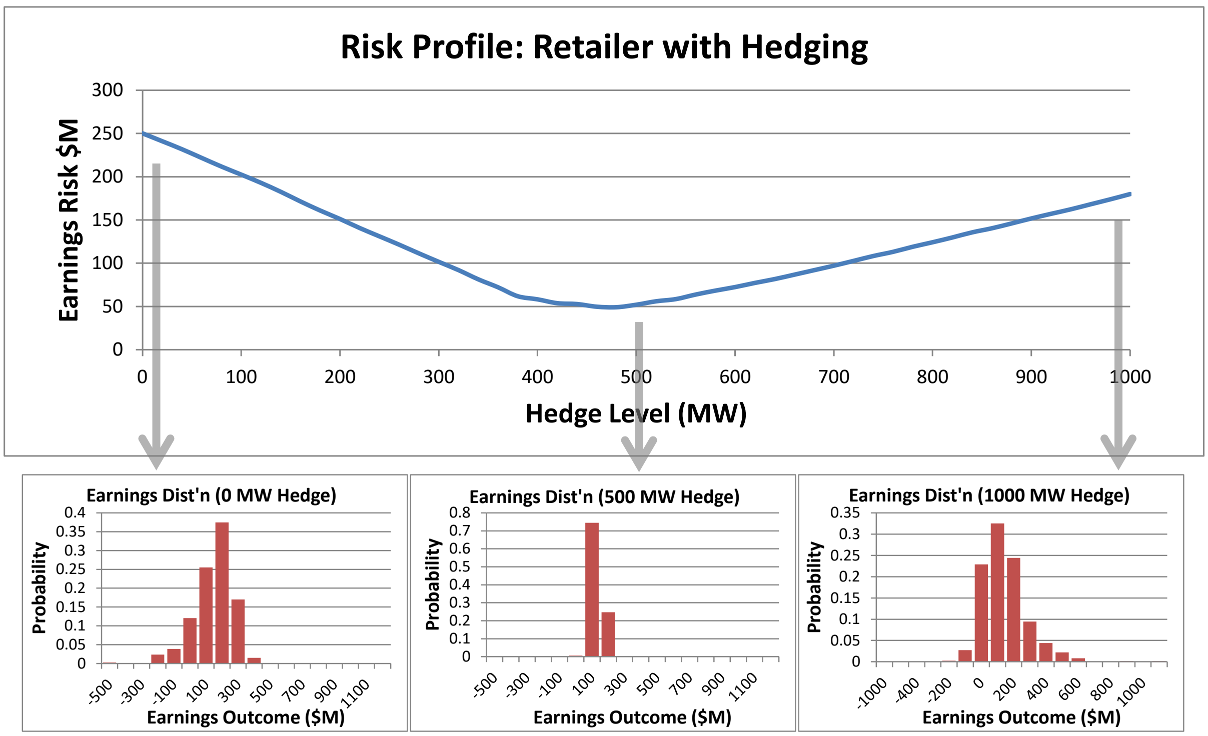


Figure 2: Effectiveness of hedge levels to deliver a retailer improved financial risk profiles. As the hedge level rises the financial risk on the spot market diminishes to an optimal point, whereupon adding more hedges leads to a deteriorating risk position.

Comparing Figure 1 and Figure 2, it is apparent that at low hedge levels the generator distribution is skewed to the right, while a retailer is skewed to the left (that is tail of the distribution extends further). At high hedge levels, the situations are swapped. This phenomenon illustrates that financial risk is more acute for high-priced market events, and that the retailer is subject to such risks when under-hedged and the generator when over-hedged.

Again, the payoffs from the financial instruments do not perfectly offset the earnings from the retail load. There are volume mismatches from, for example, customer flex, 5/30 issues, customer churn, changed consumption profiles, uncertain solar displacement and so on.

Various parts of this report contemplate whether a change to 5-minute settlement would impact on the imperfect hedging risk, residual risk, for participants using derivatives to manage financial risks from physical exposures.

3.2.3 Generator and Retailer Natural Hedge Position

The figure below illustrates the mechanics of a typical contract (a swap) to hedge exposures. At high prices, the swap instrument leads to the generator compensating the retailer and at low prices vice versa, delivering price certainty to both parties. However, in a realistic environment where the volumes of the swap and generation/load do not match exactly, residual risk arises (Residual Risk). This paper considers whether the 5-minute settlement process will contribute to elevating that risk for swap and other derivative instruments.

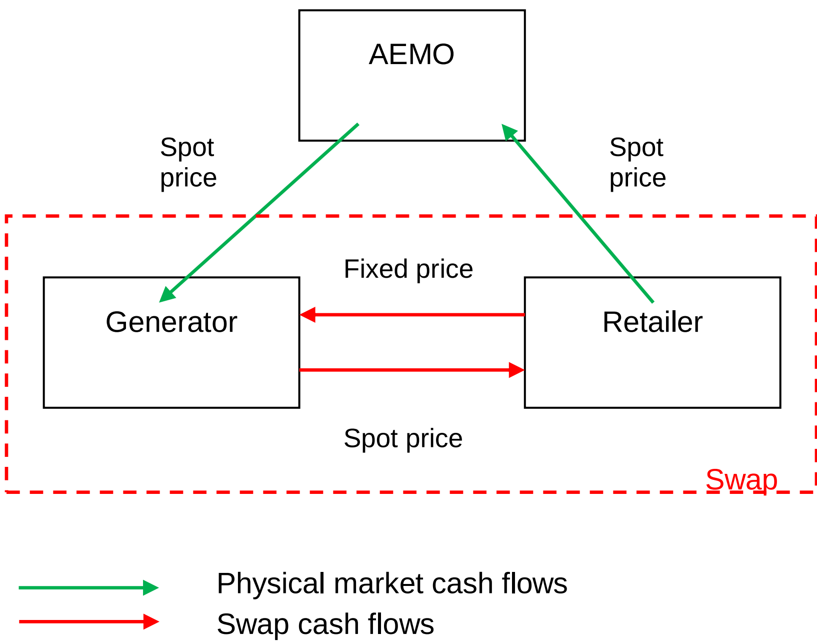


Figure 3: Flow diagram for physical exposures and hedging

A simple illustration of a typical Retailer portfolio structure is as follows:

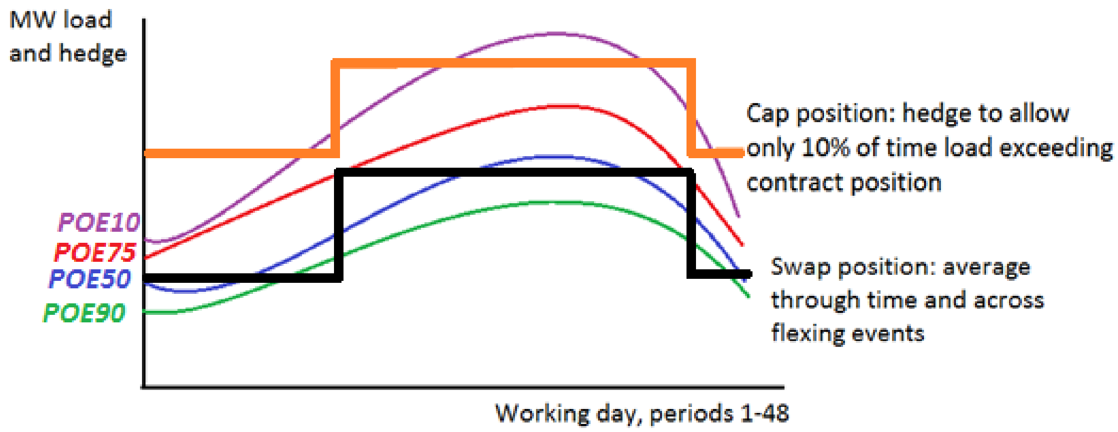


Figure 4: An illustrative example of a retailer hedge profile with Caps used to hedge the majority of Flex in their customer load. The derivative positions are represented by swaps (in black) with caps stacked atop (in orange) and represent a static, fixed position which is set ahead of time. The curves represent demand outcomes which may be randomly lower or higher depending on weather, consumption patterns and other uncertain drivers. A retail strategy presented here covers the 50% Probability of Exceedance level of demand with swaps and adds caps to the 'extreme' 10% Probability of Exceedance level.

In essence the nature of a Retailers underlying electricity price risk profile arising from their aggregated and evolving customer loads can be broken into high probability and consistent price exposure (base exposure often approximated by POE 50 forecast customer demand) and Flex in their load (often approximated by POE 10 of their forecast customer demand, which represents a high level of demand to be exceeded with only 10% chance). A simple hedge portfolio for a retail customer load is typically dominated by swaps up to POE 50 and caps from POE 50 to approximately POE 10. These can be seen layered in the illustrative example above. The application of these products to the different parts of the possible customer load is reflective of the different risk management characteristics of the swap relative to the cap and their ability to manage the different risk characteristics associated with these different parts of the forecast retail customer load.

A Retailer is typically reluctant to substitute substantial volumes of caps in their hedge portfolio with swaps and vice versa. If swaps are used to hedge substantially above expected retail load, more often than not, the retailer will have a net long exposure to pool prices as they will have bought swap settlement payments/receipts for every half hour that regularly do not have offsetting retail contract and pool price settlements. This dramatically increases the retailer's cashflow and gross margin risk profile. As a result, most retailer Governance Frameworks will in effect limit the extent to which swaps can be used as hedges for the Flex part of their retail customer load. Conversely there is a limited extent to which caps can used to hedge the expected or base profile of retail customer loads. In effect this means that, as with generators, retailers use swaps and caps for different risk management purposes and therefore any surplus in supply of swaps can only be used to a limited extent by retailers to offset a deficit in caps.

Of course, there are a number of other products used to manage the targeted risk profile of a hedge portfolio but swaps and caps are the dominant hedge products of choice across the

NEM. A rule change that adversely impacts the supply of swaps and/or caps which are the key risk management tools in nearly all generator and retailer portfolios will result in physical market participants being forced to either hedge less or use more expensive and/or less effective hedge products (more Residual Risk). Inevitably, in the absence of emerging alternative low cost low Residual Risk solutions, over time this results in a higher cost to the end user of electricity.

3.2.4 Vertically integrated entities

Vertically integrated (VI) energy businesses in the electricity sector hold exposures in both generation assets and retail loads. Most of the big names and top tier businesses in the electricity sector are vertically integrated enterprises. While it has become common in the sector to adopt corporate strategies targeting VI, invariably the portfolios are not completely balanced, that is, the generation and load profiles do not correspond exactly.

Some examples are as follows:

- An enterprise may hold a large retail load but only a small generation portfolio. The generation asset provides a partial natural cover for the retail load, but to further mitigate the financial risk such a business would typically buy additional derivative instruments (most commonly swaps, swaptions and caps) to balance the exposures.
- An enterprise might have a customer load with a very peaky profile (that is, flexes dramatically during high temperature periods and at particular times of the day) but a power station profile which consists of baseload generation (that is, generates consistently independent of time or price). While the baseload generation provides partial cover, the business would engage in derivative trading to acquire cap contracts which provide a financial hedge against residual exposures during the periods of extreme demand and pool prices when the wholesale costs are highly elevated.
- A VI entity's portfolio could contain residual risk if it is heavy in generation in one region and heavy in retail load in a different region, which leaves an exposure of interregional basis risk that enterprises will typically hedge with derivative instruments (e.g. interregional swaps being the simultaneous purchase of and sale of swaps against two different regions) and other contracts (e.g. Settlement Residue Auctions).
- A generating business might hold some industrial customers on retail contracts. However, the bulk of the remaining generation capacity is exposed to the pool price, and the risk arises of diminished revenues during periods of unexpected, extended low pool prices. Typically, such an entity will cover some of the residual generation exposure by selling derivative contracts, e.g. swaps and caps, to hedge against low price outcomes.

There are numerous other combinations and many other concrete examples can be identified in the NEM.

Almost all NEM participants hold financial services licenses enabling their trading operations to execute and hold electricity derivative contracts. All NEM participants hold financial exposure to the wholesale electricity prices to some degree, and the universal approach to balance the portfolios to within the financial tolerance of each corporate enterprise is achieved by hedging with derivative contracts.

3.2.5 Market Network Service Providers

The power transmission network within the NEM consists of a high voltage network to transport energy from generators to consumption sites. Generally, the network is owned by utilities which are compensated by regulated returns funded by access charges levied on consumers through their retail bill.

Interconnectors (transmission links connecting distinct NEM regions) fall into two classes, namely *regulated* and *entrepreneurial*. Regulated links are owned by the State via TNSPs and funded through the same regulated returns approach as the rest of the network. Entrepreneurial links are privately owned and generate their earnings by purchasing power at a low price in one region, transmitting the power and then selling it at a higher price in another region.

At present, there is only one remaining entrepreneurial link in the NEM, namely Basslink joining Victoria and Tasmania. The remaining DC links have been returned to regulated status, they no longer bid into the market and do not have commercial positions with contemporaneous exposures to NEM spot prices.

The owner of the Basslink faces financial risks if prices equalise in the adjacent regions, meaning that no significant margin can be extracted because the price differential vanishes. Essentially, if each respective region is able to meet its respective power demand with domestic power stations, at roughly equivalent marginal prices, then the interconnector is under-used and receives low earnings.

In reality, the operator of Basslink (with market exposures)also holds a portfolio of assets including power stations and retail loads in one or more regions. They invariably engage in derivative hedging to stabilise the risks from high or low pool prices in respective regions, and from an unexpectedly high or low differential between adjacent regions. Typical instruments to perform the hedging include swaps, caps and their futures variants.

3.3 Market liquidity

Market liquidity is assessed by analysing the trading turnover volume and liquidity ratio for each NEM region. The data that is summarised below has been sourced from AFMA annual survey responses, ASX Energy, AEMO publications and MMS data sources. It should be noted that there are various data compatibility and transparency issues with the key ASX and AFMA data sources on electricity derivative total turnover, regional segregation of turnover and product mix information. However, Energy Edge has used our extensive data base of historical data and trends in these areas and substantial market experience to ensure that where assumptions and extrapolations have had to be made that the results are consistent with historical trends and our understanding of current market activity. The margin for error in the trading turnover analysis undertaken is not considered material for the depth of analysis required for the purpose of this paper and its objectives.

Market Liquidity is needed to:

- Enable price discovery and communicate price signals so that entities in all spheres of the physical market can respond effectively to consumer requirements and system demands;
- Ensure a supply of contracts to enable Intermediaries to transform those contracts into secondary products;

- Ensure a supply of contracts to enable participants to effectively engineer the risk profile of their portfolios to meet risk return objectives and to effectively service customers maintaining prudent risk management practices;
- Enable market participants to minimise basis risk and residual risk and manage the financial consequences of those risks by maintaining a supply of derivatives to service differing hedge timing and hedge tenor objectives;
- Enable risk-taking business models to be sustainable whether intermediaries or physical market participants so that product diversity can be provided to manage mismatch between natural seller and buyer objectives in relation to shape, firmness, transaction type;
- Minimise cost of transacting; and
- Dilute potential market power of physical market participants in the supply and structure of available hedges.

Table 1 shows the trading turnover volume, measured in GWh, for each instrument by region and the corresponding Liquidity Ratio. The Liquidity Ratio is defined as the ratio of the total volume of traded electricity derivatives that settle against the regional reference price to the total energy demand for the region.

The table shows that, except for SA, all other NEM regions are supported by relatively strong electricity derivative trading markets with moderate trading turnover for key instruments, including Swaps, Caps and Options.

A suspension of AFMA electricity survey data in 2016 means that the OTC component of the trade volumes has been extrapolated from 2015 trading volumes and instrument mixes based on the ratios of OTC volumes to ASX volumes. The Futures data remains available and actual ASX trade volumes have been applied for 2016.

Region	OTC				Futures				Derivative	Physical	Liquidity Ratio
	Swap	Cap	Options	Total	Swap	Cap	Options	Total	Total		
QLD	18,090	5,956	1,275	25,322	64,196	18,207	45,602	128,005	153,327	49,986	3.1
NSW	24,192	4,079	1,075	29,346	67,756	15,157	32,638	115,551	144,897	65,478	2.2
VIC	12,646	116	1,033	13,795	80,702	14,578	43,557	138,836	152,631	42,007	3.6
SA	1,714	712	189	2,615	4,419	1,073	782	6,273	8,888	12,060	0.7
NEM	60,080	12,496	3,693	76,269	217,073	49,014	122,579	388,665	464,935	179,238	2.6

Table 1 – Fin 2016 turnover volume (GWh) and liquidity ratio split by region, channel to market and key instrument type.

Figure 5 shows the proportional splits in trading turnover volume for the NEM for the last decade for Swaps, Caps and Other instruments. It can be seen from the figure that over the last 5 years, the split between the key instrument types has remained fairly consistent.

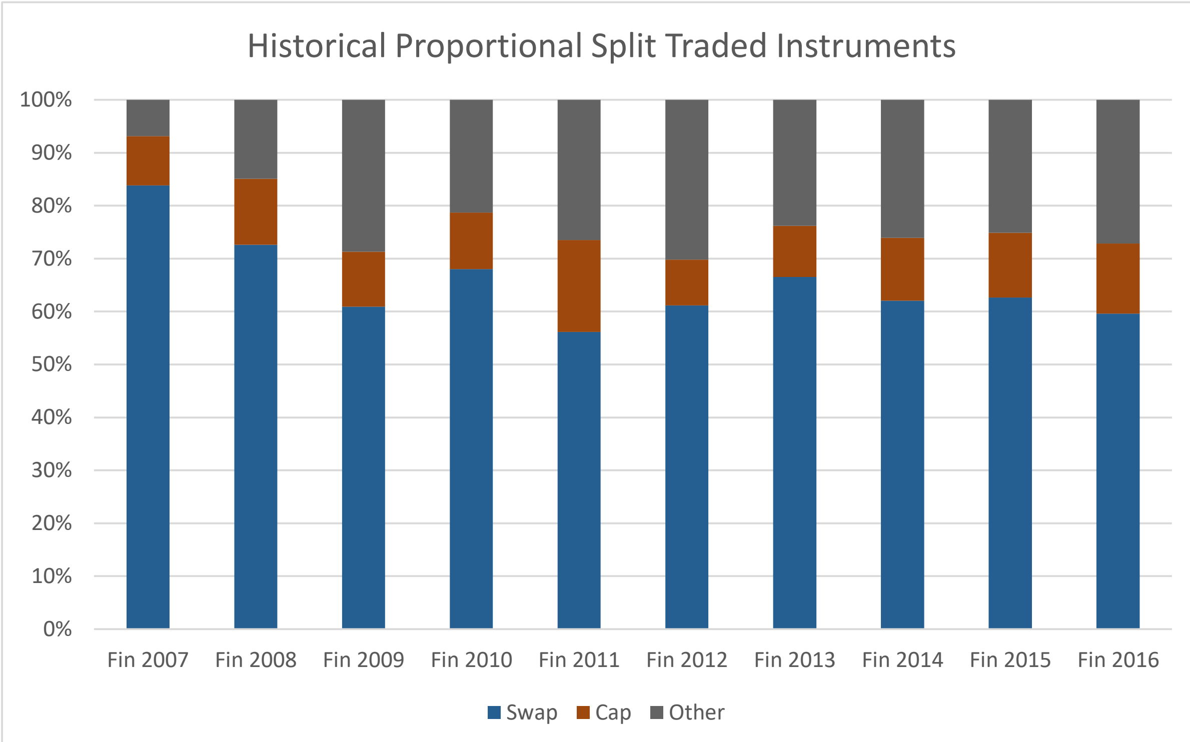


Figure 5 - NEM historical turnover by proportion of traded volume (GWh) split by key instrument type

Further analysis of trading volumes is shown in section 4.4.1

3.4 *Instrument risk management characteristics*

3.4.1 Swap

A firm swap is the primary financial contract traded in the electricity financial market. It has been developed to manage the price risk (in $/MWh) associated with the electricity spot market. They are traded either directly through negotiation with another party or via a broker, and allow both parties to swap the half hourly spot price for a pre-agreed fixed price for a defined period. One party agrees to receive the fixed price (and pay the spot price), and the other party pays the fixed price (and receives the spot price).

	Retailer or market customer	Generator
Natural position in the physical wholesale market	Pay half hourly spot price to AEMO for load used	Receive half hourly spot price from AEMO for generation
Risk position	Exposed to the risk of high average spot prices. Customers typically pay a fixed price per MWh	Exposed to the risk of low average spot prices. Revenue may be lower than cost of generation

Motivation for entering a swap	Remove the risk of high average spot prices and lock in a margin	Remove the risk of low average spot prices and lock in a margin
Typical party to a swap	Buyer	Seller
Obligations under a swap	• Receive half hourly spot price per MWh • Pay fixed price per MWh	• Pay half hourly spot price per MWh • Receive fixed price per MWh
Net effect of combined physical position and swap	• Pay fixed price per MWh (for the MW transacted as swaps) i.e. Spot price +/- swap settlement	• Receive fixed price per MWh (for the MW transacted as swaps) i.e. Spot price +/- swap settlement
Rationale	Used as a hedge against spot price variability. Provides a retailer or market customer with a fixed cost per MWh for the volume of swaps, thereby removing the risk of high average spot prices but commits the retailer to contract-for-difference (CFD) payments for every half hour whether they have a matching retail load or not i.e. if actual demand does not reach the level hedged with swaps.	Used as a hedge against spot price variability. Provides a generator with a fixed revenue per MWh for the volume of swaps, thereby removing the risk of low average spot prices and seeks to provide certainty in gross margin and cashflow outcomes within corporate risk appetite.
Suitability	Suitable for hedging a component of a retailers load most typically the high probability base of the retailer portfolio load profile. Depending on load shape and variability of load, may be suitable for a market customer to hedge a large part of their load. If the retail load contains a large amount of flex, then hedging too highly with reference to the load shape potentially increases the risk profile for outcomes where the spot price is low due to over-hedging.	Suitable for hedging baseload generation (using flat and peak swaps). Peak or 7-day peak swaps could be used to hedge intermediate generation. Not widely used for peaking generators as it doesn't match their generation profile and therefore has material risk consequences.

The benefit of this is that a generator who receives the variable half hourly spot price for its generation can fix the price that it receives by selling a swap. From a retailer's perspective, the variable half hourly spot price that the retailer pays can be swapped for a fixed price by buying a swap.

The items that are specified at the time of execution of an OTC swap are:

- Region
- Volume (MW)
- Fixed Price ($/MWh)
- Period (e.g. Q1 18) (always a period in advance of today)
- Profile (Flat: 24 hrs a day, 7 days a week, Peak: 7am – 10pm working week days, Off Peak: Non-peak hours i.e. 10pm – 7am working week days and all hours on weekends and public holidays)

The settlement timing is in alignment with the AEMO settlement calendar, which results in one settlement amount per NEM week (the NEM week runs from the first half hour of a Sunday until the last half hour on a Saturday). This once weekly settlement amount is transferred between the parties 20 business days after the end of the settlement week.

Settlements of swaps are calculated by taking the difference between the average half hourly regional reference price (spot price) for the NEM week and the fixed price, multiplied by the volume of the swap and then multiplied by the number of hours in the period (based on profile). Depending on whether the spot price has averaged higher or lower than the fixed price for the week, the settlement amount may be either payable or receivable by either party.

3.4.2 Futures

Futures are the exchange-traded equivalent of a swap. They are used to manage the price risk (in $/MWh) associated with the electricity spot market. They are traded on the exchange, with the ASX clearing house being the effective counterparty to both sides of the transaction. (i.e. the ASXCH effectively buys from the seller and sells to the buyer at the price agreed between the two parties). Futures allow both parties to swap the half hourly spot price for a pre-agreed fixed price for a defined period. The mechanism for doing this via the exchange is different from an OTC swap, with cashflows between each of the parties and the exchange occurring from the day after execution. This is due to the initial margin and daily variation margins (the settlement of the daily mark to market value) that the exchange utilises to manage credit risk. Regardless of this, the economic outcome of a futures product is the same as an OTC swap (except for funding of margins), with the result being that the difference in value between the fixed price and the average spot price for the quarter is paid from one party to the other. This provides a hedge against variable spot price outcomes.

As shown in Section 4.4, approximately 83 percent of the traded volume in FY 16 was transacted via the ASX. Futures constitute the bulk of the traded volume via the ASX, accounting for 47% of the total traded volume.

We refer the reader to section 3.4.1 for the hedging characteristics of a swap which also apply to a futures contract. The trading preferences towards futures or OTC contracts are driven by the following key points of differentiation:

- Anonymity: The futures exchange sits between buyers and sellers meaning that trading actions remain anonymous from all market participants. Deals executed through OTC channels rely upon confidence of the other party and brokers.

- Credit mitigation: The system of margining means that futures deals are fully insured against credit defaults by the counterparty.
- Cashflow characteristics: The cashflows arising from margining payments do not align with the NEM settlement timetable, meaning that substantial cash positions may be required to support a strategy of hedging physical loads or generators with futures.
- Carbon risk mitigation: The futures traded instruments are 'carbon inclusive', and parties wishing to execute instruments with carbon pass-through or regulatory-dependent clauses must turn to the OTC market.
- Customised features: The ASX deal is entirely commoditised, with pre-determined product specifications, while an OTC deal can be customised by negotiation between the dealing parties.

The items that are specified at the time of execution of a futures contract are:

- Region
- Volume (MW)
- Fixed Price ($/MWh)
- Period (e.g. Q1 18)
- Profile (Flat: 24 hrs a day, 7 days a week, Peak: 7am – 10pm working week days)

Whilst the cash flows are based on the variation and initial margins, the underlying settlement calculation is based on the difference between the half hourly spot price and the fixed price.

3.4.3 Caps (ASX and OTC)

A cap contract is an automatically exercised half hourly call option, where the seller receives a premium relating to each half hour of the agreed period and pays out the value associated with the difference in the half hourly spot price and the strike price only where the spot price exceeds the strike price. Caps are traded both OTC and on the exchange, and act as an insurance product for the buyer against extreme price events. For the seller, the premium allows a regular cashflow to cover fixed costs and when combined with its physical generation, the seller receives revenue from generation up to the strike price. The value above the strike price is paid out under the cap contract. The market convention for the cap strike price is $300/MWh although the OTC market has seen various cap strikes such as $100/MWh and $150/MWh strikes.

	Retailer or market customer	Generator
Natural position in the physical wholesale market	Pay half hourly spot price to AEMO for load used	Receive half hourly spot price from AEMO for generation
Motivation for entering a cap contract	Remove the risk of high half hourly spot prices above the strike price.	Provide a stable fixed price (premium) in return for paying out when the spot price is high.
Typical party to cap	Buyer	Seller

contract		
Obligations under a cap contract	• Receive the difference between the half hourly spot price/MWh and the strike price/MWh only when the half hourly spot price is higher than the spike price. • Pay a premium per MWh to the seller of the cap for each half hour of the agreed period.	• Receive the premium per MWh from the buyer for each half hour of the agreed period. • Pay the difference between the half hourly spot price/MWh and the strike price/MWh only when the spot price exceeds the strike price.
Net effect of combined physical position and cap	Pay the half hourly spot price on volume covered by caps (plus the cap premium) only up to the strike price.	Receive the premium, even when not running, and when running, keep the spot revenue under the strike price. Net Revenue of the portfolio upside is capped at the contract strike, but in return the generator receives a known earnings stream from premiums.
Rationale	Provides a retailer or market customer with some insurance against high half hourly spot prices for the volume of caps purchased.	Provides a generator with a small amount of revenue to cover fixed costs, and some further under-cap revenue when it runs. The contract fits the generation profile of peaking plant.
Suitability	Suitable for hedging a component of a retailer's load. Depending on load shape and variability of load, may be suitable for a market customer to hedge a large part of their load. Provides insurance for parts of the load that may not be hedged using other products. Could be a reasonably priced product to cover flex risk. Compared to Swaps (or Futures), Caps are the most suitable product to hedge volume that is less certain. In	Particularly suited to peaking generators that can use their fast start capability to generate quickly at times of high spot prices for relatively short periods of time during market stress.

	the case where the volume is uncertain, entering into a Swap commits the party paying a fixed price for a firm volume even when there may not be the underlying customer load. In this instance, a Cap, which is an insurance style product, provides protection only for high spot price outcomes and does not lock the retailer into potentially large CFD payments.	

The items that are specified at the time of execution of a cap contract are:

- Region
- Volume (MW)
- Strike Price ($/MWh)
- Premium
- Period (e.g. Q1 18)
- Profile (Flat: 24 hrs a day, 7 days a week, Peak: 7am – 10pm working week days)

The settlement calculation for caps, both OTC and ASX-listed is based on the half hourly spot price. Although the margining process for exchange traded caps alters the cashflow timing relative to OTC traded caps, the economic outcome for both instruments are the same (except for funding of margins).

3.4.4 Floors

A floor contract is an automatically exercised half hourly put option, where the seller receives a premium relating to each half hour of the agreed period and pays out the value associated with the difference in the half hourly spot price only where the spot price is less than the strike price. Floors are only traded on the OTC and do not have a market convention strike price. They are not traded much as an isolated instrument, and tend to be traded as part of a half hourly collar structure. The reason for this is that unlike caps, there is not a natural seller of floors. They tend to be sold by financial intermediaries, or by retailers or directly from very-large scale industrial consumers. The buyer of a floor is protected against the risk of low spot prices or parties looking to offset some of the premium cost for bought caps. Standalone floor deals are relatively rare, and they more often constitute a leg within a collar contract – see section 3.4.6.

	Retailer or market customer	Generator
Natural position in the physical wholesale market	Pay half hourly spot price to AEMO for load used	Receive half hourly spot price from AEMO for generation
Motivation for entering	Very little. A retailer is likely	Pay a premium in return for

a floor contract	to enter a floor contract only as part of a half hourly collar.	receiving cashflows when the spot price is low.
Typical party to floor contract	Neither	Buyer
Obligations under a floor contract	N/A	• Pay the premium per MWh to the seller • Receive the difference between the half hourly spot price/MWh and the strike price/MWh only when the spot price is less than the strike price.
Net effect of combined physical position and floor	N/A	Revenue is not less than the floor strike price for the volume of the floors
Rationale	N/A	Provides the generator with a floor to its generation price, whilst allowing it to participate in higher spot prices.
Suitability	Not suitable for a retailer as an isolated hedge product as it doesn't provide any protection against risk of high spot prices.	Could be suited to a base-load generator at times of high spot market volatility to ensure that its minimum net revenue for each half hour is sufficient to cover costs.

The items that are specified at the time of execution of a floor contract are:

- Region
- Volume (MW)
- Strike Price ($/MWh)
- Premium
- Period (e.g. Q1 18)
- Profile (Flat: 24 hrs a day, 7 days a week, Peak: 7am – 10pm working week days)

The settlement calculation for floors is based on the half hourly spot price.

3.4.5 Asian Options

An Asian Option is an automatically exercised product where the payout is determined with reference to a specified averaging period. There are two standard Asian Option products that are traded.

An Asian Cap (Call) is a derivative where the payoff is calculated with reference to a specified averaging period that places a ceiling on the price the buyer pays for electricity. The seller will compensate the buyer, on prescribed reference dates, to the extent that the unweighted arithmetic mean of the reference pool price during the specified averaging period exceeds the strike price.

An Asian Floor (Put) is a derivative with a payout calculated with reference to a specified averaging period that protects the buyer from a fall in pool prices below a specified level. The seller will compensate the buyer, on prescribed reference dates, to the extent that the unweighted arithmetic mean of the reference pool price during the specified averaging period is less than the strike price.

An Asian Option is very similar in nature to a half-hourly Option, although, rather than the payoff being determined on a half-hourly basis, the payoff is determined using the average pool price over the averaging period.

The result of this is that the strike price of the Asian Cap is usually set substantially lower than the half-hourly Cap, and, because the payout is based on the average price, the probability of payout is reduced and therefore premiums are lower.

The buyers, sellers and motivations of Asian Calls are analogous to half-hourly caps (section 3.4.3). The buyers, sellers of Asian Floors are analogous to half-hourly floor contracts (section 3.4.4). The key difference is that the payoffs are based on average prices across a full quarter rather than each half-hourly interval. As a consequence of the longer averaging period, the premiums are much reduced, and protection is provided against average price outcomes, rather than each individual price event.

3.4.6 Collars

A collar is a combination of any of the following products, where one is sold and the other is purchased:

- A half-hourly Cap and a half-hourly Floor;
- An Asian Cap and an Asian Put; and
- A Call Swaption and a Put Swaption.

Following market convention, the party that purchases the collar will purchase the call/cap and sell the put/floor. Typically, the strike prices for both legs (cap and floor) of the collar will be set such that there is no premium that is to be paid/received by either party under the collar. The strike price of the call/cap will be greater than the strike price of the put/floor. The volume that is referenced will be firm and the same for both legs of the transaction. For half-hourly options and Asian options, the exercise will be automatic. For swaptions, it is typically the responsibility of the buyer to notify the seller of their intention to exercise the option by the agreed expiry date.

If the index (spot price) that is referenced in the collar transaction is greater than the floor strike price and less than the cap strike price, no cash flow will be transferred to either party as neither leg will be exercised. If the spot price is less than the strike price of the floor, then the purchaser of the collar will pay the difference between the strike price of the floor and the spot price to the seller. If the spot price is greater than the cap strike price, the seller of the collar will pay the difference between the spot price and the strike price of the cap to the other party. The outcome is that both parties are exposed to spot price volatility between the strike price of the floor and cap, with no volatility if the spot price falls outside these bounds.

In the same way that a half-hourly Cap and Floor provide protection against pool price risk, a collar made up of these two instruments does the same. It provides one party with protection against high pool prices (usually the Retailer), whilst providing protection to the other party against low pool prices (usually the Generator). An Asian collar provides similar protection against pool prices as the half-hourly Cap and Floor collar, with the exception that the payoff is linked to the average pool price over a period rather than half-hourly prices. The Swaption collar provides protection against movements in *forward* prices. It provides one party (usually the Retailer) protection in the event that forward prices become high, whilst providing the other party (usually the Generator) protection in the event forward prices become low.

As discussed when describing Floors, unlike Caps, there is no natural seller for a Floor. A Generator will typically want to buy a Floor as this will provide a lower bound on the spot price outcome that will be received. In order to purchase a Floor, a generator will typically sell a collar which will allow them to apply a lower bound on the spot price (revenue) that they will receive. The cost to the generator is that they are also losing some potential upside by selling the cap and paying the difference between the spot price and the strike price of the cap to the other party.

Given the issues with finding a natural buyer and seller for a Floor, market liquidity for collars is greater. Given that typically no premium is exchanged under a collar transaction, they are an important product that is used to manage spot price risk, similarly to Caps and Asian Options.

Collars are an important way in which both parties can gain some price protection (either spot price or forward price). Depending on the levels that the strike prices of the call (Cap) and put (Floor) are set, there may be a premium paid by one party to the other. However, collars are quite often traded where the strike prices of options are set so that the value of the call (Cap) and the value of the put (Floor) offset, so that there is no cost to either party in entering the collar.

3.4.7 Non-firm transactions

A non-firm swap is an agreement between two parties to exchange the difference between a fixed price per megawatt hour (MWh) of electric energy and a variable price that is referenced to the pool price, as determined by the market operator, in a stated reference node, where the volume of the transaction is based on a non-firm volume, typically linked to an observable, auditable meter or event.

Two key types of non-firm, load-following transactions are commonly traded, one where the meter refers to a generator's output and one where the meter (or meters) refer to consumption volumes.

The generator-linked non-firm transaction (often classified as offtake contracts) are most often executed against smaller and intermittent generation, where an owner or operator seeks to transfer the volume risk of the generation to a counterparty, and will accept a price reduction in return. The inclusion of force-majeure clauses in OTC contracts is also an example of non-firmness in a derivative transaction.

The consumption-meter linked non-firm transaction (of which load-following swaps in section 3.4.7 is a special category) is a mechanism where a retailer or end-user can transfer the volume risk to a counterparty, and will accept a higher price in return.

The natural sellers of these products are small generators and the natural buyers are retailers who do not have the scale of customer load, risk appetite or appropriate systems and people to enable them to actively manage the shape of their portfolio in the wholesale market.

3.4.8 Load following swaps

A load following swap is an agreement between two parties to exchange the difference between a fixed price per megawatt hour (MWh) of electric energy and a variable price that is referenced to the pool price, as determined by the market operator, in a stated reference node, where the volume of the transaction is based on a variable reference amount (e.g. a customer meter, a collection of meters or the Net System Load Profile).

For a Retailer, this type of contract fully manages the Retailer's volume risk that arises from this customer's usage. This risk has been transferred to the seller of the contract to manage. This risk is transferred to the seller of the swap through the payment of a fixed price over and above the price for a fixed quantity swap.

The natural buyers of this type of product are retailers, predominately small retailers who do not have the scale of customer load, risk appetite or appropriate systems and people to enable them to actively manage the shape of their portfolio in the wholesale market.

The natural sellers of these products are generators who are able to charge a premium on top of fixed quantity Swaps and have a generation portfolio capable of absorbing changes in load profile in a quantum associated with the customer's expected load. The generators do not execute the swap against a particular nominated plant, but the full portfolio is used to support the contract, but there is no obligation to generate at the same profile as the contracted load.

3.4.9 Options

The following derivatives are included for completeness, but are not reviewed as they relate to options over underlying products (which have been discussed above) and address forward market risk, which is not the subject of this review paper.

3.4.9.1 Swaptions

A Swaption is an option to enter into a Swap on a future date and at a predetermined fixed price.

The buyer of a Call Swaption has the right, but not the obligation, to buy a swap on a future date at a predetermined fixed price. The buyer of a put Swaption has the right, but not the obligation, to sell a Swap on a future date at a predetermined fixed price.

The fixed price of the swap is the strike price of the Swaption. In return for offering the Swaption, the seller receives a premium. The value of the premium is largely dependent on the strike price of the Swap relative to the market price, the amount of time until expiry of the option and the expected volatility in pricing of the Swap until expiry. If exercised, the Swaption becomes a Swap, and will be taken to pool as a hedge.

Call Swaptions provide the buyer with flexibility in managing volume risk, whilst providing some *forward* price certainty and allowing for participation in forward price upside. It allows the buyer to prudently manage event uncertainty, including market impacts of some regulatory risks (e.g. climate change policy changes). The seller gives up their optionality as to whether to sell the Swap in exchange for the premium. They provide Retailers the opportunity to lock in a price for a volume that they may or may not need in the future. They are an important product in managing volume risk, event uncertainty and forward price risk.

Put Swaptions provide the buyer with flexibility in managing volume risk, whilst providing some *forward* price certainty and allowing for participation in forward price upside. It allows the buyer to prudently manage event uncertainty. The seller gives up their optionality as to whether to buy the Swap in exchange for the premium. A bought put allows Generators to manage market liquidity risk by establishing some volume certainty for future swap sales whilst buying time to achieve even higher swap prices than the strike price of the put swaption. They are an important product in managing volume risk, event uncertainty, and forward price risk.

The Natural Buyer of a call Swaption is a Retailer. When exercised, the buyer of the call Swaption ends up with a bought swap. The Natural Seller of a call Swaption is a Generator who might seek to enhance revenue by earning the premium by selling the options at a strike price they are happy with for the underlying swap. Short dated bought call Swaptions can be used by Retailers to manage hedge price risk during C&I Retail contract negotiations.

The Natural Buyer of a put Swaption is a Generator. When exercised, the buyer of the put Swaption obtains a sold Swap. The Natural Seller of a put Swaption is a Retailer.

3.4.9.2 Captions

A Caption is an option to enter into a Cap on a future date and at a predetermined premium and fixed price.

A call Caption gives the buyer the right, but not the obligation, to buy a Cap with a predetermined strike price and premium at a future point in time. The buyer pays an upfront premium for the option over the Cap and a subsequent premium if the buyer exercises that option to enter into the Cap transaction.

The call Caption is similar in nature to a call Swaption, although, rather than entering a Swap when a call Swaption is exercised, the exercised call Caption results in a Cap being entered into.

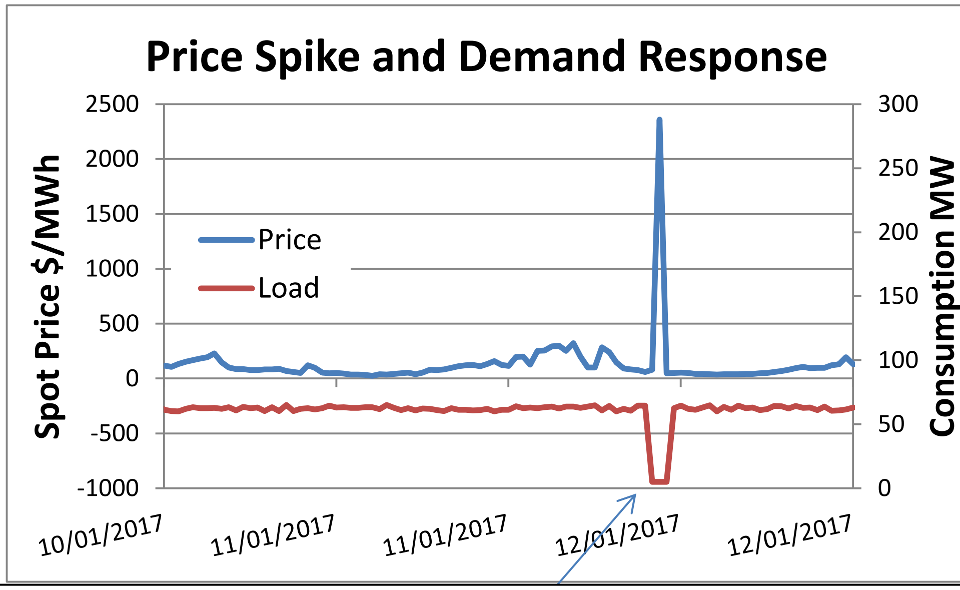
A put Caption gives the buyer the right, but not the obligation, to sell a Cap with a predetermined strike price and premium at a future point in time. The buyer pays an upfront premium for the option over the Cap and subsequently receives a premium if the buyer exercises that option to sell the Cap.

The put Caption is similar in nature to a put Swaption, although, rather than entering a Swap when a put Swaption is exercised, the exercised put Caption results in a Cap being entered.

3.5 Demand Side Management

Demand Side Management (DSM) is ostensibly performed by consumers rationally in response to high electricity prices to achieve energy cost savings. Additional drivers also motivate DSM including regulatory and financial motivations to deliver Ancillary Services, system stability and security (which we do not address in this report).

The inclusion of DSM in a portfolio transforms the risk profile. The interaction of a load-exposure, DSM and derivative contracts makes for a relatively complex setting for risk management purposes. In this section we outline how DSM may be used in conjunction with or in place of derivative instruments in a risk-management framework.



Two-fold influences arise during a DSM turn-down:

(1) There may be market-wide impact as reduced system demand delivers a lower spot price;
(2) The curtailing entity gains a benefit as it pays for electricity on the basis of a lower consumption volume and possibly the lower price from (1)

Figure 6: Illustration of DSM during a price spike event (by trading interval)

Standard retail contracts (fixed price arrangements) do not facilitate significant savings from demand response. But sophisticated participants and retailers may establish retail arrangements to share the savings arising from activating demand side management (in both attributes (1) and (2) in the figure above.

For a consuming entity who is purchasing all of the electricity from the spot market, the benefits of DSM are immediately apparent. A source of complexity on the practical effectiveness of DSM relates to the ability of the consumer to respond to price events in an accurate and timely way, namely:

Price spike forecasting: An entity successfully engaging in DSM must implement short-term forecasting capabilities to detect that a price spike is imminent and the ability to prepare industrial processes to reduce load for that period (and reinstate load after that period).

False positives: Predispatch and other metrics may forecast that a price spike will arise on the spot market, but conditions change and high pricing does not eventuate, meanwhile industrial processes have been turned-down unnecessarily;

Successful Turn-Down: The implementation of turn-down is a complex exercise for many large industrial users, and complex to coordinate for large numbers of smaller consumers.

Manage 5/30 issues: Under current regulations, there is a potential for a price spike in the final 5 minutes of the 30-minute trading interval. The consumer will pay electricity costs on the basis of the 30-minute price and consumption. So, a price spike in the final 5 minutes does not enable turn-down over the full half-hour of the trading interval, and the DSM has attenuated financial impact.

In all of these cases, a DSM strategy can work effectively in conjunction with a derivative portfolio. The underlying reason is that most derivatives will settle independently of the consumption load. In other words, if a consumer purchases electricity through the pool, then they may also hold a derivative contract, say a swap, to manage their risk. If spot prices become elevated, then the swap will deliver compensating cashflows to cover the high electricity price.

However, should the entity choose to reduce demand, then that entity will continue to receive incoming derivative settlements while incurring diminished energy costs from the pool. (This consumer may be directly exposed or the financial outcomes may be channelled through a sophisticated retail contract). In this way, there is an interaction between clearing and settlement characteristics for physical load on the NEM, derivatives, spot prices and DSM actions.

3.6 Potential changes to settlement and usage under proposed rule

If the physical market moves to a 5-minute settlement, but the contract market remains on a 30-minute settlement basis, with products referencing 30 minute prices, then for the products identified there will be a mismatch between the exposures faced in the physical market and the hedges that are in place to manage that risk. This would result in the hedges that are in place to manage the underlying spot price risk, not being effective in hedging that risk.

OTC products are likely to have clauses under the ISDA Master Agreement that trigger a change to the contract. Without working through the legality of this pathway, these contracts are likely to either be transferred to 5-minute settlement due to a material change in the underlying market, or alternatively there may be a disruption clause invoked under which the parties are to negotiate to determine a solution to resolve the change. However, the nature of the products identified will change with the move to 5-minute settlement and therefore the value of those products will no longer be the same. This will undoubtedly require a change to the pricing of affected products.

It is our view that the contract markets, both OTC and ASX would need to adopt the change in the settlement timing to allow participants to continue to manage their risk with products that match their underlying exposures.

There are two levels of potential risk that can result from the proposed change to a 5-minute settlement frequency for the underlying physical market. The first consideration is the impact on the settlement, valuation and risk management if the contract market evolves to a 5-minute frequency to align with the underlying physical market. The second consideration is the potential basis risk that is introduced from having a mismatch between the settlement frequencies of the two related markets. As can be seen from the table below, there is some popular traded products that have non-linear payoff structures that would introduce an additional risk if the misalignment of the two settlements. It is likely that this would drive changes in the contract market (documentation) to align the settlements between the contract and physical market.

Instrument	Typical sellers and buyers	Calculation of settlement	Change in settlement?	Impact of change on instrument	Impact on participant behaviour
Swap	Typical hedging transaction is a Generators selling a Swap to a Retailer.	References half hourly spot price, but can be settled based on 5-minute price. Contractual volume does not	No change as the sum of the 5-minute settlement for a half hour is mathematically equivalent to the half hour settlement for the	Would make no difference to pricing of contract, or settlement calculation.	No change to participant behaviour. Swap is a financial contract independent of physical generation or load

Instrument	Typical sellers and buyers	Calculation of settlement	Change in settlement?	Impact of change on instrument	Impact on participant behaviour
		change between 30 minute and 5-minute settlement.	average spot price for a firm contract volume. Therefore, no change to settlement values. Given equality between the settlement between both 5 minute and 30-minute settlement frequency, there is no residual settlement frequency basis risk.		and settles against the half hourly average of the 5 minute prices.
Futures	As per swaps	As per swaps	As per swaps	As per swaps	As per swaps
Caps	Typical hedging transaction is a low-capacity flexible Generators selling a Cap to a demand-flex exposed Retailer.	Caps are automatically exercising call options for the trading price over the trading interval (30 minutes)	As they are structured and traded at present, caps could still be settled on a half hourly basis by averaging the six 5 minute prices. However, a change to a product based on 5-minute settlement (i.e. a 5-minute cap product would fundamentally change the product as the market would need to reassess the pricing of a 5-minute cap product as well as reassess the appropriateness of current pricing and risk	If the cap still settled on a half-hourly basis, there would be a potential mismatch in the contract settlement versus the physical settlement because the average 5-minute cap payoff will be at least equal to or greater than the payoff above the strike price based on the average 30-minute spot price. If both the contract and physical market settled on a 5-minute resolution, then there	Cap settlement does not reference physical generation; however, participant behaviour would be expected to change given interlink between cap payoff and ability for participant to ramp to cover exposed volume and offset contract market settlements.

Instrument	Typical sellers and buyers	Calculation of settlement	Change in settlement?	Impact of change on instrument	Impact on participant behaviour
			methodologies used in systems and governance frameworks across the market.	would be a change to the value of the product as the distribution for spot price outcomes would be different. Would potentially result in a larger market premium to cover the additional risk around being able to ramp plant to cover exposed volume.	
Floors	Typical hedging transaction is an industrial end user, retailer or intermediary selling a Floor to a high capacity Generators looking to manage low prices. Potentially bundled to form a collar contract with a cap.	Settlement is linked to settlement period and price (half hourly).	As currently defined, Floors could still be settled on a 30-minute basis by referencing the average of each 5-minute price within the half-hour. If the product settled on a 5-minute frequency, the settlements would not align given the non-linear payoff structure.	If the floor still settled on a half-hourly basis, there would be a potential mismatch in the contract settlement versus the physical settlement because the average 5-minute floor payoff will be at least equal to or greater than the payoff below the strike price based on the average 30-minute spot price. If both the contract and physical market settled on a 5-minute resolution, then there would be a change to	Floor settlement does not reference physical generation. No expected change in participant behaviour. Intermediaries have on involvement in underlying physical market. Generators receive settlement from floor and Retailers have limited ability to change outcome. DSM lowers price which would increase payoff under floor.

Instrument	Typical sellers and buyers	Calculation of settlement	Change in settlement?	Impact of change on instrument	Impact on participant behaviour
				the value of the product as the distribution for spot price outcomes would be different. Would potentially result in a larger market premium to cover the additional risk around being able to ramp plant to cover exposed volume.	
Half hourly collars	Typical hedging transaction is a generator selling a cap to retailer. The generator will lock in a minimum spot price received (via the bought floor) and receive a premium for selling a cap and paying the retailer when the spot price exceeds the cap strike price.	Settlement is linked to the half-hourly spot price outcome. If the spot price falls between the floor and the cap there is no payment. If the spot price is below the floor, the buyer of the collar will have to compensate the seller by the difference between the floor price and the spot price. If the spot price is above the cap, the	A half-hourly collar contains a cap and a floor transaction. The impact to settlement is based on the underlying settlement of each leg as discussed above.	A half-hourly collar contains a cap and a floor transaction. The impact to the pricing and settlement is based on the underlying components of each leg as discussed above.	A half-hourly collar contains a cap and a floor transaction. The impact to the participant is based on the underlying components of each leg as discussed above.

Instrument	Typical sellers and buyers	Calculation of settlement	Change in settlement?	Impact of change on instrument	Impact on participant behaviour
		seller of the collar will have to compensate the buyer by the difference between the spot price and the cap price.			
Asian Cap (Asian call option)	Typical hedging transaction is a Generator selling an Asian Cap to a Retailer.	The settlement is based on the difference between the unweighted arithmetic mean of the reference pool price during the specified averaging period exceeds the strike price	No change as the average period used for the Asian Cap is greater than the half-hour interval and therefore for a firm volume, the average spot price is the same.	Would make no difference to pricing of contract, or settlement calculation.	No change to participant behaviour. Asian Options are a financial contract independent of physical generation or load and settles against the half hourly average of the 5 minute prices.
Asian Floor (Asian floor option)	Typical hedging transaction is a Retailer or financial intermediary selling an Asian Floor to a Generator looking to manage low prices.	The settlement is calculated as the how far the unweighted arithmetic mean of the reference pool price during the specified averaging period is less than the strike price	No change as the average period used for the Asian Floor is greater than the half-hour interval and therefore for a firm volume, the average spot price is the same.	Would make no difference to pricing of contract, or settlement calculation.	No change to participant behaviour. Asian Options are a financial contract independent of physical generation or load and settles against the half hourly average of the 5 minute prices.
Non-firm	Typical hedging	The settlement is	The non-firm swap could	Pricing and settlement	No change to

Instrument	Typical sellers and buyers	Calculation of settlement	Change in settlement?	Impact of change on instrument	Impact on participant behaviour
transactions	transaction is a small generator who do not have the ability to actively manage their portfolio in the wholesale market and wish to mitigate both price and volume risk.	calculated with reference to the spot price and the non-firm volume	still be able to be settled on a 30 minute by calculating the time weighted average load and multiplied by the time weighted average price. If the non-firm swap settled on 5-minute interval, the settlement would not be consistent with the current 30-minute settlement given that the volume is not firm and the volume weighted 30-minute settlement will not be equal to the time weighted 30-minute settlement unless the volume is the same for each 5-minute period.	would be derived based on 5-minute settlement. Depending on the intra 30-minute generation flex, and the correlation between volume and price, there could be difference between the value under each settlement regime.	participant behaviour. A non-firm swap will still hedge the price and volume risk for a generator on a 5-minute basis.
Load following swaps	Typical hedging transaction is a generator with a portfolio capable of absorbing changes in load profile to a small retailer who do not have the ability to actively manage their portfolio in the	The settlement is calculated with reference to the spot price and the load.	The load following swap could still be able to be settled on a 30 minute by calculated the time weighted average load and multiplied by the time weighted average price. If the load following swap settled on 5-minute interval, the settlement	Pricing and settlement would be derived based on 5-minute settlement. Depending on the intra 30-minute load shape flex, and the correlation between volume and price, there could be a difference between the value under each settlement regime.	No change to participant behaviour. A load following swap will still hedge the price and volume risk for a retailer on a 5-minute basis.

Instrument	Typical sellers and buyers	Calculation of settlement	Change in settlement?	Impact of change on instrument	Impact on participant behaviour
	wholesale market.		would not be consistent with the current 30-minute settlement given that the volume is not firm and the volume weighted 30-minute settlement will not be equal to the time weighted 30-minute settlement unless the volume is the same for each 5-minute period.		
Options (Swaptions and Captions)	Typical hedging strategy involves using Options to manage forward price risk.	The seller of the option receives a premium (typically upfront) that reimburses the seller for providing the buyer with the right to exercise the option at a future time. The settlement of the underlying transaction behaves following the respective methodology outlined above. For example, an exercised swaption results in a swap	No change in the settlement of the option. The settlement of the underlying swap or cap will be impacted as outlined above.	Pricing of captions would be impacted because the price/premium for the underlying instrument will be impacted. Swaptions would not be impacted.	No change to participant behaviour. Options are a financial contract independent of physical generation or load.

Instrument	Typical sellers and buyers	Calculation of settlement	Change in settlement?	Impact of change on instrument	Impact on participant behaviour
		and an exercised caption results in a cap.			

4 Detailed Impact of Rule Change on Contract Types

4.1 Main instrument types impacted by rule change

Our assessment of the main contract types impacted by the 5-minute settlement rule change covers the following instruments:

- Half hourly caps
- Half hourly floors
- Half hourly collars
- Captions – Options over half hourly caps
- PPAs, Whole of (generation) meter swaps

Based on our earlier analysis, we have assumed for this section that 5-minute settlement will be introduced to traded instruments, both OTC and exchange traded. This may be an incorrect assumption based on the potential for demand side optionality for 5 or 30-minute settlement (as discussed in section 5.3).

4.1.1 Half hourly caps

The main reason that caps would be affected under a 5-minute settlement period is that a cap contract is essentially a sequence of half hourly automatically exercised options. Assuming that the contract specifications align with the settlement period, then it is a mathematical fact that shorter settlement intervals lead to monotonically increasing dollar payoffs.

That is, for a given strike price and a given underlying quarter, the payoff from a quarterly-exercised cap contract will be no greater than the payoff from a daily-exercised cap contract, which will be no greater than the payoff from half hourly-exercised caps which is no greater than the payoff from 5-minute-exercised caps.

For proof, we may appeal to the observation that if the average in a half hour exceeds the $300 threshold, then a 30-minute and 5-minute cap will have identical payoffs. But if the average in a half hour falls below the $300 threshold, then there still remain ways for a 5-minute cap to deliver a payoff, while it is impossible for a 30 minute cap.

Consequently, from a trading perspective, 5-minute caps deliver larger payoffs and therefore would attract a greater premium than 30-minute caps. In an analogous way, we presently see that 30-minute caps attract a higher premium than quarterly caps (Asian calls).

In section 4.3 a comparison of respective cap values under the 5- and 30-minute settlement timetables are compared using historical price data.

Of the affected instruments, caps are the most traded and widely used as a risk management tool by retailers, and provide an effective hedge for fast start generators. The issue arises that the fast start generators (gas and hydro) physically and operationally are fast enough to capture the majority of the price spikes' pay-offs under a 30-minute settlement period. However, their ability to respond fast enough to increase generation in response to five minute prices is materially eroded and substantial value is lost (if they continue to use the same operational strategies that they use now).

4.1.2 Half hourly floors

Half hourly floors would also be affected as they are essentially the inverse of a cap in that they payout when the spot price is below the strike price. As with caps, there would be more situations where floors would pay out under the proposed 5-minute settlement, as the whole half hour spot price does not need to average under the strike price, but rather only one 5-minute period. Therefore, all other things being equal, floors will pay out in more instances than 30 minute floors and will therefore be worth more.

Floors are less commonly traded than caps and there is no market convention surrounding strike price. They are only traded in the OTC market and are more often than not traded as part of a half hourly collar. Liquidity in floors is quite poor, as there are no natural sellers of floors. Whilst 30 minute caps are a suitable and effective hedge for fast start generators, there are no natural participants that gain benefit from selling a floor.

For this reason, and due to their limited utilisation in the financial market, we will not review the impact of the proposed change to 5 minute settlements on half hourly floors beyond this point.

4.1.3 Half hourly collars

As described above, a half hourly collar is the combination of either a bought cap and a sold floor, or a sold cap and a bought floor. The strike prices of each of the instruments are set by agreement between the parties to the transaction. In the same way that the change from a half hourly payout of the cap and floor would change with the proposed 5-minute settlement, the collar would also be affected.

As with floors, due to the volume of collars traded in the market being quite small, and caps being the more dominant instrument in terms of traded volumes, we will not review the impact of proposed 5-minute settlement on collars beyond this point.

4.1.4 PPAs, whole of (generation) meter swaps

Offtake arrangements for the purchase of power based on the quantity of electricity generated are also likely to be affected by 5-minute settlement. Unlike most financial products traded that reference a fixed volume, the volume under these types of products is based on the amount of electricity generated. Therefore, rather than the settlement amount being based on the half hourly average price and volume, it would be based on the 5-minute price and volume. These types of arrangements are common in relation to offtakes from some generation asset classes and are seen in a number of renewable energy offtake agreements where generation is non-scheduled (or semi-scheduled). This would have some ramifications for arrangements that are transacted under this structure, however, unless the generation is capable of being ramped up or down in response to price, then it is unlikely to have a material effect on the offtake price.

On this basis, we will not review the impact of 5-minute settlement on PPA or whole of (generation) meter swaps beyond this point.

4.2 Natural buyers and sellers of caps

There are a number of market participants that transact caps. These are identified below:

4.2.1 Retailers – Natural Buyer of Caps

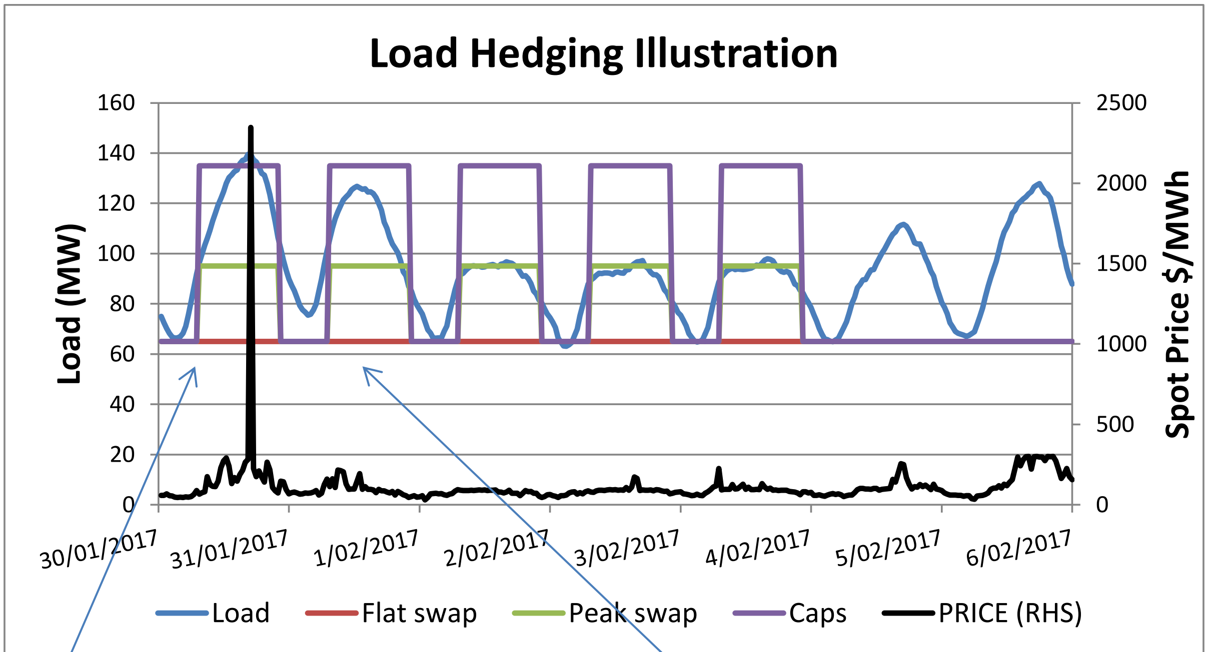
Caps are used as a risk management tool by retailers to manage the risk of high half hourly spot prices. Retailers purchase caps as part of their derivative portfolio as a cheaper alternative to swaps to manage the flex in the retail load as demand varies from day to day.

In essence, a prudent retailer's hedge portfolio aims for a profile to cover the consumption load of its customers. However, while the derivative portfolio is built up to a particular volume and daily profile across the coming quarter, the customer loads fluctuate (flex) in an uncertain way as the weather varies and industrial processes fluctuate.

So, a retailer seeks a derivative product that is there to protect against high spot prices, but is only sometimes needed to cover the load, when it flexes to particularly high levels. A widespread approach adopted in the NEM and advocated by risk management professionals is to cover the typical consumption levels with swap derivatives, and then stack additional cap derivatives to provide protection for the flexing load against extreme price events.

Some retail loads contain more flex than others and would therefore require a larger percentage of caps to help manage these changes in load shape.

The mechanical operation of the cap is that the retailer pays a cash premium (akin to an insurance premium) to purchase the cap derivative. When spot prices lie in their 'regular' range (around $50-$100/MWh) there are no payments back to the holder. However, when prices suffer spike events (to say $1000/MWh), the cap holder is compensated by the amount above the strike price of $300/MWh (here $700/MWh). Since the load typically also flexes upwards during high price events, the net outcome for the retailer for the additional load cost is $1,000/MWh in pool costs, but a $700/MWh receipt in derivative settlements: in other words, the cost is capped at $300/MWh (and hence the derivative's name).



The retailer purchases additional cap contracts to cater for load flex during high price periods. On the first day, there is a severe price spike and load flex but for the extent of flex the wholesale cost to the retailer has been capped at $300/MWh. Of course, the retailer has paid an upfront premium to acquire this insurance.	On the second day, there is again significant flex but no price spikes. The cap contracts provide no cash payments, but compensation is not needed because the spot prices remained low anyway. While the retailer has paid a premium for the insurance, it was not called upon during this day.

Figure 7: Industry standard retailers' approach to employing cap contracts as a hedge to provide insurance against high price excursions during periods of load flex.

4.2.2 Open Cycle Gas Turbines – Natural Seller of Caps

From a peaking generator's perspective, caps allow the generator to earn a premium for every MW sold through caps, regardless of whether the generator is running or not. This premium in theory allows the generator to cover its overhead costs and provides a level of revenue certainty. When running, the aim is to anticipate the higher priced periods and generate through this period to capture the high spot prices. The payout associated with the cap is then covered by the income from generation, with the 'under cap' value (the spot revenue below the strike price) being retained by the generator to pay for fuel costs etc. The generator is unlikely to capture the full value associated with all the price spikes, due to the time to ramp to full capacity and whether the price spike is expected or unexpected. Therefore, OCGT's tends not to sell caps to their full capacity as it is not able to physically back this full volume of cap contracts.

Historically, OCGTs have run at relatively low capacity factors due to their low thermal efficiency (conversion of GJ to MW). Their decision to generate to cover their sold contract position is balanced against their high short run cost and the high cost of each start, measured in Equivalent Operating Hours (EOH) – each start of an OCGT equates to approximately 20 EOH for the dominant technologies in the market, which brings forward the timing of maintenance overhauls.

In recent years with the shortage of gas and linkage to international pricing via the east coast LNG facilities, the fuel costs of OCGTs have increased such that their capacity factors in theory should have decreased slightly. With a change to a five-minute settlement, OCGTs may find that their capacity factor may decrease even further, as they would likely only respond to price spikes if they believe they would last longer than the current five-minute period. In this case the natural supply of caps would decrease. The extent to which they would decrease is subject to many variables but most likely the minimum decrease in supply of caps from OCGT is likely to be approximated by the decrease in achievable dispatch of available generation capacity in response to 5-minute price spikes relative to 30-minute price spikes (notionally the delta of the generator's achievable pay off profile to that of a cap pay off profile). Refer to section 4.5.1 and 4.5.2 for analysis of these changes to deltas when moving from a 30-minute to a 5-minute settlement.

In the worst case the ability of a peaking generator to physically capture the cap pay off would reach a point where the residual risk is too great and that generator type simply ceases to sell any firm caps. It is not clear at what point this might occur as certainly some generators with quite low capacity factors and price event capture rates are known to sell Caps. However, if such a tipping point was reached for a key natural supplier of caps then the quantum of the reduction in the underlying supply of caps could be materially greater than assessed in section 4.4 and estimated in Table 6 and Table 7.

4.2.3 Liquid fuel generators

The main type of liquid fuels used in generation are diesel, distillate and aviation fuel. Due to their higher running cost than gas, these generators tend to react to price spikes once they occur, rather than run in anticipation of a spike, as it is cost prohibitive to run for periods without a price spike. Most of the liquid fuel generators in the NEM are held within vertically integrated portfolios and so they do not sell caps in the traded market, but rather operate as required for the benefit of the vertically integrated portfolio and their position at the time. It is therefore hard to know how they would operate under a 5-minute settlement as this is likely to depend on the individual requirements of each portfolio.

4.2.4 Hydro generators

Hydro generators tend to have fuel constraints that they must manage, either through a limitation of the size of and inflow into their storage, or in the case of pumped-hydro, the amount of water that can be pumped for use in generation. Due to these constraints, they look to optimise the returns that they receive from their generation, and this is often through the sale of caps, whereby they are paid a premium even at times when they are not generating, and then they are able to generate to cover high price events. By only generating during these times, they are able to extract both a premium that is a representation of the value of the price spikes, and also material under-cap revenue to warrant generating and eroding finite fuel reserves.

As with OCGT and CCGT the natural supply of caps from hydro generators is likely to decrease under the 5-minute rule change. The extent to which they will decrease is subject to many variables but most likely the minimum decrease in supply of caps from hydro generators is likely to be approximated by the decrease in achievable dispatch of available generation capacity in response to 5-minute price spikes relative to 30-minute price spikes (notionally the delta of the generators achievable pay off profile to that of a cap pay off profile). Analysis in section 4.5.2 and Table 6 notes that while hydro generators can ramp up faster than OCGT and CCGT, their effectiveness in capturing 5 minute pricing relative to capturing 30 minute pricing is greatly reduced.

One benefit of 5 minute settlement for a hydro generator is due to not incurring large start-up costs, they are able to economically generate for short periods. Therefore hydros are able to reduce or cease generation after a price spike, so that they conserve water for use at other times.

4.2.5 Combined Cycle Gas Turbines (CCGT)

Due to their higher capacity factors, combined cycle gas generators are generally more suited to selling swaps (either flat or peak depending on their capacity factor). Therefore, for the purposes of this analysis we have excluded them from the list of cap sellers. While in the current market, they tend to be energy constrained, this would likely result in slightly reduced capacity factors. However, due to their inability to start quickly, they do not fall into the category of a fast start generator.

4.3 How caps are priced (non-technical)

The premium that participants are willing to pay for caps and the price that sellers are willing to sell caps are driven by a number of factors. These are listed below.

- The expected payoff of the cap. This is based on the market's expectation of the time and quantum of spot price excursions above $300/MWh for a particular region and period. A useful input into this assessment is prior period actual results. It will also be influenced by the value of the forward price for swaps for the region, in that the higher the forward swap price, the more chance that that value will be made up of pricing above $300/MWh.
- The supply/demand balance for cap products. Through pure economics, a lack of cap supply will drive up the price of caps. The converse is also the case.
- The value of a cap relative to other products. A risk/return decision is made around whether to continue buying caps or use other products that serve similar risk management purposes, e.g. weather derivatives, but may incur costs or require parties to carry additional basis risk.

As discussed previously, the payoff of a 30-minute cap will be less than or equal to a 5-minute cap due to the 5-minute cap paying out whenever the 5-minute price exceeds the strike price, as opposed to the average 30-minute price exceeding the strike price. This is demonstrated in the diagrams below.

Figure 8 shows an example of a single high Dispatch Price ($1,300/MWh here) with five low Dispatch Prices ($50/MWh here). This results in an average Spot Price for the Trading Interval of $258/MWh, which is below the typical $300/MWh strike price for a 30-minute cap financial contract and therefore would have no financial settlement under a 30-minute settlement period.

However, on the 5-minute settlement, the initial period of $1,300/MWh has $1,000/MWh over the 5-minute settled cap contract. If the contract was just for this Trading Interval, the payout of 1MW contract would be ($1300/MWh-$300/MWh) × (1/12) MWh = $83.33.

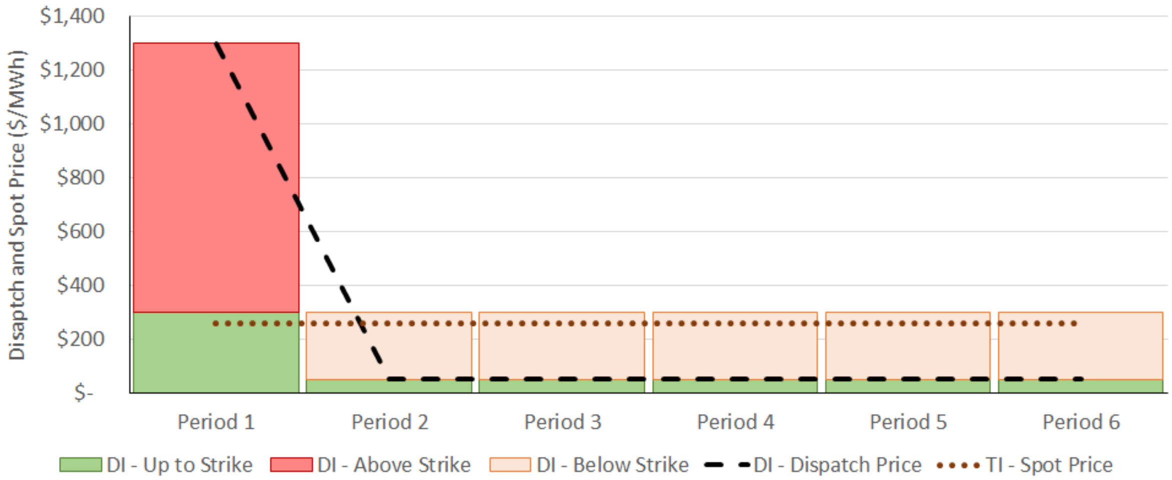


Figure 8 – Single high Dispatch Price with five low Dispatch Prices during a Trading Interval

Figure 9 shows an example where all six periods of Trading Interval are greater than the strike price. Under this scenario, the 30-minute cap contract and 5-minute cap contract would financially settle with the same result (e.g. 1MW contract payout would be $62.50/MWh).

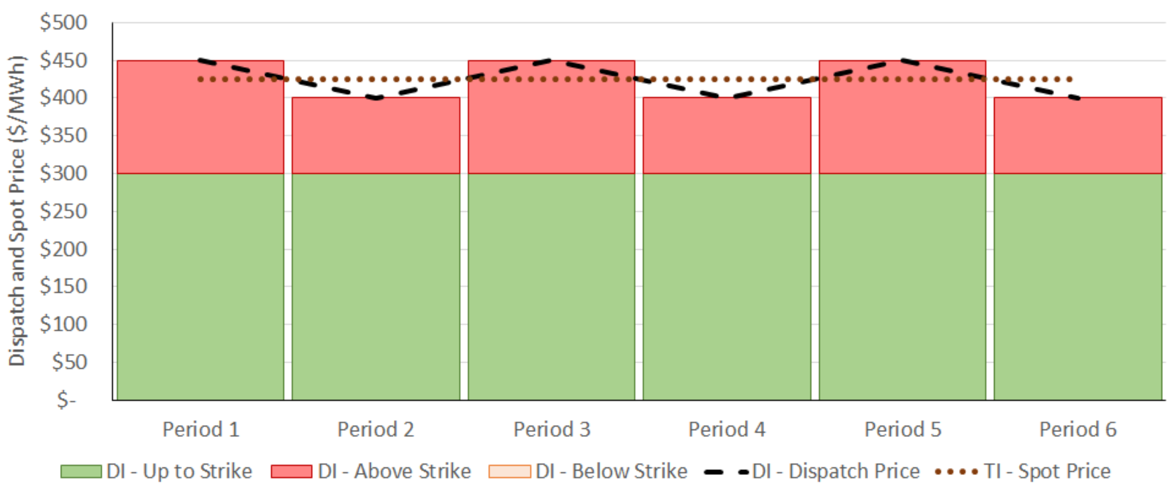


Figure 9 – Six high Dispatch Prices during a Trading Interval

To gain an understanding of the potential quantum of the difference in value of the payoff of a 30-minute cap relative to a 5-minute cap, we have undertaken some analysis for each region over the period January 2015 - December 2016. We acknowledge that this analysis is based on operational decisions made in a 30-minute settlement market, and therefore may not represent the results if participants had operated under a five-minute market. However, the analysis provides some guidance as to the level of difference in cap payoffs between the two market structures.

Region	Cap payoff (30-minute settlement) ($/MWh)	Cap payoff (5-minute settlement) ($/MWh)	Difference (%)
Queensland	$14.12	$15.41	+9.1%
New South Wales	$1.48	$1.54	+4.2%
Victoria	$0.72	$0.82	+14.2%
South Australia	$10.55	$15.46	+46.5%

Table 2 - $300/MWh strike historical annual cap payoff under 30 and 5-minute settlement

Whilst the above provides a historical theoretical cap payoff under a 5-minute settlement market, there are other factors that are likely to impact on the price that caps trade at. These include:

- Supply / demand balance of caps; and
- The value of caps relative to other products on a risk / return basis.

Due to the move to 5-minute settlement, it is highly likely that the price that retailers pay for the caps would increase in the short term, therefore increasing the cost to the end user. However, it is likely that over time strategies will evolve, alternative products emerge and physical solutions and technology will progress to at least in part off-set the higher risk profile, and therefore the price impact is likely to be diluted.

4.4 Trading volumes and pricing

4.4.1 Current trading volumes

The figures below provide some indication of current trading volumes across regions and across instrument types. As can be seen, the bulk of trading occurs across the east coast regions, with very limited trading in SA, with caps making up between 10 – 20% of traded volume in each region.

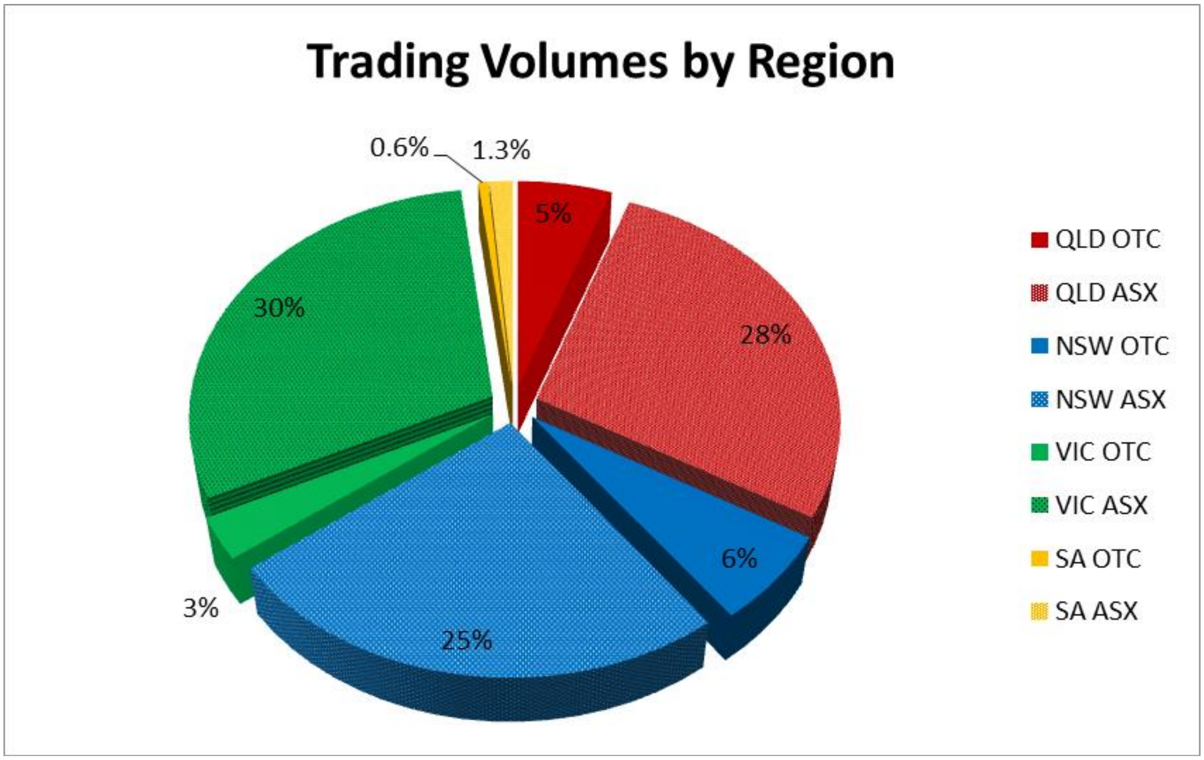


Figure 10 - Trading volumes by region

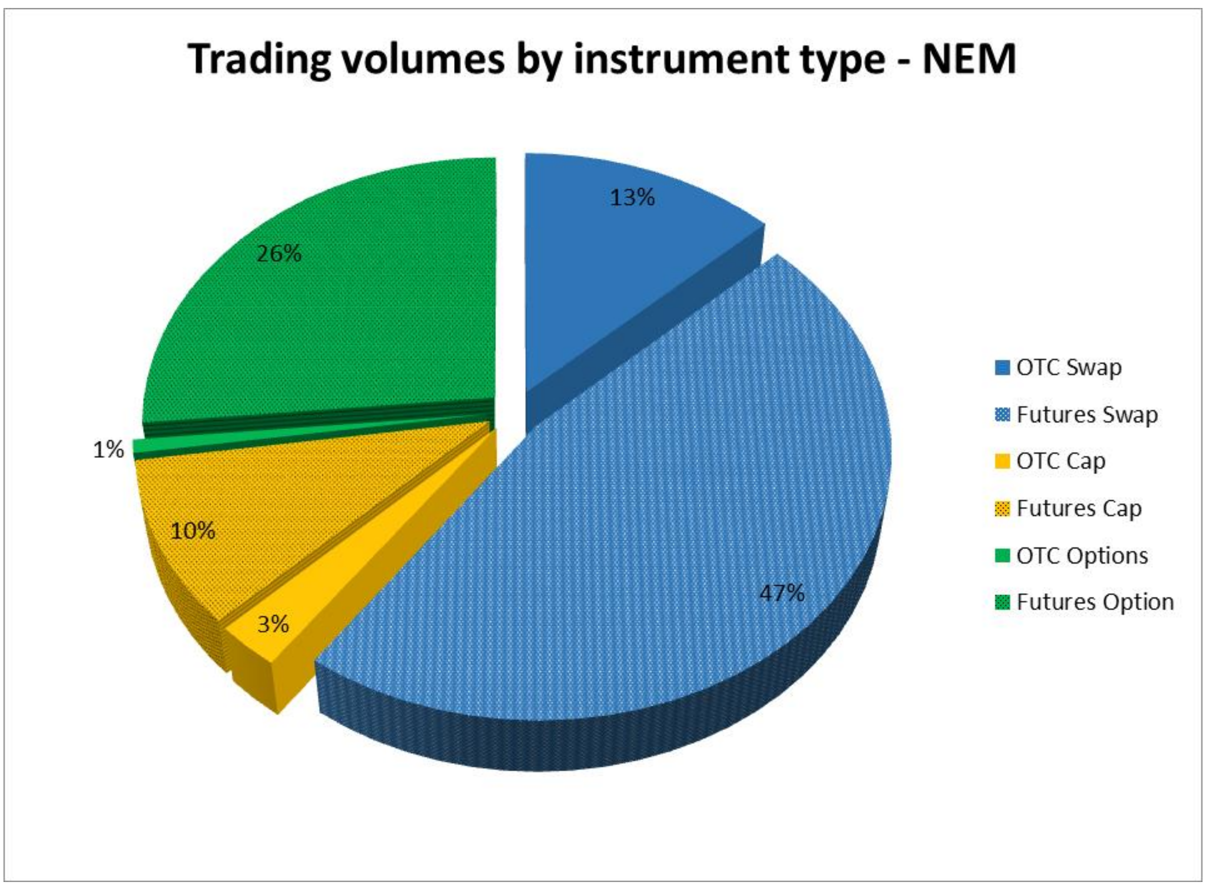


Figure 11 - Trading volumes by instrument type

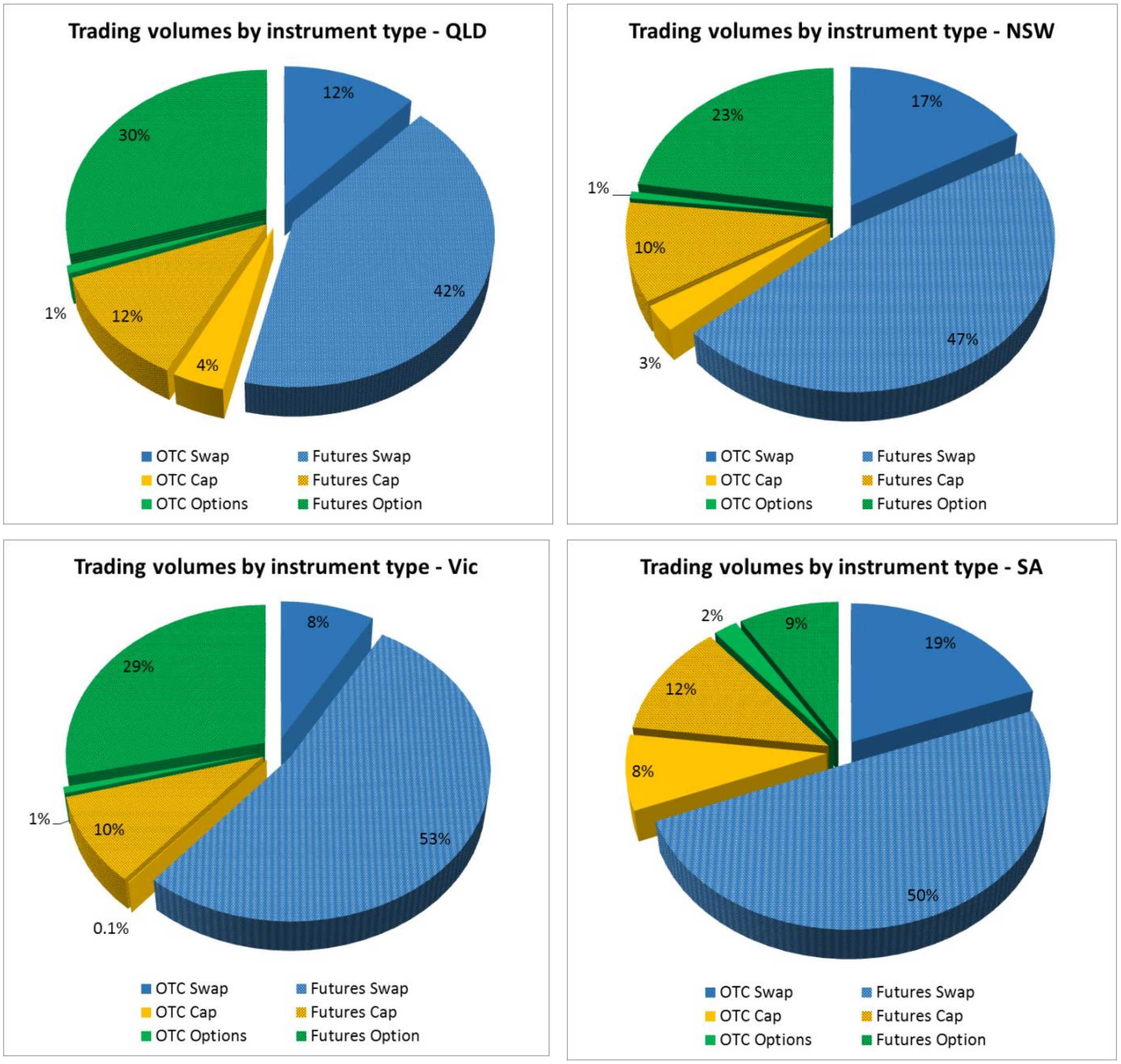


Figure 12 - Trading volumes for each state by instrument type

4.4.2 Historical Cap Prices

The charts below show the historical pricing of $300 caps covering the quarters of the past 5 years as traded on the ASX. The data is derived from the daily closing prices of quarterly caps for the two-year period leading up to the relevant quarter. The chart shows the range of pricing that each of the quarterly caps have traded through the two-year period, together with the Inter-Quartile Range (IQR). The IQR provides an insight into the range of pricing that the cap product spent 50% of the time. i.e. it shows the range between the 25^{th} and 75^{th} percentile of prices.

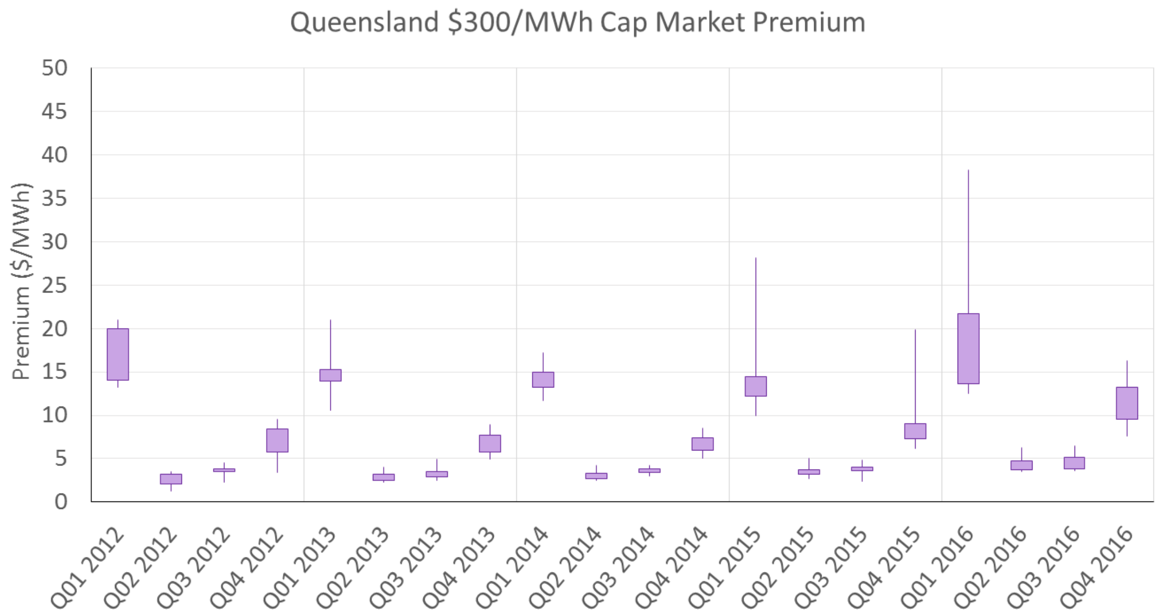


Figure 13 - Queensland historical cap premiums

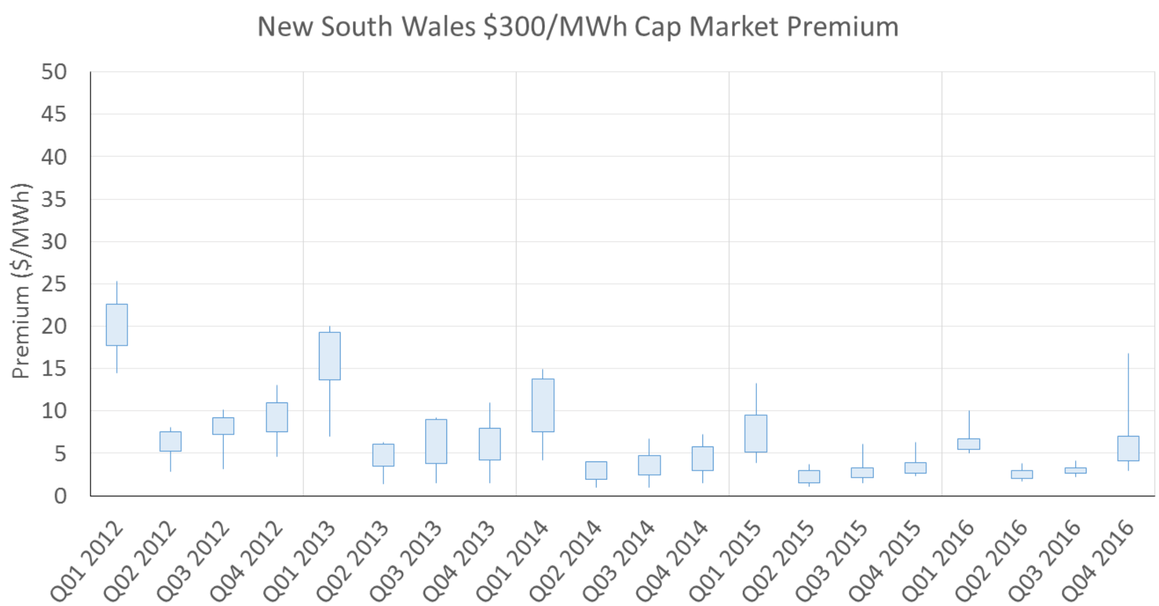


Figure 14 - NSW historical cap premiums

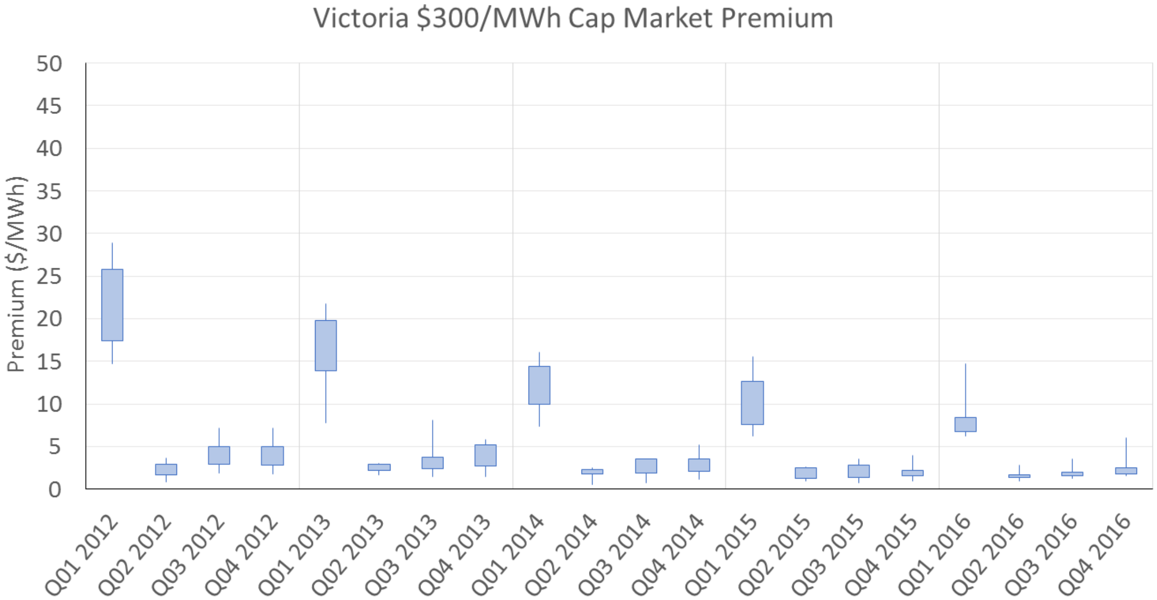


Figure 15 - Victoria historical cap premiums

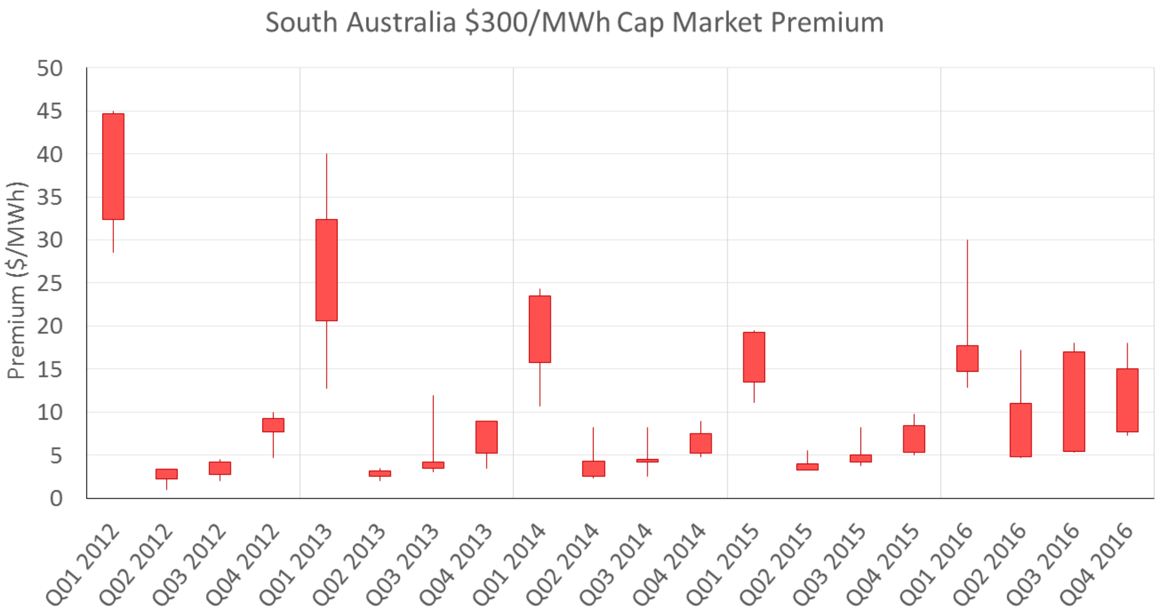


Figure 16 - South Australia historical cap premiums

4.5 Applications and strategies in which caps are used

4.5.1 Currently under 30-minute settlement

The analysis below uses historical generation over 2015 and 2016 combined with spot pricing at the time to provide the effectiveness of certain fuel types across the NEM regions to capture $300/MWh spot pricing. The gradient represents the percentage of the value of prices above $300/MWh that each generation type captures. A gradient of 1 equates to a generator capturing 100% of the value of spot pricing above $300/MWh.

The cap effectiveness methodology incorporates all of the complexities of one-off pricing, fast start profiles, ramp rates, trader decision management and portfolio interactions that reduce the ability of physical assets to match financial contracts. This is achieved by analysing the actual ability of asset classes to capture higher price outcomes using their actual generation results, rather modelling a theoretical result.

The calculation of cap effectiveness reviews generator dispatch across each half hour of the analysis period when spot prices are $300/MWh or greater and determines the extent of generation through these periods relative to the unit's capacity.

Using this analysis, we have determined the levels of caps that generators would sell, using an economic return basis. The basis for this conclusion is that if a generator is only able to physically capture 75% of the pay-off of caps through its generation, then we have assumed that it would only sell caps covering 75% of its generation capacity.

The main reasons that generators are not able to capture 100% of spot price value above $300/MWh are due to factors such as:

- generator maintenance and outage schedules mean that the unit is unable to generate;
- the ramp rates of some generators do not allow them to ramp up from either rest or minimum load to capture the value of the price spike for their full capacity;
- the quantum of unexpected price spikes (as shown in Table 5) result in generators not always running at full capacity at the time the spike occurs;
- due to the high cost associated with each start for most gas fired generators, a commitment decision may not be made to start the generators in all cases;
- in the case of most gas-fired generation, nominations for the amount of gas to be delivered to the generator need to be made the day ahead, resulting in the generator only having a certain amount of gas to utilise for the day;
- limitations on fuel may result in the fuel being withheld during some periods which may include prices beyond $300/MWh in an attempt to capture greater value at other times through the day. These decisions may not always result in the correct outcomes in hindsight; and
- increases to the dispatch of the generators also depresses the resultant dispatch price so it follows that higher price outcomes can be due to the generator being unavailable or offline.

The analysis shows that hydros in NSW and Victoria are quite effective at capturing price spikes on a 30-minute settlement basis, and black coal in Victoria also is quite effective but only in the context that as baseload generators they would already be running anyway. It also shows that gas fired generation and liquid fuel generators would not economically sell 100% of their generation as caps, as they would be unable to physically capture the spot revenue to support these assets. The gradient is a proxy for the percentage of the generator capacity that it might sell using cap products. This is unlikely to be the case for coal fired generation as they would usually secure more certain revenue that matched their generation profile through the sale of swaps. But for the intermediate and peaking generation assets, the analysis provides a useful picture as to the level of caps that each generation type would theoretically sell to enable them to physically back their contract position with generation.

It is noted in some cases (e.g. Qld hydro) that due to assets being part of a larger portfolio with other incentives, their dispatch and effectiveness in capturing high price events may not align with the expected dispatch and effectiveness of other similar generation types. This effect is discussed in section 0.

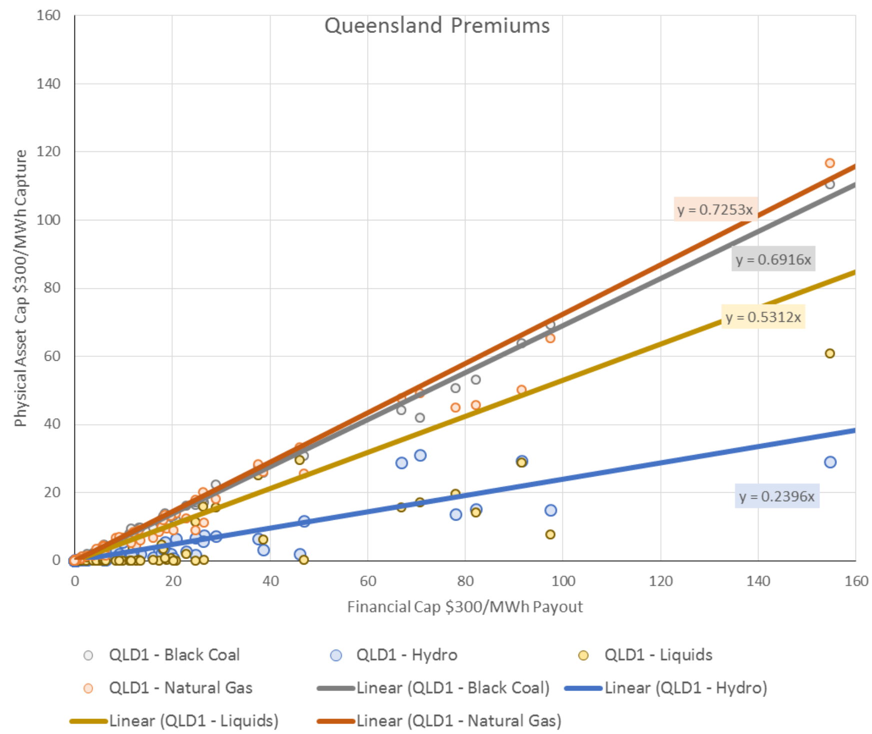


Figure 17 - Effectiveness of Qld generator types to capture spot pricing above $300/ MWh

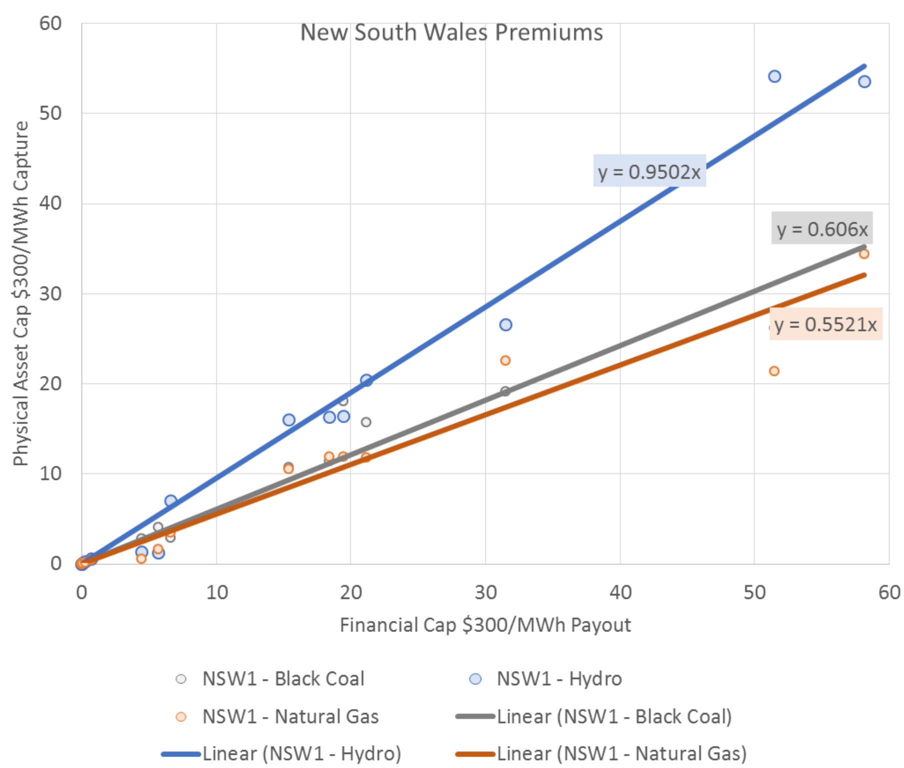


Figure 18 - Effectiveness of NSW generator types to capture spot pricing above $300/MWh

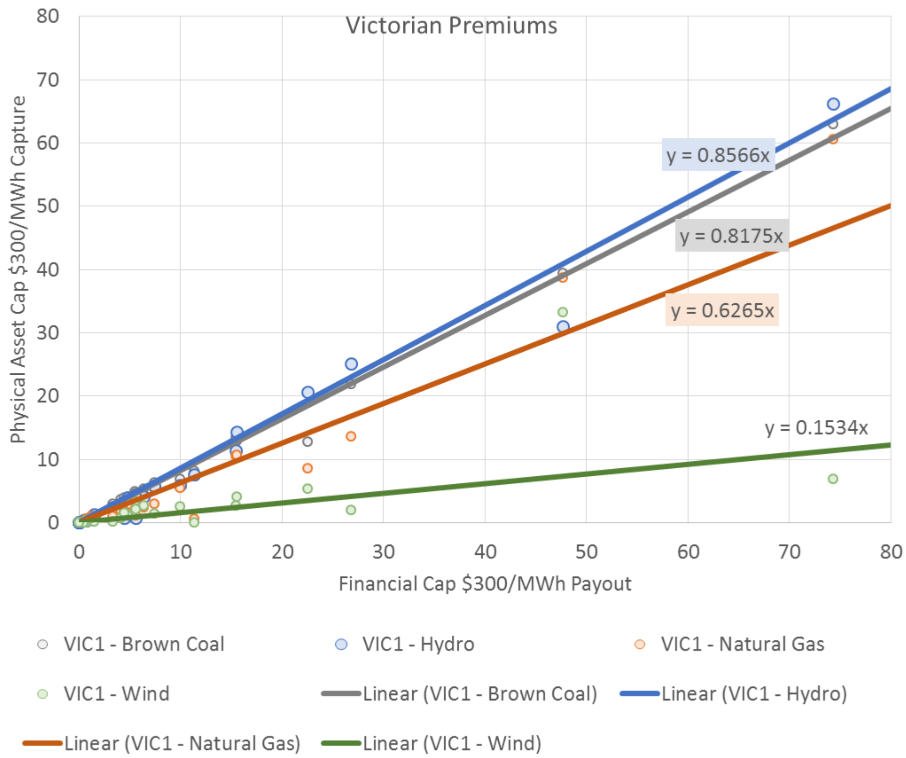


Figure 19 - Effectiveness of Victorian generator types to capture spot pricing above $300/MWh

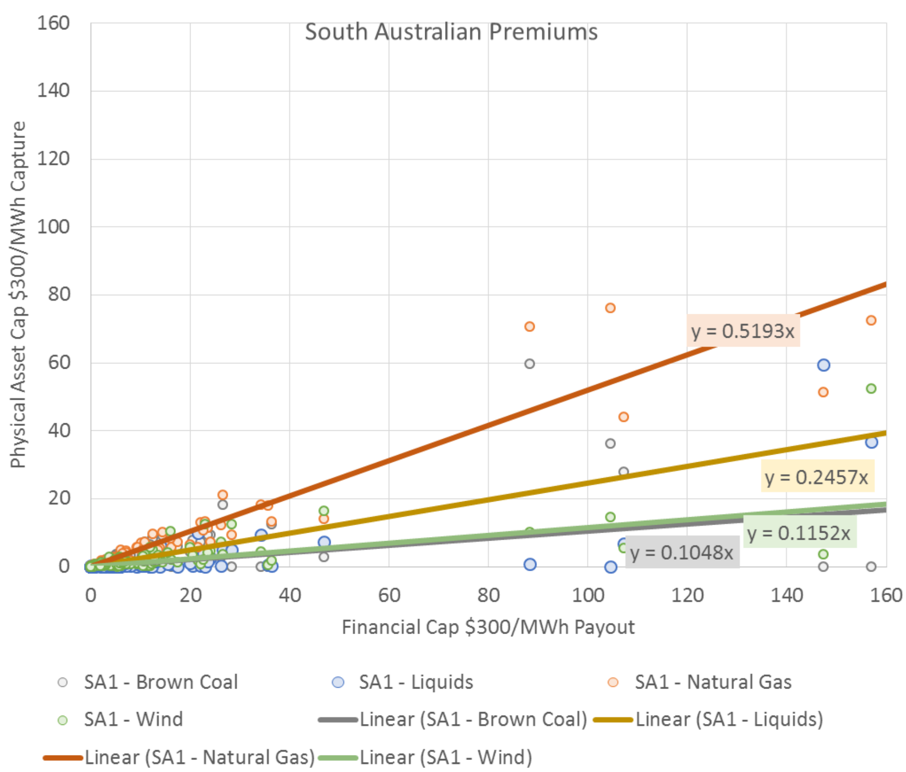


Figure 20 - Effectiveness of SA generator types to capture spot pricing above $300/MWh

The above results are summarised in the table below:

	Coal	Gas	Hydro	Liquid Fuel	Wind
Qld	69.2%	72.5%	24.0%	53.1%	
NSW	60.6%	55.2%	95.0%		
Vic	81.7%	62.6%	85.7%		15.3%
SA	10.5%	51.9%		24.6%	11.5%

Table 3 - Capture rates of value above $300/MWh by fuel type under 30-minute settlement. (Analysis period is 2015 – 2016)

4.5.2 Under proposed 5-minute settlement

There are a number of factors that preclude generators from capturing all of the price spikes above $300/MWh, including fuel cost and fuel availability, but the main reason is the physical parameters surrounding each of the generation types. Under the proposed 5-minute settlement market, these physical parameters will become more pronounced.

In its Five-Minute Settlement Working Group, Working Paper No 1, the AEMC analysis identifies

> *"that there is very little fast-start capacity in the NEM that can respond from rest within a 5-minute period. In South Australia and Queensland there is a small amount of scheduled capacity that can provide energy within 5-minutes. In other regions, this response from rest is in the order of 6 to 10 minutes."*

From the analysis presented and reproduced for convenience below, it can be seen that across the NEM, there is very limited capacity for fast start generators to capture 5-minute price spikes when they are at rest. However, currently under the 30-minute settlement mechanism, these fast start generators receive no benefit if the price spike occurs in the sixth dispatch interval but an increasing benefit the earlier in the half hour the price spike occurs, dependant on their ramp times. Under a 5-minute settlement, one-off 5-minute price spikes would not be captured by such generators if they are responding from rest, thereby reducing their revenue and reducing their ability to physically back cap contracts.

The figures below are extracted from AEMO's Five-Minute Settlement Working Group, Working Paper No 1 and represent the theoretical response times of fast-start plant from rest in each region. They are relevant to establishing the MW of supply which are available for response to price spike events in each NEM region, and by association, what level of cap contracts can be backed by a prudent generator.

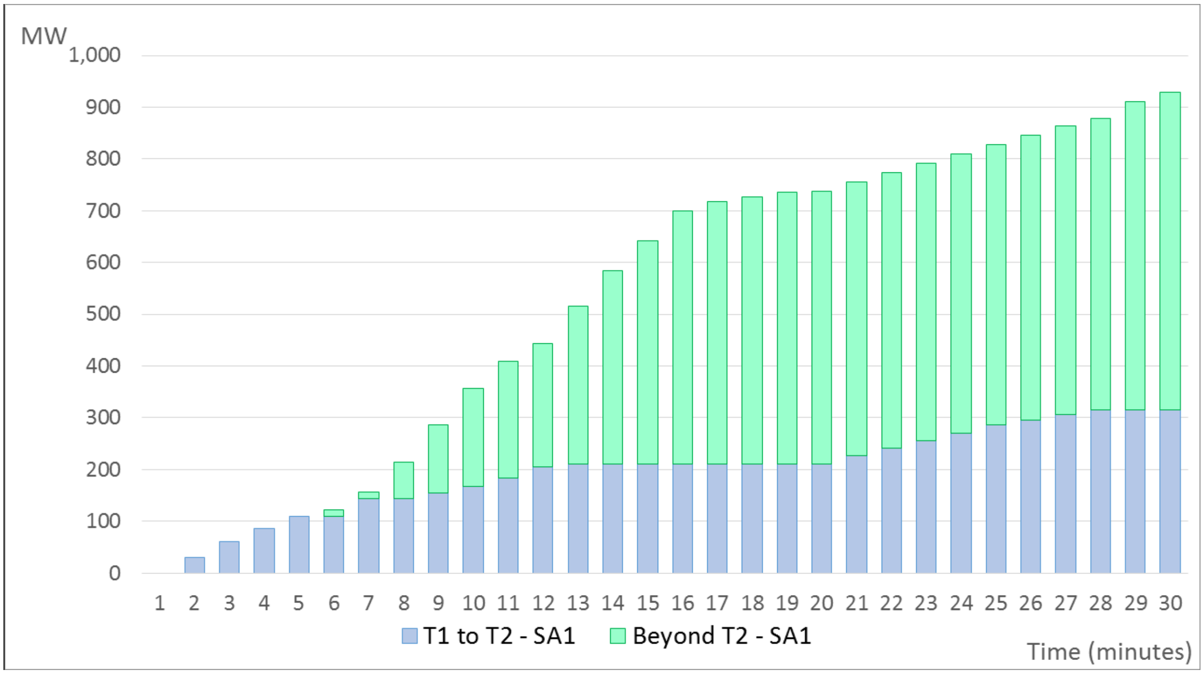


Figure 21 - Theoretical response from fast-start plant in South Australia

Source: AEMC Five Minute Settlement Working Group: Working Paper No. 1, 12 Oct 2016

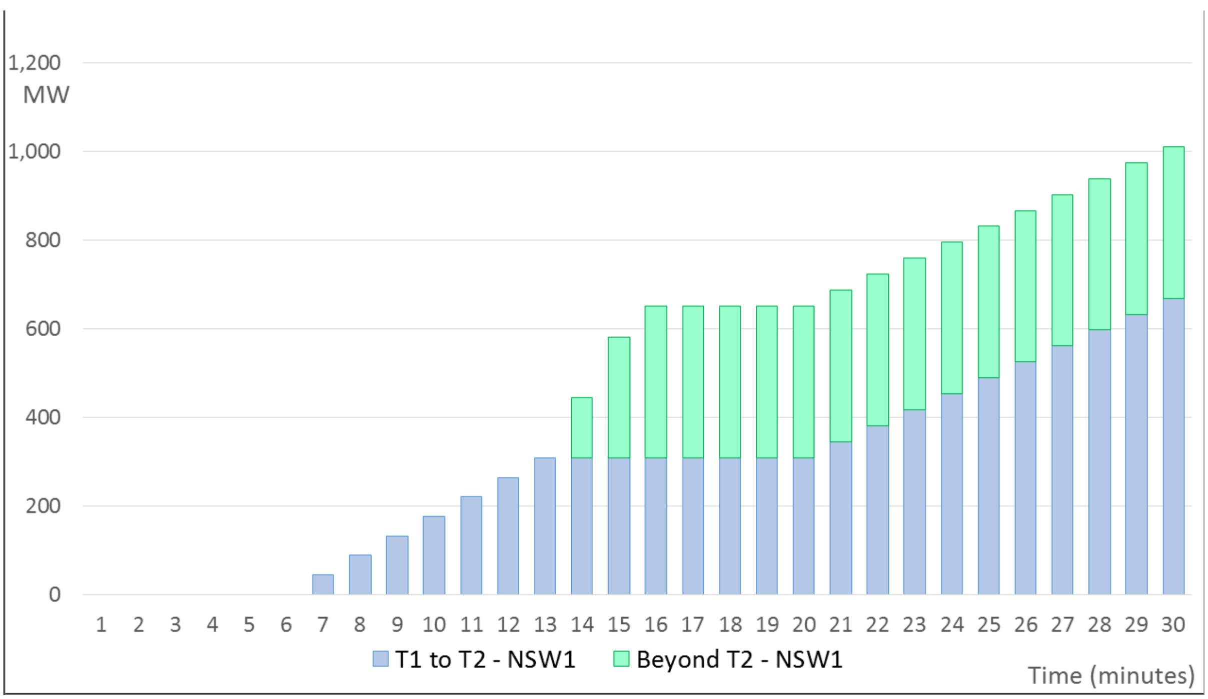


Figure 22 - Theoretical response from fast-start plant in New South Wales

Source: AEMC Five Minute Settlement Working Group: Working Paper No. 1, 12 Oct 2016

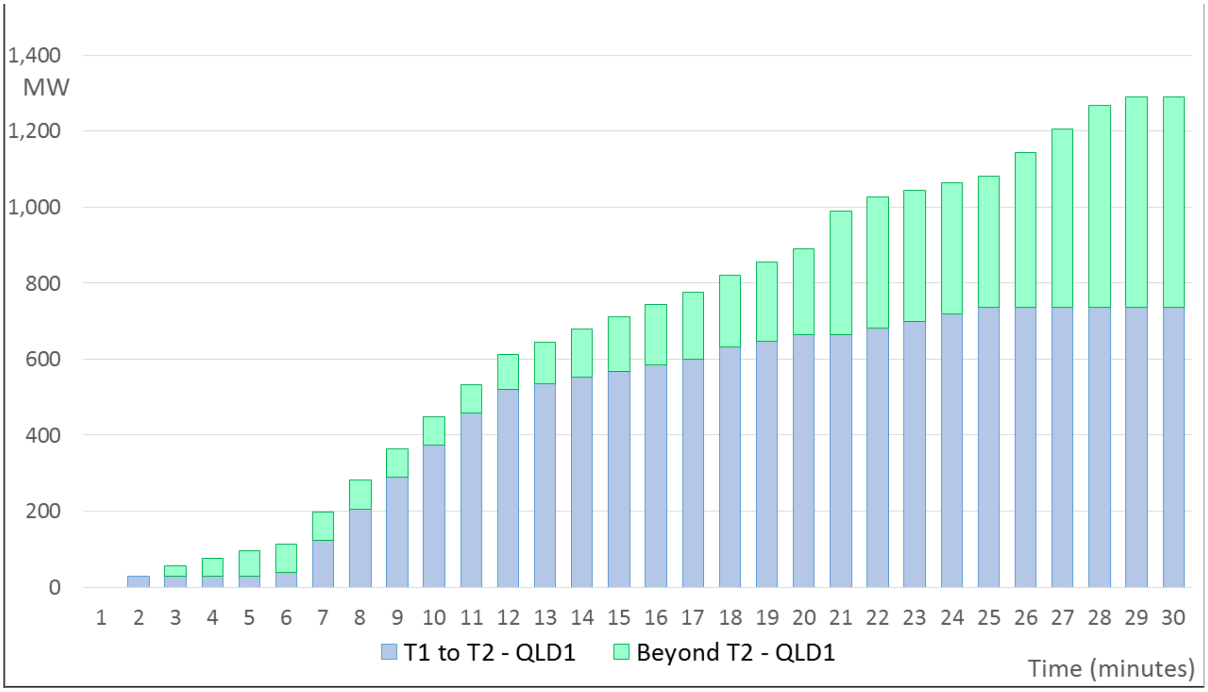


Figure 23 - Theoretical response from fast-start plant in Queensland

Source: AEMC Five Minute Settlement Working Group: Working Paper No. 1, 12 Oct 2016

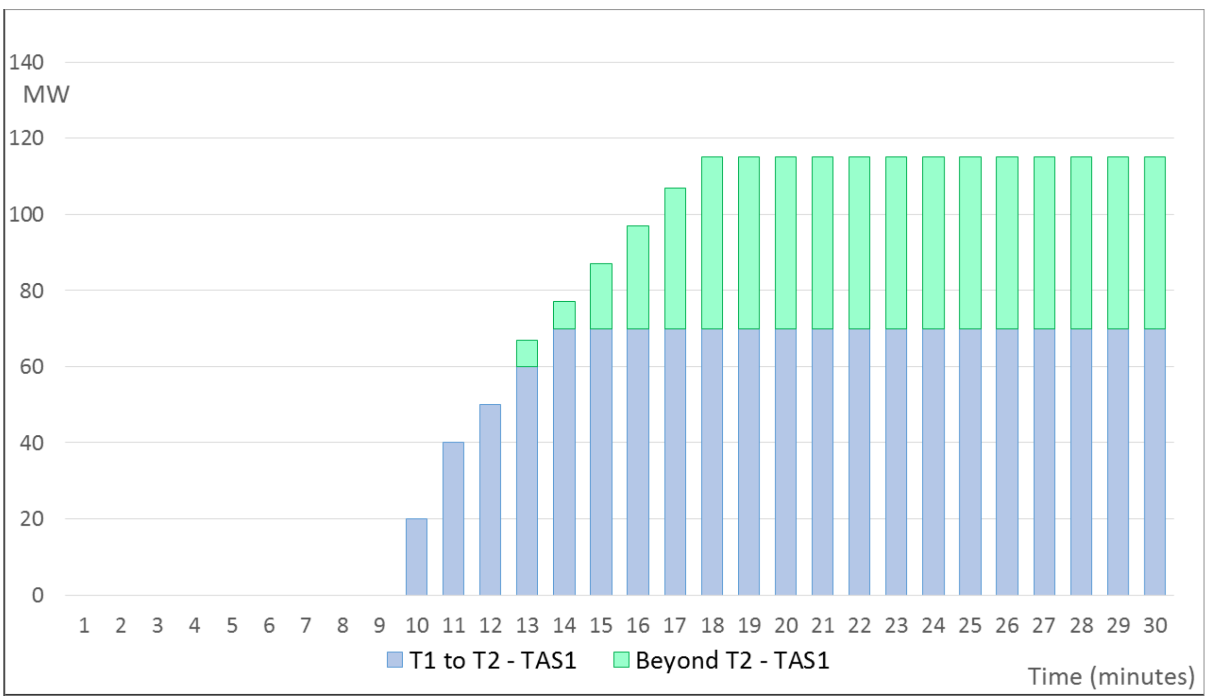


Figure 24 - Theoretical response from fast-start plant in Tasmania

Source: AEMC Five Minute Settlement Working Group: Working Paper No. 1, 12 Oct 2016

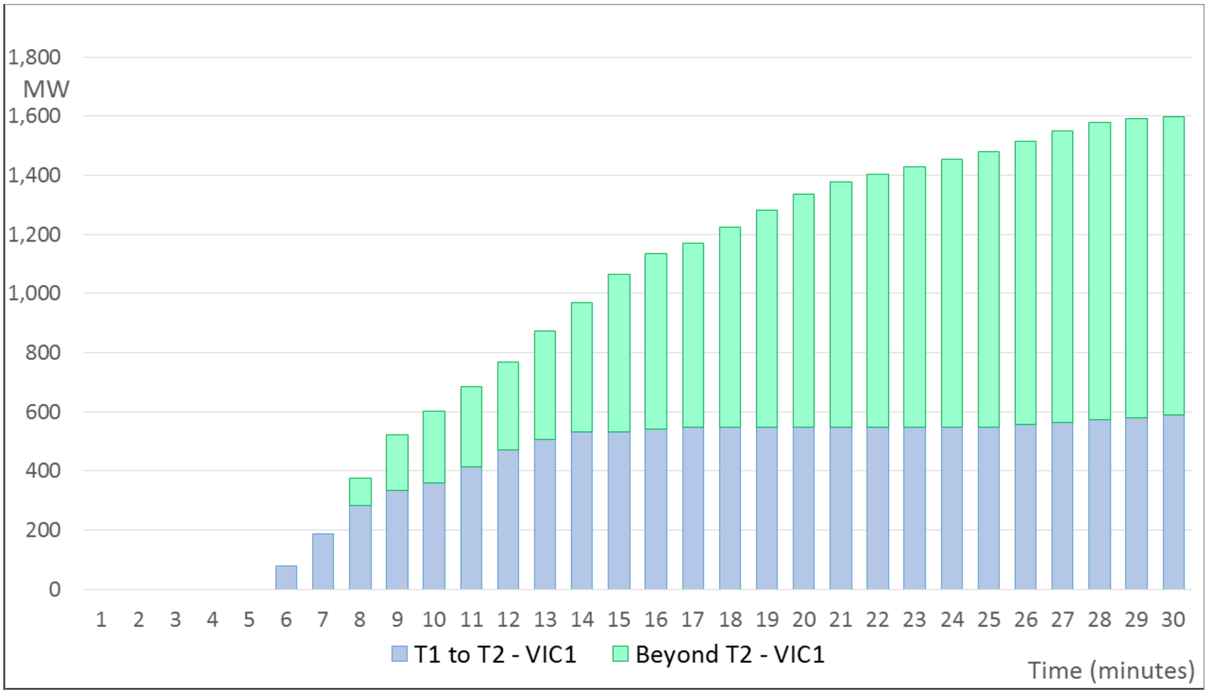


Figure 25 - Theoretical response from fast-start plant in Victoria

Source: AEMC Five Minute Settlement Working Group: Working Paper No. 1, 12 Oct 2016

We have attempted to provide some context as to how often isolated price spike events occur and how predictable these are by providing statistics on the following:

- The proportion of price spikes that are 'isolated' (Table 4)
- The ability of 5 minute predispatch pricing to predict high actual pricing. (Table 5)

The following statistics on market spot prices over 2015 - 2017 quantify the number of isolated price spikes to support the significance of the quick-response concerns. The results show that in all regions except NSW, the majority of dispatch price spikes (pricing greater than $1,000/MWh) were isolated events.

Of course, there are second order effects which are not incorporated but may eventuate under 5/5 pricing. For example, the current 5/30 arrangement incentivises generators to dispatch in the intervals following a 5-minute price spike, thus suppressing subsequent intervals. In section 5.2 of this report we describe how this behaviour may not eventuate under 5/5 pricing, but it is not feasible to retro-engineer the historical market price outcomes to account for this possible change in behaviour.

Region	Number of hours containing dispatch price spikes[1]	Proportion of hours containing only one dispatch price spike	Proportion of hours containing two dispatch price spikes	Proportion of hours containing three or more dispatch price spikes
Qld	265	71.3%	15.1%	13.6%
NSW	22	27.3%	13.6%	59.1%
Vic	10	70.0%	20.0%	10.0%
SA	173	65.9%	15.6%	18.5%
Tas	33	93.9%	6.1%	0.0%

Table 4 – Number of hours containing dispatch price spikes by region and the number of price spikes within each of those hours (Jan 2015 to Mar 2017)

The following statistics on market spot prices over the 2013 – 2016 period quantify the usefulness of 5 minute predispatch pricing as a predictor of actual spot pricing. In reality a commitment decision for a large proportion of fast start generators will need to be made prior to 5 minutes before the relevant period. However using the 5 minute predispatch analysis for the period immediately prior to the relevant periods provides the best case scenario of the level of predispatch accuracy.

The results show that even 5 minutes prior to the relevant 5 minute period, predispatch pricing is highly inaccurate and therefore a large proportion of high price events are unanticipated. This provides some indication of the difficulty of the commitment decisions for fast start generators, and validates the concerns that fast start generators have in being able to respond in time from either rest or low load to capture revenue under the proposed 5 minute settlement rule change.

	>$300/MWh	>$2,000/MWh
The probability that a high price (at or above the level shown) showing in 5 minute predispatch will result in an actual dispatch price at or above the level shown.	58.4%	27.8%
The probability that a high actual dispatch price (at or above the level shown) was showing in 5 minute predispatch immediately prior to the period	65.2%	37.9%

Table 5 – Probability of anticipating actual price events (false positive and false negative)

We have performed some analysis on the ramping capabilities of the various fuel types across the regions using the average published dispatch inflexibility profiles for generators

[1] Spikes are classified as 5 minute price events above $1000/MWh

during January 2017. This provides a further breakdown by generator type as to the response times and therefore ability to capture value from 5-minute price spikes both from a resting state and from minimum load.

The analysis relating to response times from rest assumes that the price event is 'unanticipated' and the generator was at an 'off' state at the setting of the spot price prior to the dispatch interval. While this contains a degree of conservatism, there are certainly realistic aspects to the scenario which means that the resulting numbers provide a meaningful guidance to the cap volumes which may be supported.

- Certainly a large proportion of price spike events occur at unexpected times, driven by unplanned outages, by unexpected constraint invocations or network limit reratings. Table 4 above outlines the large volumes of isolated price events experienced historically in the NEM.
- Realistically, a generator with fuel constraints and significant start costs cannot respond to each predispatch signal which indicates a potential price spike, because there are far too many such signals which do not eventuate (false positive issues refer Table 5 above).
- High price events may well sometimes eventuate in a sequence of several successive high prices, and in such a case this analysis is directly relevant to the first of the sequence.

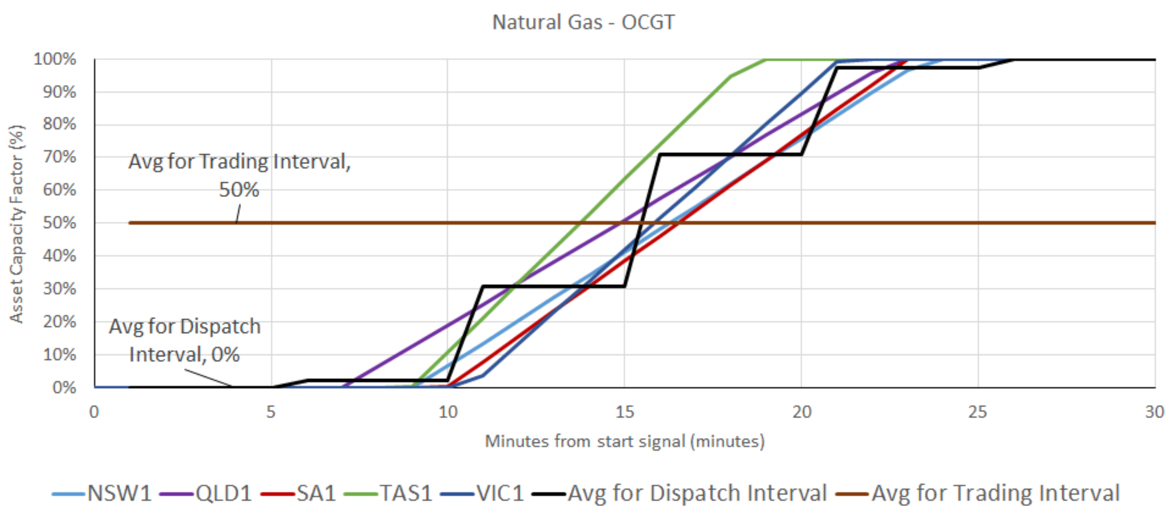


Figure 26 - Open cycle gas turbine's responsiveness from rest and average capacity factor on a 5-minute (dispatch interval) and 30-minute (trading interval) basis

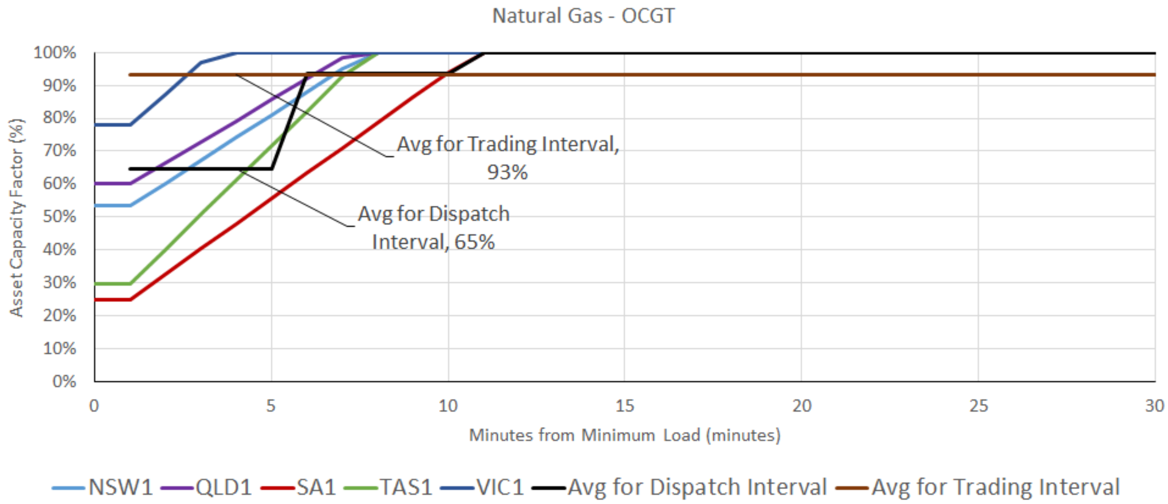


Figure 27 - Open cycle gas turbine's responsiveness from minimum load and average capacity factor on a 5-minute (dispatch interval) and 30-minute (trading interval) basis

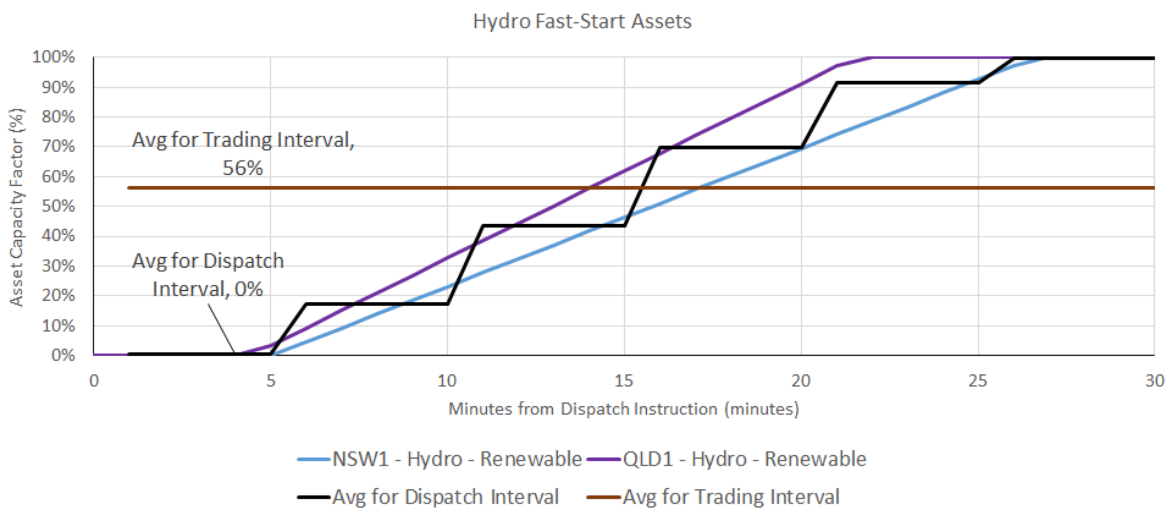


Figure 28 – Conventional hydro responsiveness from rest and average capacity factor on a 5-minute (dispatch interval) and 30-minute (trading interval) basis

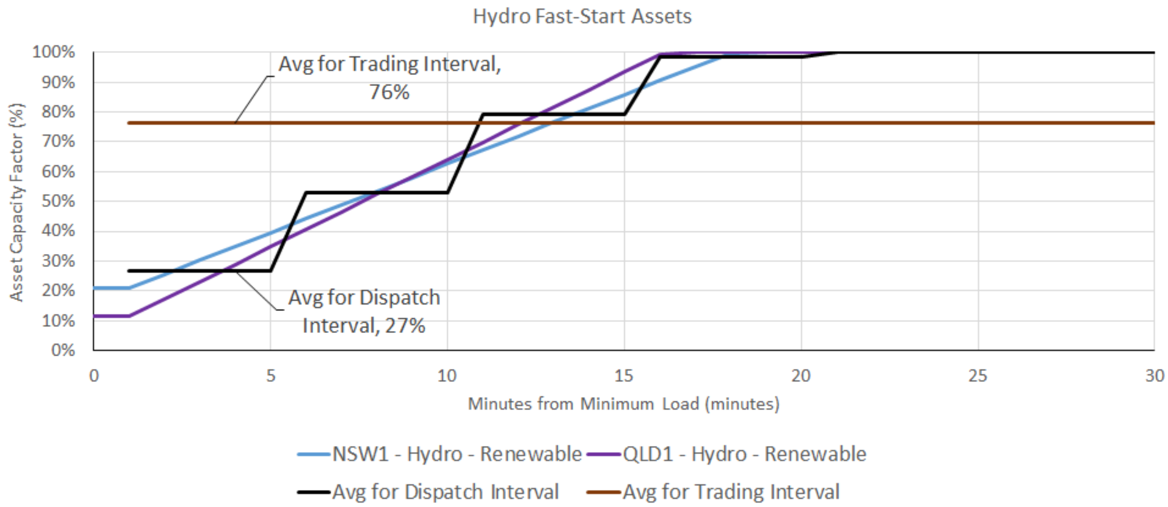


Figure 29 - Conventional hydro's responsiveness from minimum load and average capacity factor on a 5-minute (dispatch interval) and 30-minute (trading interval) basis

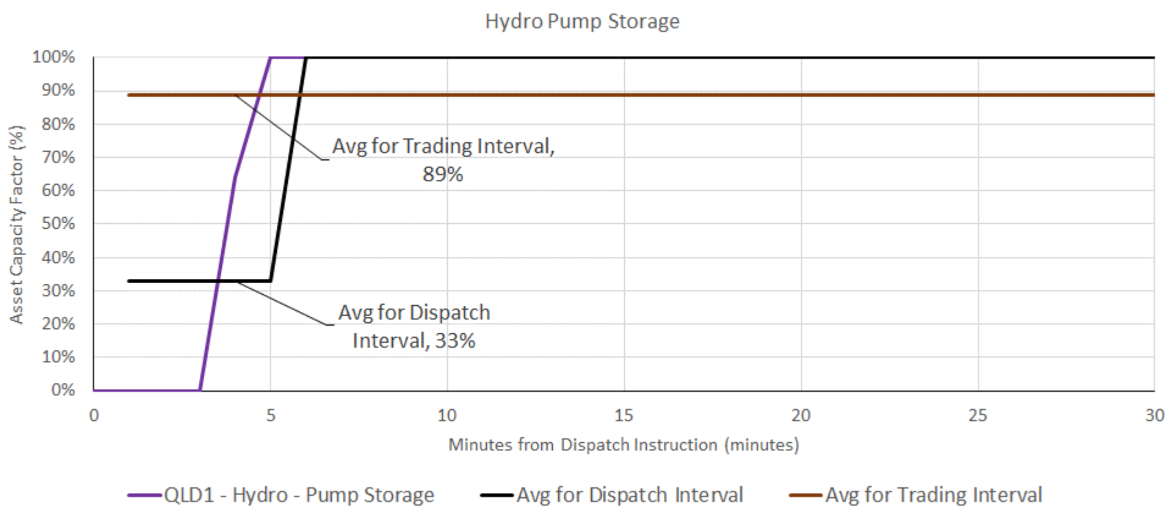


Figure 30 – Pumped storage hydro's responsiveness from rest and average capacity factor on a 5-minute (dispatch interval) and 30-minute (trading interval) basis

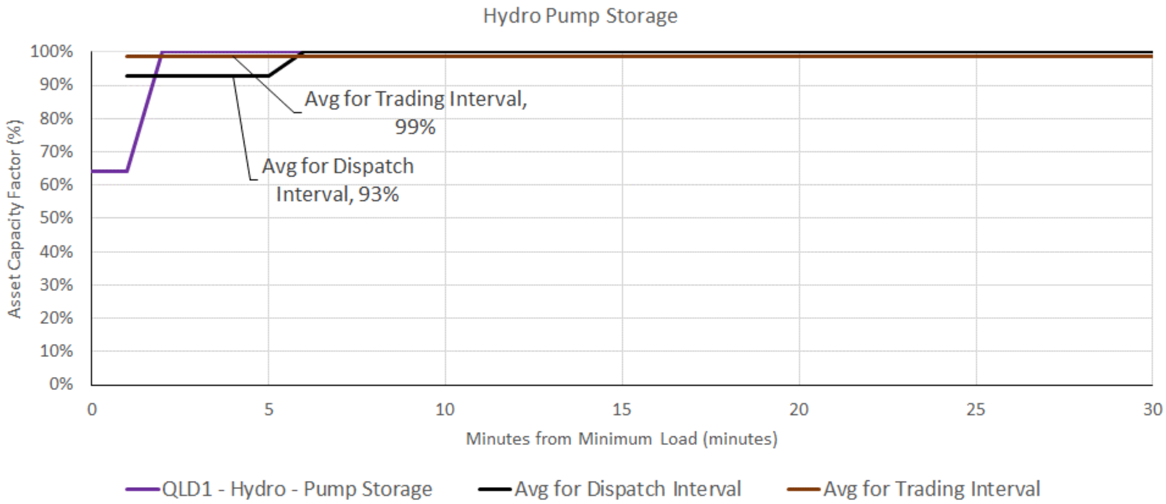


Figure 31 – Pumped storage hydro's responsiveness from minimum load and average capacity factor on a 5-minute (dispatch interval) and 30-minute (trading interval) basis

For some of these assets, their physical capability does not allow them to respond within the period of a 5-minute dispatch interval from a cold or even warm start. Their current ability to capture some value from one off price spikes comes from the averaging of the 30-minute settlement price. In these instances, under a 5-minute settlement, these assets would miss out on capturing this value, and therefore could only capture a portion of the value of price spikes beyond the cap strike price at times they were online.

To determine the extent of the difference in peaking generators' ability to capture prices under a five-minute market, we re-perform the analysis that we performed in section 4.5.1 over the same two-year historical period of 2015 and 2016, assuming that a 5-minute market was in place. This analysis is obviously not a true reflection of how generators might react under a five-minute settled market as they were operating under a 30-minute market during the reference period of 2015 and 2016. However, it provides a guide as to the extent of the differences that may occur.

The result of this analysis is that fast start generators would be less effective in physically backing 5-minute cap contracts, and would therefore be less likely to sell caps to the same level that they currently do, without taking on a lot more risk. This inability to capture as many price spikes would lead to reduced spot revenue for those generators, and likely the sale of a lower volume of caps, which results in a lower amount of cap premium. The potential effect will be that OCGT generators will be unlikely to earn sufficient revenue through cap premiums and spot revenue to be financially viable in the long term, reducing the value of these assets. We have provided some analysis of the potential level of effectiveness of these generators under normal operating conditions to determine the level of caps that they might be capable of selling.

Generator Type	Reduction in Theoretical Volume of Caps Sold (%)
Hydro (Conventional)	-18.2%
Hydro (Pumped Storage)	-46.4%
Liquids	-24.0%
Natural Gas (CCGT)	-7.8%
Natural Gas (OCGT)	-26.0%
Natural Gas (Steam)	-29.1%

Table 6 - Modelled reduction in volume of caps by generator type

Of particular note in Table 6 is that Pumped Storage Hydro has a large reduction in volume of caps sold. The very fast ramp rates of hydros allow for highly effective responses to 30 minute prices (i.e. the generator output starts low but is able to capture a very high percentage of the 30 minute volume (89% from rest, and 99% from minimum load)). This is not necessarily true for 5-minute settlement as the generators will ramp quickly but only capture a lot lower average volume (33% of volume captured for 5 minute period from rest, and 93% from minimum load). So the large reduction in expected caps sold from pumped storage hydro is not a representation of the hydro's inability to respond or ramp quickly but simply that the relativity of the capture rates is quite pronounced between 30 minute and 5 minute settlement due to being highly effective at responding to and capturing 30-minute price events.

Other fast start plant reductions in caps sold are not as large due to the relativity of the volume of generation output they can produce at times of high price events under a 30 minute market compared to a 5 minute market.

4.6 Effect of 5-minute settlement on cap volumes

The graphs below show the calculated volumes of caps sold by generator type by region under both a 30 minute and 5-minute settlement market. This highlights the proportionate volume of caps that will no longer be sold under a 5-minute market due to caps seller's reduced ability to physically back these contracts to the same extent.

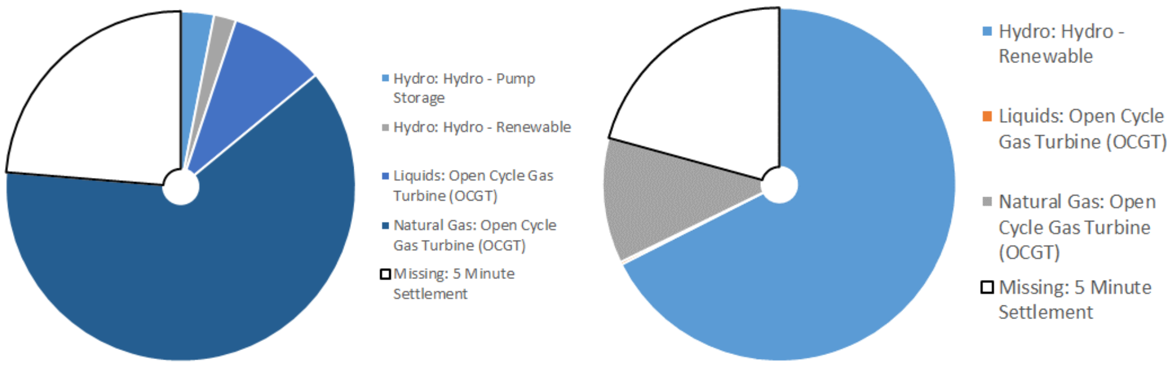


Figure 32 – Theoretical Cap Sales Volumes for Queensland (left) and New South Wales (right) under 5 Minute Settlement. "Missing" (shown as white space) is the reduction in cap volumes under 5 minute settlement relative to caps currently sold under 30 minute settlement.

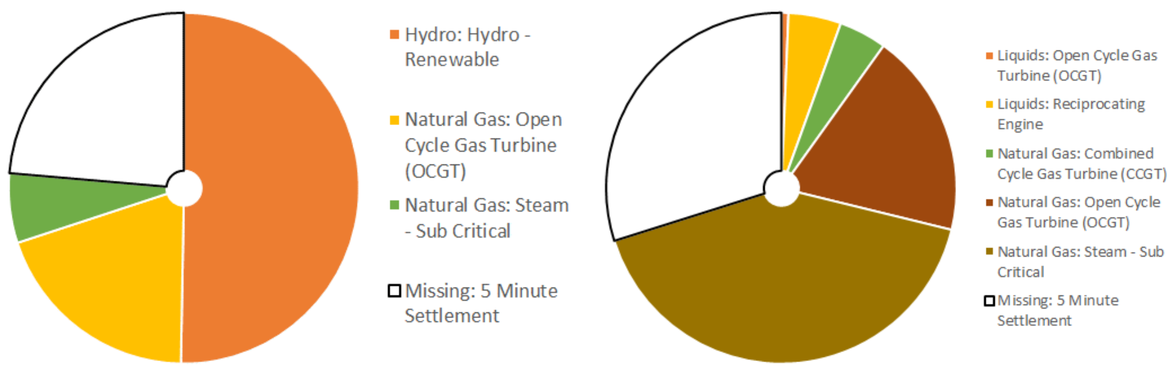


Figure 33 - Theoretical Cap Sales Volumes for Victoria (left) and South Australia (right) under 5 Minute Settlement. "Missing" (shown as white space) is the reduction in cap volumes under 5 minute settlement relative to caps currently sold under 30 minute settlement.

We have utilised the FY 2016 traded cap volumes statistics from section 3.3 to calculate an underlying cap position which is taken to market as hedges for the loads. The traded statistics from section 4.4 contains all trades conducted, and it is well known that trading strategies from physical players and intermediaries involves both buying and selling caps. That is, trading strategies buy caps at low prices and on-sell them at higher prices. Our methodology to distill the final net volumes of caps taken to market was to use the traded cap volumes by region and convert these from GWh into MW of flat caps. This produced an estimation of the volume of flat caps that were traded. We have then divided this by the region liquidity ratio to produce an estimate of the underlying volume of caps that are supplied for each region. This number was then rounded to the nearest 10 MW. Given that the proportion of caps traded across the market and across regions over the last three years has remained relatively stable (refer Figure 5), we believe this is representative of the volume of underlying caps traded.

The following Table 7 summarises the estimated underlying volume of Caps as financial products traded on the ASX and OTC markets and in turn estimates the extent to which the generators that write the Caps may need to reduce the volume of underyling Caps offered in the market due to their inability to physically respond adequately under the proposed 5-minute settlement. It should be noted that the 625 MW reduction in volume of Caps only relates to Caps currently able to be traded on the OTC and ASX. In the NEM there has been an increasing trend to vertical integration over the years (the use of generation assets as natural hedges for retail loads). Some of these vertically integrated generation assets are Hydro, OCGT and CCGT and therefore used as a physical alternative (Natural Hedge) to a Cap. These natural hedges will also experience a dilution in their effectiveness for covering a 5-minute Cap pay-off profile in the range of 20 – 30%. As a result, generators currently used as cap-like Natural Hedges will also contribute to the demand and supply imbalance that might arise for 5-minute caps as a financial product. Therefore the net impact on Cap supply will be larger than the 625MW per Table 7, potentially to the equivalent of 23% of cap like generation capacity held within vertically integrated corporations.

Region	Calculated underlying traded volume of caps for FY 16 (MW flat equivalent)	Reduction in ability to sell caps under a 5-minute settlement (%)	Reduction in cap volume under a 5-minute settlement (MW flat equivalent)	Projected volume of caps sold by natural sellers (MW flat equivalent)
Queensland	900	24%	-215	685
NSW	1,000	21%	-210	790
Victoria	470	24%	-115	355
South Australia	280	30%	-85	195
Total	2,650	23%	-625	2,025

Table 7 - Approximate volume of flat caps traded based on ASX and OTC market data for 2015/16, adjusted by a market liquidity ratio, and reductions in ability of cap sellers to physically back contracts applied to cap volumes to determine reduced cap supply

The above analysis when combined with the reduced number of caps that would be willing to be sold results in a reduction of 625 MW of caps across the NEM.

One consideration in the methodology used in calculating this number is the conversion of traded caps (which is sourced from ASX and OTC data) to an underlying cap volume. We have used the derivative liquidity ratio for each region that is a measure of the volume of MWh traded against the volume of energy actually consumed. Whilst this is a valid determination of liquidity across the market we do not have any way of verifying whether this liquidity ratio is accurate specifically for caps. Given the average liquidity ratio across the NEM was 2.6, a lower liquidity ratio for caps may result in cap volumes and the reduction in caps under a 5-minute market increasing by a factor of up to 2.6.

To assess the impact of the calculated reduction in cap volumes on the ability of retailers to buy cap contracts, we have provided a NEM-wide diagram of average system demand against the levels of the main contract types available to hedge this demand (refer Figure 34 – NEM representative demand vs Effective Contracts (Flat and Peak Swaps, 30min Caps and 5min Caps)). The analysis provides an average demand shape across the year, together with an approximation of the 90th percentile summer and winter demands which we have used as a proxy for the levels that retailers may hedge to using the main standard products traded in the financial market. This shows that the reduced level of caps (illustrated by the orange dotted line) that would be sold in a five-minute settlement market is likely to have a reasonable influence on the ability of retailers to cover their load shape. Obviously, each retailer's load shape and flex is different, but this graphic shows the potential quantum of the reduction in caps and its residual risk implications. Section 5 refers to some potential current and future avenues to, in part, offset the consequential gap in supply and demand for Caps post 5-minute rule.

Figure 34 illustrates the National Electricity Market using the following combination of financial and physical outcomes to show theoretical contractual coverage.

- Flat Swaps (Dark Green area);
- Peak Swaps (Light Green area);
- 30-minute settlement period Cap Contracts (Orange area);
- 5-minute settlement period Cap Contracts (Orange dotted line);
- NEM average time of day demand (Black line);
- NEM demand on 90th percentile summer day represented with 22 February 2016 (Red line); and
- NEM demand on 90th percentile winter day represented with 25 July 2016 (Blue line).

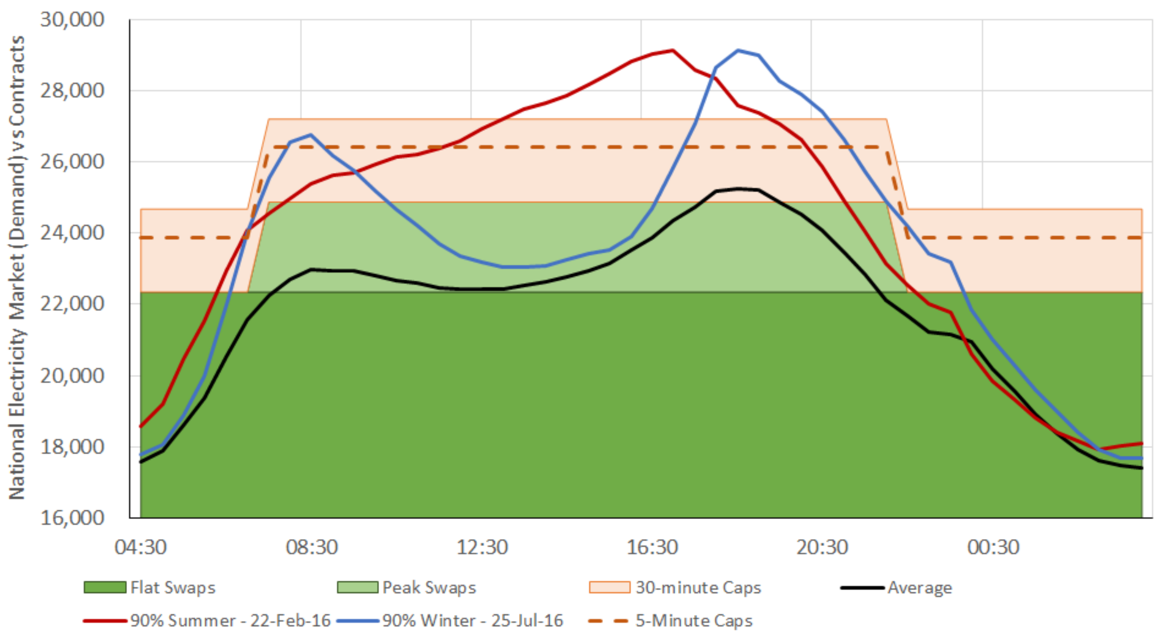


Figure 34 – NEM representative demand vs Effective Contracts (Flat and Peak Swaps, 30min Caps and 5min Caps)

5 Alternative Hedging Strategies and Practices

5.1 Overview

The potential changes to physical settlement timetables from 30-minute to 5-minute clearing introduce some complex changes to incentives and it is not entirely clear how the behaviour of market participants will eventuate under conflicting drivers. The flow-on impacts to derivative markets, and particularly cap contract liquidity and pricing are even more obscured. However, in this short overview we discuss the drivers and issues underlying the potential market changes.

To illustrate the principle, we discuss the behavioural responses of a market participant possessing a position long in peaking generation typical of the fleet of current peaking power plants. Such a scenario has been well documented in other AEMC background publications[2].

Upon the instance of an unanticipated (5-minute) price spike eventuating in the market, a price signal is issued to the generator that above normal profits can be attained if volumes are dispatched in the current dispatch interval. However, sections 4.5.2 above illustrate that relatively few power plants are able to respond adequately within that 5-minute horizon. Section 4.5.2 highlights the frequency and significance of isolated and unanticipated price events.

Consequently, such a generator has three alternative philosophies:

a. Respond anyway, with anticipation of capturing revenue in the subsequent 5-minutes if conditions might be inclined to sustain high prices again;
b. Decline to respond, with the view that either ‘someone else’ is likely to be there to capture the value, or enough respondents will suppress the next intervals’ prices;
c. Maintain the power station in an operating state in order to be able to respond faster, even though it is usually operating in an uneconomic state.

Fundamentally, all of these strategies result in either reduced revenue to the asset or a higher cost base. Note that we are comparing the situation to current market rules which enable a generator to respond to the residual of a trading interval and capture the average price across the trading interval, even if they have missed the current dispatch interval. It is true that physically and strategically generators with operating flexibility may be able to extract more economic efficiencies in operating under a 5-minute settlement than the above three simplified strategic approaches. Therefore, the extent to which revenues are reduced or costs increase may not be as substantial, as strategies and operating profiles adapt over time. However, there is no doubt the net impact is adverse although the complexity of modelling optimisation strategies under the rule change is beyond the scope of this paper.

Under 5/30 pricing, the value in a 5-minute spike is ‘smeared’ across the 30-minute interval, enabling participation by the current fleet of generators. Under 5/5 pricing only very-fast-start power plants (of which there are currently very few) can capture the value in a price spike.

In other words, the generator fails to reliably capture the spot prices above $300/MWh, or incurs a higher cost in capturing the levels of high price events currently experienced.

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[2] AEMC, 12 October 2016, Five Minute Settlement Working Group: Working Paper No. 1: Materiality of the Problem and Responsiveness of Generation and Load

A risk-averse enterprise with such a generating asset seeks to sell caps only to a level which can be reliably covered by the physical generator. Figure 1 illustrates the concept that overcommitting hedges to an asset will actually *increase* the risk profile.

As a consequence, the rational behaviour from the generating business will be to either (a) sell a smaller volume in cap contracts or (b) offer caps at a higher premium, or both. This effect is entirely associated with deterioration in the capture rate. The phenomenon of 5-minute caps paying out higher than 30-minute caps (section 4.3) is an additional increase in contract premiums above and beyond these behavioural arguments.

5.2 Change to Operational Strategy

The discussions below all allude to the combined influence of generating assets (earning revenue) and cap contracts (receiving a premium but incurring a liability during high price intervals). Risks to generators arise when unfunded liabilities occur, that is, the power station is unable to respond in time, but the financial contract invokes outgoing payments. An advocate may argue that it is perverse for the financial product to drive the physical behaviour of the power station: the colloquial tail wagging the dog. However, the structure of the NEM as an energy only market means that peaking power stations can only generate revenue from the occurrence or risk of price spike events. In contrast to markets structured with capacity payments, the key facility of a generator to mitigate the uncertainty of frequency and intensity of price spike events is to sell cap contracts for a known and certain premium. A change in the 5/30 settlement cycle to a 5/5 may induce physical operational changes as power stations seek to continue selling cap-style contracts to shore up revenue certainty, as they seek to continue to respond to cover contingent financial liabilities.

5.2.1 Increase in capacity factors

This section considers the implications for the derivative market if peaking generation assets alter their physical behaviour by remaining in an online state more of the time (to permit faster responses in case of 5-minute price spikes). Such a change in operating strategy represents the most obvious and significant change to generating assets to enable traders to capture more of the value associated with 5-minute price spikes to back financial cap liabilities.

As noted in 4.5, a large proportion of existing fast start generators will be unable to capture any value during a five-minute price spike when the unit is at rest. In its Five-Minute Settlement Working Group Paper No. 1 the AEMC suggests:

> "*In a market with 5-minute settlement, fast-start plant may spend more time online in anticipation of price spikes. The AEMC is interested in understanding the potential costs and benefits associated with operating in this way."*

It is not unreasonable to review the potential costs and benefits of operating in a different manner to try to capture a higher proportion of the price spikes than fast start plant would if they were offline. However, it should be noted that operators of fast start plant currently try to optimise their usage to capture as much value as possible in a cost-effective manner. The notion that fast start generators may move to a higher capacity factor in anticipation of price spikes asserts that they do not currently try to optimise their dispatch. Notwithstanding that, we will look at both the costs and benefits of running at a higher capacity factor. It should be noted that this analysis is performed on a qualitative basis as a detailed generator optimisation modelling exercise under the proposed rule change is beyond the scope of this paper.

On the cost front, we review each of the fast start generator types separately due to their cost structures and fuel constraints.

- Run-of-river or dammed hydro generators. The marginal cost of running a run of river or dammed hydro generator is very low, due to the nature and capture of the fuel. However, this fuel is not unlimited, and hydro generators perform extensive analysis to try to optimise the usage of this limited fuel. The cost of spending more time online is the opportunity cost of not having enough fuel to run at other times of higher spot prices. The decision to move to a higher capacity factor now is at the expense of running at a lower capacity factor at a later point in time, and must be balanced with the potential earnings from running during both of these time periods. Therefore, with a limited fuel supply, and the optimisation that already takes place, it is not expected that there will be much change in the capacity factors of these types of fast start generators.

- Pumped storage hydro generators. The extent to which pumped storage generators may increase their capacity factors to try to capture more of the price spikes will depend on the following factors:
    - The amount of time that the generator needs to pump (rather than generate) to refill its water storage
    - The price of electricity during the period it fills its water storage versus the expected price during generation
    - Due to fuel constraints, the amount of time it can generate at low levels versus full production and its capacity to ramp up quickly in response to 5-minute price spikes.
    - The broader portfolio that they are held within and how their use might be optimised within that portfolio relative to a stand-alone asset or alternative portfolio.

  We have not undertaken detailed analysis on these factors for each of the three pumped hydro generators that currently operate in the NEM.

- Gas-fired OCGT. The price of gas has shifted markedly upwards over the past 12 months (refer Figure 35) brought on by the gas shortage associated with the completion of construction of the six Gladstone LNG trains, and their combined lack of gas to operate all six at full capacity. Due to restrictions on gas exploration in a number of states, this situation is unlikely to change in the short to medium term.

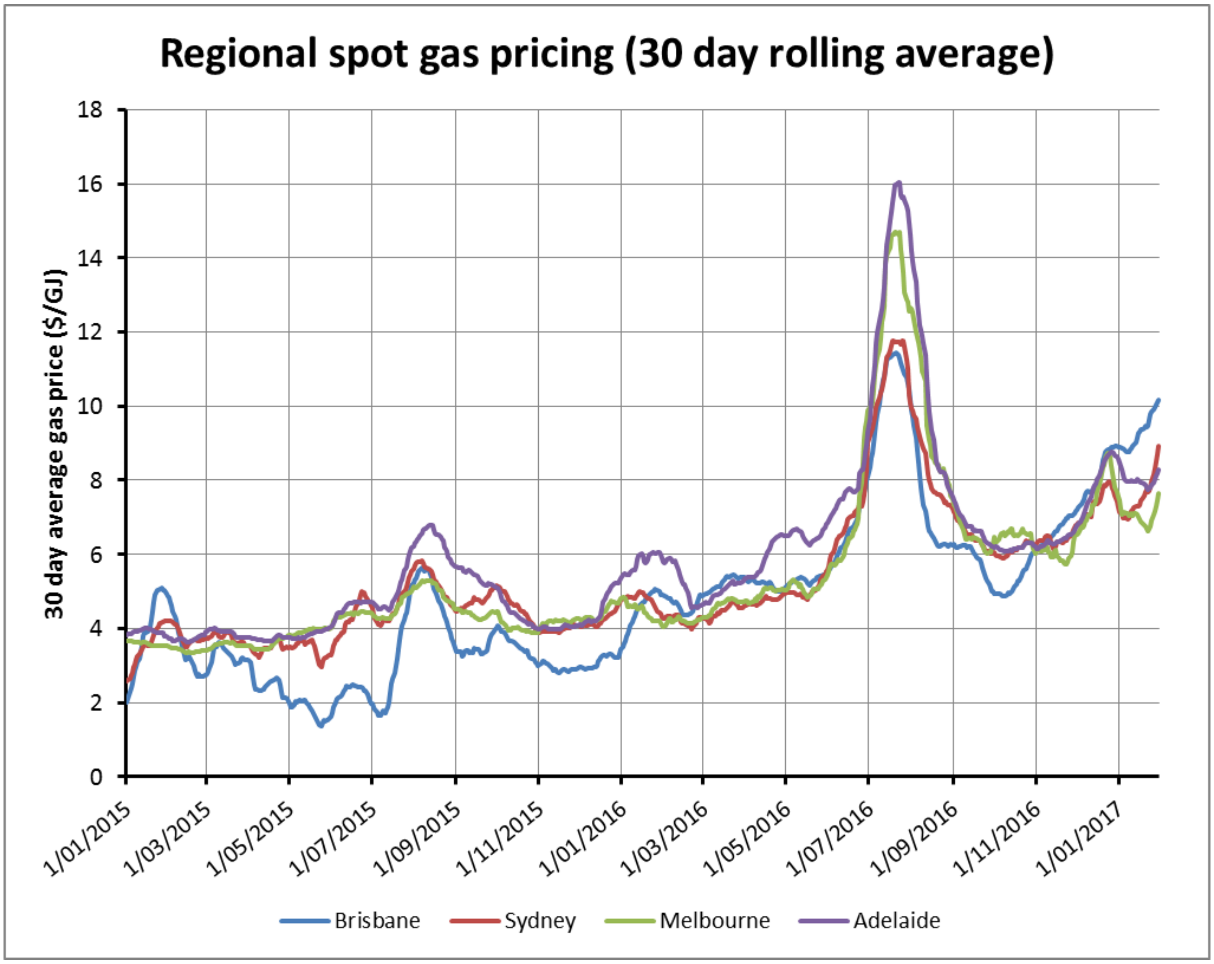

Figure 35 - Historical regional gas market pricing (30 day rolling average)

Source – Gas Market Analysis Tool, Energy Edge

This obviously impacts the cost of generation for those gas-fired generators without long term, lower priced gas contracts in place. OCGT generators typically have a heat rate of 11.5 – 12 GJ/MWh, and so from a short run marginal cost perspective their fuel cost on average (assuming a gas price range of $6 - 8/GJ) is approximately $70 - $95/MWh. However, it should be noted that there is an increasing correlation between gas and electricity prices such that on days of expected high electricity prices, gas prices are likely to also be high, thereby increasing the marginal cost of generation. This relationship is not always proportional or symmetrical with periods where electricity prices have fallen but gas prices have remained high (as noted in Victoria in Q3-2016). This is due to the gas market having its own underlying seasonal requirements and own response to the supply and demand balance.

Therefore, in order to run at a higher capacity factor, gas would need to be available at economic prices. Given OCGT generators already target the expected highest priced periods of the day, any additional periods they generate for are likely to result in exposure to lower priced periods than they currently target. If it was already economic to do this, the OCGTs would likely already be doing this, so it is questionable as to whether the change to 5-minute settlement would result in a change to their generation pattern.

- Liquid fuel OCGT. These generators have similar characteristics to gas-fired OCGTs, except that the decision has been made to use liquid fuels as the fuel source to provide more flexibility around the location of the unit and avoid the costs associated with the construction and operation of a gas pipeline. However, the trade-off associated this decision is that the cost of fuel is significantly higher. A typical diesel generator has a fuel cost of approximately $180 - $260/MWh. At these prices, there is little incentive for these units to generate pre-emptively unless it is highly predictable that they will capture high electricity prices. Due to prohibitive costs, there is very little scope for these generators to increase their capacity factors in an attempt to capture prices that they would not have captured from a cold start. For this reason, these assets will have the least ability to capture price spikes under a 5-minute settlement, and are likely to be forced to look at alternative ways to make a financial return, if at all possible.

On the revenue front, the expectation is that the higher the capacity factor, the lower the return on a $/MWh basis. It should be noted that these fast start generators are classified as peaking plant, and generally run in that configuration as it is not economical for them to run at higher capacity factors due to either their need to optimise their limited fuel supply or the fact that their high short run marginal costs do not justify them running during lower priced periods.

Figure 36 below provides Queensland as an example of the increased price duration curve between 2015 and 2016, and plots the short run marginal cost (SRMC) of an OCGT generator for each year against the curve. The SRMC is made up of the average Brisbane STTM spot gas price for the year plus $1/GJ for Variable O&M costs. This is an optimal capacity factor, but on any given day OCGTs are likely to be generating either at a lower capacity factor (indicating that they are missing out on revenue above their SRMC) or at a higher capacity factor (indicating that they are incurring negative gross margins in order to stay online).

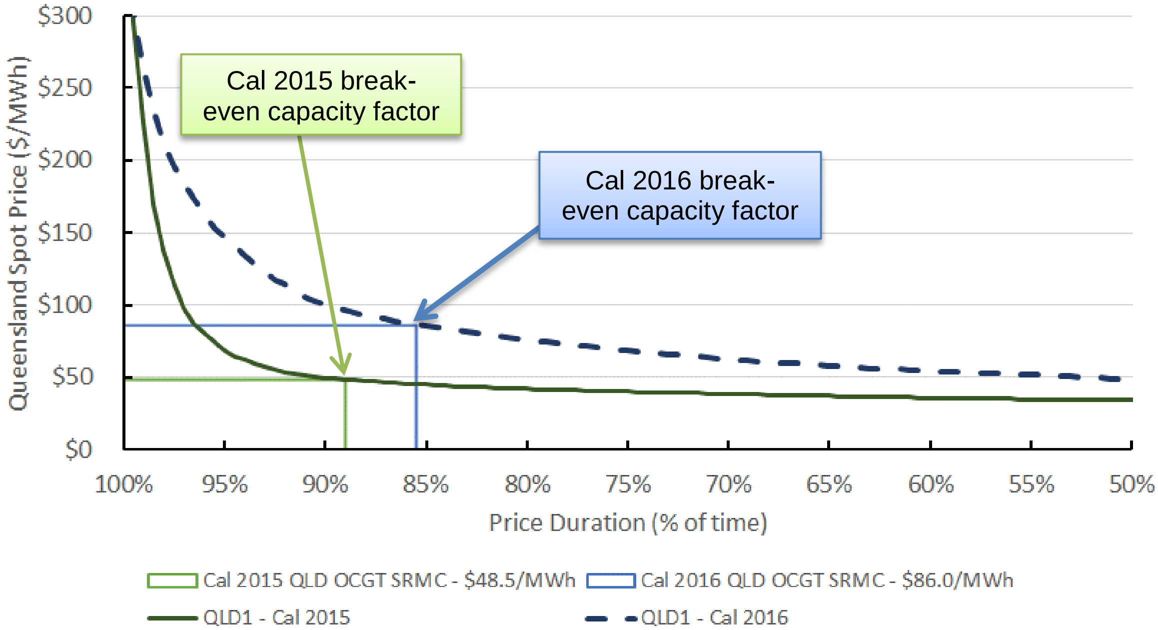

Figure 36 - Qld Price duration curve with relevant year's OCGT SRMC

Although there has been an upward trend in spot market price outcomes over the past 3 years, there has also been a drastic shift in fuel prices for the gas fired generators, which if sustained could result in reduced capacity factors unless electricity prices rise commensurate with the rise in gas prices. Therefore, there are a number of factors that must be considered by a generator in determining its optimal running profile. The desire to run at a higher capacity factor in an attempt to capture a higher percentage of high price events needs to be tempered by the economics of doing this. Taken to its logical extreme, peaking plant could run at 100% capacity factor to ensure (except during periods of outage) that it captured all the spot price spikes. However, the flat-load electricity spot revenue that it earned through running in this manner (with or without the sale of caps) would not be enough to cover its costs, and therefore it is not economically feasible.

5.2.2 Potential physical changes to existing infrastructure

A potential operational strategy for existing generation assets to allow them to capture more of the value associated with 5-minute price spikes is to remain online for extended periods which are even at minor risk of delivering price spikes. However, as discussed above, this is an economic decision based on expected cost versus expected return.

Other potential physical changes to generation assets and other infrastructure to allow peaking generators to capture a higher percentage of value under a 5-minute market include:

- Adjusting gas turbine configurations to allow them to run at a lower minimum load, essentially allowing them to be running for a longer portion of the day without consuming too much gas. This may allow them to ramp up quicker when the price spikes.
- Adjust turbines to allow them to ramp faster.

- Improve data timing so that they receive the notice from AEMO of price events sooner.
- Converting existing gas fired generators between open cycle and combined cycle operating configurations depending on the economics of the expected revenue and costs.
- Investing in new fast-start technologies to supplement the existing portfolios, including batteries, flywheels or other devices.

All of these options will require changes to existing assets which will add cost. Therefore, such changes are only likely to be undertaken if there is a demonstrable risk adjusted return.

5.3 Demand Side Management Responses

The reader is referred to section 3.5 which explains how DSM is applied within portfolios to achieve cost savings and manage risk.

Under a transition to 5/5 settlements, we view that DSM may become even more effective in achieving these goals.

Along with this list of complexities in section 3.5, the additional items arise for a portfolio (potentially) containing loads, generators, derivatives and DSM capabilities to respond to price events in an accurate and timely way, namely:

- **Manage 5/5 issues**: Even under a settlement arrangement of 5-minute dispatch and 5-minute pricing, an entity performing DSM will need to respond by turn-down of volume within the 5-minute interval, again requiring timely and rapid response.
- **Manage 5/5/30 issues**: Under proposed arrangements, a consumer may remain on the 30-minute pricing schedule, which retains the 5/30 issue described above.

An issue highlighted throughout this report is that response time for generators becomes a crucial issue in a 5/5 market. Namely that in the presence of dispatch interval price spikes which do not sustain beyond the interval, an immediate rapid response within the 5-minutes is required to capture value.

Industrial processes which are capable of rapid turn-down are able to also capture the value in the 5-minute period. And to the extent that turn-down can be achieved quickly, even more value can be attained.

The existence of wholesale derivatives does not impact this value. However, an enterprise with a standard retail contract is not capable of capitalising on the value of DSM. Instead, innovative retail structures are required which enable the value in DSM to be financially captured by the retailer and then compensation in some form to be returned to the end-user.

Depending on how the market convention evolves after the potential rule change is adopted, the following scenarios are possible depending on the choice of the consumer.

Quantity	Settled Load (MWh)	Settled Spot Price ($/MWh)	Derivative Settlement	Financial Risk Impacts
Load chooses 5-minute intervals, possible 5-minute derivative conventions	5 minute	5 minute	5 minute	DSM must be completely aligned with times of price event. Lose the ability to perform DSM for later dispatch intervals based on price spikes early in a trading interval.
Load chooses 30-minute intervals, possible 5-minute derivative conventions	30 minute	30 minute	5 minute	On physical, participant achieves benefit during price spikes early in Trading Interval but loses ability to react for price spikes late in each Trading Interval. Derivative settlements back to consumer will be in line or slightly elevated from current conventions.
Load chooses 5-minute intervals, current 30-minute derivative conventions	5 minute	5 minute	30 minute	DSM must be completely aligned with times of price event. Derivative settlements back to consumer may be slightly diminished compared to settlements aligned by 5-minute schedules.
Load chooses 30-minute intervals, current 30-minute derivative conventions	30 minute	30 minute	30 minute	Current state.

Table 8 - Potential DSM scenarios if proposed rule change is implemented

5.4 Utilisation of other assets within a Portfolio

5.4.1 Conflicting drivers

Presently there are some assets with the capability to sell caps and physically back those caps in a five-minute market that due to their ownership structure and strategy do not operate, or operate only sporadically. Due to being part of a larger generation portfolio, these assets are not incentivised to run to protect against price spikes, as in doing so would potentially supress the price spike. This behaviour is counter to the strategy that may be adopted across the rest of the portfolio, that is incentivised to drive spot price higher. Providing the size of their other generation fleet is adequate, it is not in the interest of the company to sell caps and operate these assets as they would in a standalone portfolio. Therefore, in some instances these assets are underutilised (from the perspective of increasing the supply of caps). However, they may already be used within the generation portfolio as self-insurance products to allow baseload generators to hedge more highly with swaps. Therefore, the re-arrangement of the operation of such assets may not result in additional hedges coming to the market, but possibly just a change in hedge products used (i.e. more caps, but less swaps). However, for this to happen, generators need to have sufficient incentives to enter into such alternative arrangements, and given the risk profile and pricing of caps, it could be argued that baseload generators are unlikely to reduce the sale of swaps significantly in favour of selling caps.

The additional complication of selling caps and generating to that contract position on a regular basis is that it reduces the value of those caps over time. If the market expects that the generator will always run when spot price exceeds the cap strike price, then parties will be less willing to buy the caps at a high price as the payoff, relative to the premium will be minimal. Therefore, such operational strategies will also potentially result in some assets not being available to sell caps against at all times.

5.4.2 Potential use of baseload generation to sell more caps

In theory, generation assets that run at higher capacity factors would be better suited to sell caps in a 5-minute market than fast start peaking plant due to their continued generation and therefore their ability to capture price spikes. However, when determining their preferred hedge portfolio, baseload generators consider both the best return that they can gain from the hedges sold and also their risk appetite. If they sold caps as a hedge against baseload generation to fill the void left by the reduction in caps sold by peaking plant, then this would reduce the amount of downside protection that the generator received when compared to selling swaps. This variability in revenue may not suit the risk appetite of the generator and may provide an inferior financial return relative to swaps. Figure 37 and Figure 38 provide the revenue distribution for a baseload generator hedged with 85% swaps and 85% caps respectively to demonstrate at the extremes the difference in revenue risk that a cap hedging approach contains relative to a swap hedging approach. In practice if a baseload generator decided to sell some caps against its baseload generation, it would likely only sell a small proportion.

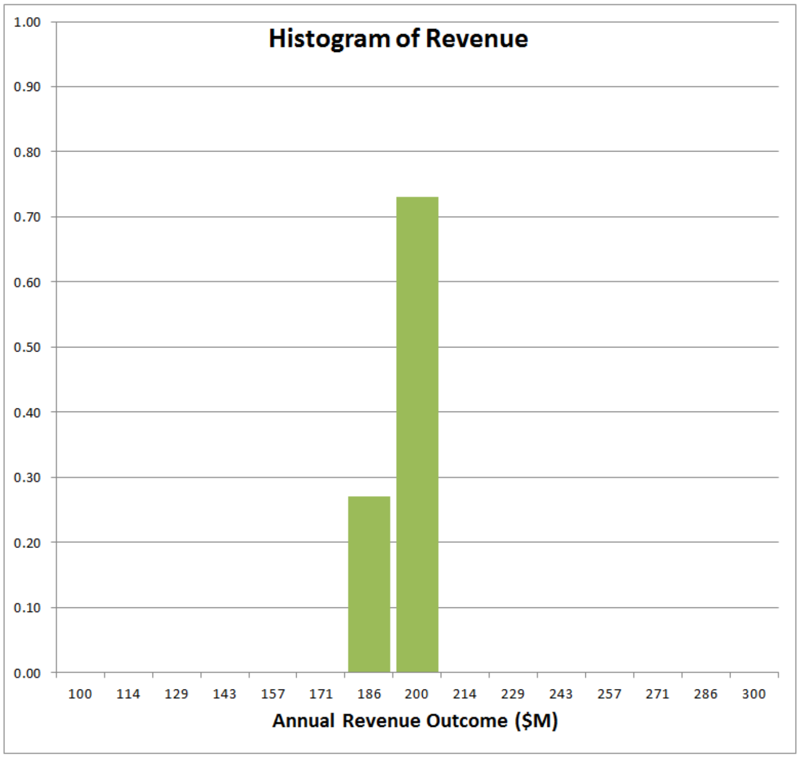

Figure 37 - Revenue distribution for a baseload generator hedged with 85% swaps

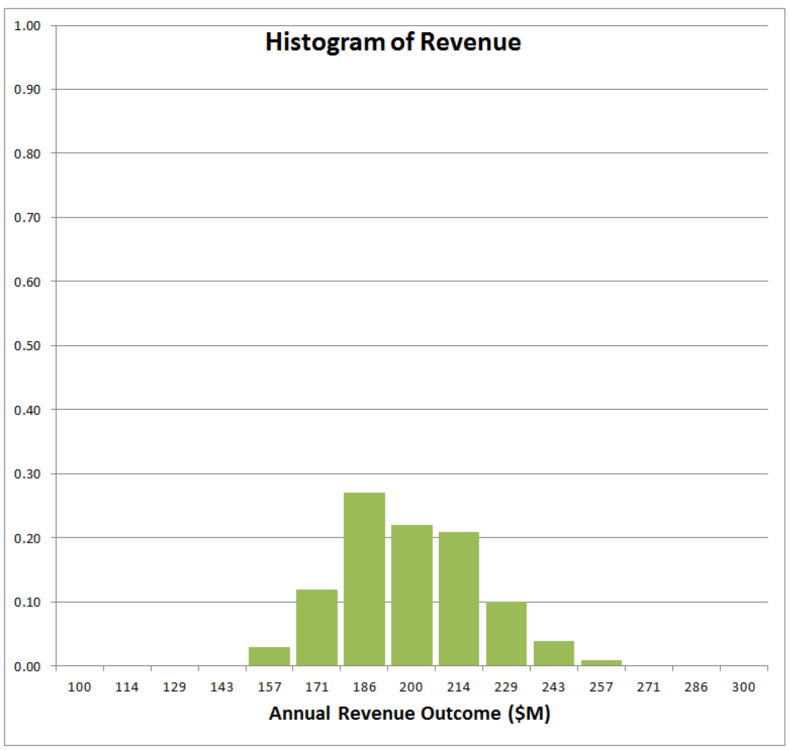

Figure 38 - Revenue distribution for a baseload generator hedged with 85% caps

The other issue that this presents is that even if the generator decided to sell a certain volume of caps rather than swaps, then this would mean that swap volumes would be reduced. The loss of cap volumes will result in an overall deficit of hedge contracts, and so the selling of caps rather than swaps would then create a shortage in supply of another product (in this example Swaps). It is certainly the case that as corporate risk appetites, strategies and price profiles e.g. relative value of under cap pay-offs to Cap pay-offs and swap prices relative to generator SRMC and LRMC, change over time and across business cycles, the extent to which base load generation maybe willing to sell more caps relative to swaps will change. This is the case to a degree already under the 30-minute rules. However, what is a constant is that physical capacity can only effectively underwrite a given volume of hedges. To the extent product substitution occurs it will not increase the net supply of hedges.

5.4.3 Vertically integrated portfolio

The peaking assets within a VI portfolio (which may otherwise be available to back cap contracts) may be internalised within a VI enterprise to support flexing retail load (which would otherwise be a source of demand for cap contracts).

To the extent of an imbalance, a VI entity may enter the wholesale derivative market to purchase additional caps, or monetise the assets' capacity by selling caps. However, a corporate strategy may potentially be adopted to reduce offerings of caps into the market for a net long enterprise, in order that the cost or risk to competitors in the retail space is elevated.

5.4.4 Single asset portfolio

A corporation with low tolerance to risk may view that the potential for a forced outage at a time of high spot prices will lead to large contract liabilities which are unsupported from physical revenues (that is, a net position of significant outgoing cash). Such entities may be reluctant to offer contracts (caps or otherwise) into the derivative market. Macro-level market analysis which does not take into consideration the peculiar risk appetite of such organisations would otherwise overstate the available cap offerings.

Similar arguments are also common for small intermittent generation businesses which cannot guarantee supply.

5.5 Other Financial Instruments

Under the scenarios outlined above, it is clear that caps contracts based on 5-minute settlement do not provide a particularly good hedge for the asset classes that are affected by the change in settlement i.e. there is a greatly reduced correlation between the payoff of a cap and the earnings of the generator. Each owner will have their own corporate circumstances to consider and make decisions on the type of return that they are after from these assets (e.g. higher revenue with more risk, less revenue and less risk, different running regime, etc.). However, it is possible that caps no longer become an instrument that provides sufficient return for the desired level of risk, and therefore other alternative instruments and running regimes may be reviewed.

Therefore, we look at what other instruments may be suited to both a retailer and a fast start peaking generator to manage their risk.

5.5.1 Retailer

If generators were unable to sell the same level of caps as they currently do, then retailers would have to look to alternative products to assist in managing that risk. Depending on what alternative products are used (either products that are traded in the electricity financial market or insurance products), it may result in the retailer having to take on more risk, as the product may not exactly match the risk that is being hedged.

5.5.1.1 Weather derivatives

The main alternative product that would allow retailers to manage their flex risk is weather derivatives. These are reasonably widely utilised by retailers already to assist in managing their flex risk, due to the correlation between weather and demand. They are an insurance product that is purchased through an insurance broker and are not traded in the standard financial market.

However, weather derivatives expose the retailer to a higher degree of basis risk, as the main risk that is being hedged is spot price, and spot price spikes do not always align with weather events. Depending on how specialised such weather derivatives are (i.e. the number of geographic reference points, event triggers, maximum duration or number of events within a period etc.), these may result in a lower premium but higher basis risk. One downside of purchasing weather derivatives is that they are not tradeable, so that a participant cannot tailor its position if needed by selling some of this product if it was no longer needed.

The most common class of weather derivatives which are of most effectiveness in the electricity markets are temperature derivatives with payoffs which depend on both the number and extremeness of temperature events. They are typically structured on heating-degree days or cooling degree days, being a measure of the extent of temperature deviations from ‘mild’ temperature conditions, and thus inducing additional electricity demand. These efficacy of weather derivative products rely upon a strong statistical linkage between spot prices and daily temperature outcomes at reference locations in the State.

5.5.1.2 Inter-regional caps

Another way that a retailer may manage its flex risk is through inter-regional caps if there is a shortage of caps that relates to the region that is being hedged. This may involve buying caps with a reference price of another region and reducing this inter-regional risk through the purchase of SRA. Again, this approach will expose the retailer to a higher degree of basis risk, and potentially a higher cost.

5.5.1.3 Structured products including triggered derivatives

It is relatively common for retailers and generators to deal directly and to construct bespoke derivative contracts which appeal to the physical characteristics of each party. For example, derivatives which knock-out upon the failure of a generation plant or knock-in during high system loads. While important, these derivatives are relatively large and few, but most participants will hold such instruments in their portfolio from time to time. The implications for a change to the 5/30 settlement nature may be substantial as generators seek to rewrite the contract structure based on their ability to respond within the 5-minute period (rather than across the smeared 30-minute interval). Owing to the broad nature of this class of products it is not possible to draw a firm conclusion as to the outcome.

5.5.2 Fast start generators

There would not appear to be any existing alternative financial products that would be suitable for fast start generators that would cater for their peaking capacity factor. The proposed change to the market settlement structure does not cater for the physical capabilities of these assets very well, and therefore apart from caps, does not allow them to provide other firm risk management products that are very effective.

5.5.2.1 Non-firm caps

The only product that would seem appropriate from a generator's perspective is a non-firm transaction (such as a non-firm cap) that provides a retailer with a hedge against price spikes, but only for the volume that the generator is generating at the time. This then transfers the risk of missing the high price events to the buyer of the product, and would result in the buyer (usually a retailer) paying a discount to the firm pricing for such a product. To the extent that there is anticipated underperformance of the supplier in backing the cap, there is further discounts applied in the option fee paid.

5.5.2.2 Weather derivatives

One possible alternative for a fast start generator to enable them to sell firm caps is for them to buy other products such as weather derivatives to help provide a hedge in the event that weather driven high price spikes occur that they cannot capture through generation. However, this introduces another basis risk for the generator, and will also come at an additional cost. It is questionable whether such costs could be passed on to the retailer.

5.6 Factors Hindering Alternative Strategies

The main factors that we see hindering the alternative potential strategies are the following:

- Some assets that are capable of selling caps are not incentivised to do so because they are part of a larger portfolio that has drivers to push the price higher. They are therefore used as a backup generator to allow the company to sell a higher level of swaps.
- The construction of more pumped hydro may face pushback from the environmental movement, due to the creation of more dams. Notwithstanding this, the timeframe for planning, construction and connection of such assets may be beyond the implementation timeframe for this proposed rule change, leaving the market with a temporary shortage of cap sellers.
- The large-scale economics of batteries is not yet at a point that would allow the introduction of these into the Australian market. According to Australia's Chief Scientist, it may be a number of decades until these become a cheaper alternative than pumped hydro. Whilst technology is evolving rapidly and there are emerging large scale battery projects in various places around the world including under consideration in South Australia, they currently require substantial subsidies to be economic. The other drawback is that whilst they are able to address capacity constraints, they do not address energy constraints. Therefore, large scale batteries could help existing capacity write caps and therefore reduce the estimated 625MW shortfall. However, in the short to medium term, due to the extra cost of implementing large scale batteries, that cost will be passed onto the consumer as a higher cap premium or some other direct or indirect cost increase. Likewise, in the sort to medium term, whilst some large scale battery projects may be installed, they

will be a long way from addressing the estimated supply shortfall of 625MW in caps (before allowing for the adverse impact on VI portfolios).

- The risk profile and financial return of coal fired/ baseload generators is more aligned with selling high levels of swaps. Whilst these assets are likely to have high capacity factors and therefore capture a high proportion of the value associated with high price events, they are not financially incentivised to sell caps. Therefore, it is unlikely that baseload generators would add any significant volume to the cap supply. To the extent base load generators do become an incremental source of cap supply it will result in a reciprocal tightening of supply in swaps or other hedge products. If this change in hedge strategy is as a result of a change in price profiles (e.g. relative under-cap versus over-cap payoffs) in the market, a range of offsetting consequences may arise which are beyond the scope of this paper.
- The sale of non-firm caps by fast start generators as a way of reducing the risk of not being able to capture as high a percentage of price outcomes above $300 will result in the receipt of a reduced premium due to the non-firmness of the product and each generator's potential to capture value. This reduction in earnings for the generator is an issue. Additionally, we have reservations about the attractiveness of such a product for a retailer, thereby questioning the extent to which there will be demand for such a product.

In time, the increasing penetration of batteries and other very fast start response mechanisms is likely to reduce the number of prolonged price spikes. For this reason, it is expected that through time the effectiveness of existing fast start generators to capture price spikes will decrease. At some point, the economics for certain fast start generators will fail to stack up and these plants will become redundant as stand-alone generators. Their usefulness will be dependent on how or if they can adapt through the use of technology, or perform other functions within a larger portfolio (e.g. backup plant used during outages of other units within a portfolio), etc.

5.7 Factors Assisting Alternative Strategies

The main factors that we see that will assist with alternative strategies are:

- The construction of new assets such as additional pumped storage hydro, batteries and other technologies are likely to become more viable under a 5-minute settlement market, as such very fast start assets will be the only assets capable of capturing a large proportion of high price events.
- Energy storage assets will become a larger part of the energy supply mix once Australia pushes towards a higher penetration of intermittent renewable energy sources.

6 Other Factors Influencing AEMC Decision Making

6.1 Competition in markets for financial risk management instruments

While section 4.4 provides an overview in the change in the total number of caps in the market, the following analysis investigates the competition in terms of concentration of hedging capacity on the basis of those cap volumes. Energy Edge has utilised the widely accepted Herfindahl-Hirschman Index (HHI) as the metric to indicate whether there is any material dilution of competition in the supply of caps as a result the 5-minute rule change. In applying the HHI metric to this particular issue Energy Edge has adopted the following approach:

- Cap volumes have been calculated as per section 4.4 by region and asset class;
- Ownership has been calculated based on percentage ownership of asset class that are natural sellers of caps as per section 4.4;
- Market share has then been calculated on a % basis allocated to each owner; and
- Herindahl-Hirschman has been calculated as per the official formula on market share for each individual region;
- Regional results have been summarised in **Table 9**.

The United States Department of Justice utilises the Herfindahl-Hirschman Index (HHI) with the following explanation[3]:

Based on their experience, the Agencies generally classify markets into three types:

- *Unconcentrated Markets: HHI below 1500*
- *Moderately Concentrated Markets: HHI between 1500 and 2500*
- *Highly Concentrated Markets: HHI above 2500*

The Agencies employ the following general standards for the relevant markets they have defined:

- *Small Change in Concentration: Mergers involving an increase in the HHI of less than 100 points are unlikely to have adverse competitive effects and ordinarily require no further analysis.*
- *Unconcentrated Markets: Mergers resulting in unconcentrated markets are unlikely to have adverse competitive effects and ordinarily require no further analysis.*
- *Moderately Concentrated Markets: Mergers resulting in moderately concentrated markets that involve an increase in the HHI of more than 100 points potentially raise significant competitive concerns and often warrant scrutiny.*
- *Highly Concentrated Markets: Mergers resulting in highly concentrated markets that involve an increase in the HHI of between 100 points and 200 points potentially raise significant competitive concerns and often warrant scrutiny. Mergers resulting in highly concentrated markets that involve an increase in the HHI of more than 200 points will be presumed to be likely to enhance market power. The presumption may be rebutted by persuasive*

[3] https://www.justice.gov/atr/horizontal-merger-guidelines-08192010#5c

evidence showing that the merger is unlikely to enhance market power.

Region	30 Minute HHI	Definition	5 Minute HHI	Definition
NSW	6,014	Highly Concentrated	5,989	Highly Concentrated
QLD	1,500	Unconcentrated	1,523	Moderately Concentrated
SA	4,034	Highly Concentrated	3,813	Highly Concentrated
VIC	3,914	Highly Concentrated	3,956	Highly Concentrated

Table 9 - Regional Herfindahl-Hirschman Index

The results of our HHI analysis show that, based on our assumptions and inputs, there has been no material dilution of competition in terms of suppliers of caps. The current region with the lowest HHI is Queensland and this is intuitive given the dominance of independently owned gas fired generation owned by multiple entities as the source of cap supply in Queensland. However, it is notable that in most other regions the supply of caps is already Highly Concentrated. As a result, although total supply has diminished (which is not good from a hedge market perspective), the level of competition as measured by HHI has improved moderately in some regions, as the dominant party in some of those regions, e.g. Snowy Hydro, is the most adversely effected by the rule change. The HHI outcomes will be highly sensitive should our estimates of the impact on the supply of caps be materially underestimated or particular entity(ies) determine that they can no longer sell caps under the 5-minute rule change. Given the current High Concentration of competition for supply of caps any further material erosion of the level of competition could be critical at a Regional level or even NEM-wide.

6.2 Financial Intermediaries

This paper has been focussed on the effect of the proposed rule change on physical market participants and the ability to manage their risk. However, the role of intermediaries in adding liquidity to the financial market cannot be understated. If there are changes to the financial products such that they move into alignment with the proposed 5-minute settlement, then there is unlikely to be many (if any) implications for financial intermediaries unless they have exposure to physical positions, either as a retailer or a generator.

Our reasoning for this is that the underlying products that they trade are primarily to provide a mechanism for physical market participants to manage their risk. Financial intermediaries will choose if and how they are best equipped to take positions and make a return on the instruments that the physical participants require, and therefore they are likely to trade in instruments provided there is demand and supply from the physical market participants.

Certainly, the reduction in traded volumes of Caps is unlikely to dramatically impact the viability of the business model for financial institutions operating a predominantly speculative trading business model given Caps typically only represent 10 – 20% of the total turnover in electricity derivatives.

In the case of financial institutions that operate under a more client service focused business model there may in fact be an opportunity for financial intermediaries to inject some additional supply of Caps over and above generator backed supply of Caps. However, given the following points, the price and bid/offer spread for Caps is likely to be higher/wider:

- There is a high level of risk associated with selling Caps without physical generation;
- A bigger gap between supply and demand for Caps will drive up price particularly if the source of supply is to come from parties without physical generation to back the financial product;
- It's likely that Liquidity Ratios for Caps will diminish as it becomes an increasingly marginalised product which in turn will amplify the net reduction in total turnover of Caps; and
- Low turnover in a financial product will typically mean wider bid offer spreads (increased cost to transact) and more periods where a two-way price is not available at all (i.e. a bid with no offer available). In either case these equates to an increase cost to transact Caps.

6.3 Effects on Participants' Arrangements

6.3.1 Risk Management Policies

As described in 3.2, generators and retailers try to minimise their risk of variability of spot price outcomes, by executing hedges that have the effect of reducing their exposure to the spot market. The makeup of hedge portfolios for generators and retailers will depend on a variety of factors, but in most cases, there is a desire to cost effectively offset the underlying risks and exposures with a combination of hedge products. Given the level of risk appetite of the Boards of Generators and Retailers will remain constant there are some different implications which might transpire via the structure of typical Market Risk Management Policies of these two main market participant types:

- **Retailers**

As is explained in section 3.4.3 and Figure 7, Caps play a very important role in managing the Flex part of a retailer's customer load profile. There are limited alternative financial products available that manage Flex risk as effectively (either they cost more and/or require the retailer to carry more Residual Risk). Whether, a retailer buys Caps from the financial market or is vertically integrated the net effect is similar. Under the 5-minute rule change the Retailer will either have to pay more for the Caps, carry more Flex risk in its portfolio or buy more products such as weather derivatives which might be less effective than Caps.

In any scenario, the Transfer Pricing methodology and governance frameworks of a prudent retailer will eventually see the increased cost to hedge or cost of carrying more Load Flex risk transferred to their customers.

- **Generators**

For fast-start generators who currently utilise the sale of caps to hedge their plant, there is the potential that by continuing to utilise a high level of caps to hedge their output, their variability of revenue outcomes could actually increase, as they have the potential for high cap payouts that are not matched by high generation revenue.

The changing of the market settlement to 5 minutes effectively means that owners of fast start plant hold assets that are no longer particularly suited to the new market. This will cause concern for risk committees, Boards, bankers and shareholders who are left with assets that have diminished value and relevance in the new market, with little alternative avenues for revenue. The higher risk associated with selling Caps will make it more difficult to achieve Financial Investment Decision on new fast start assets such as gas-generators or hydro plant, all other things being equal or generators will require a higher price for the sale of Caps to compensate for the additional risk undertaken in selling the product.

6.3.2 Banking Obligations

Most generation assets are debt funded and so are subject to banking requirements that reduce the level of income variability so that there is a higher probability that the asset will be able to repay debt. Depending on the risk appetite of the bank, this will involve the generator putting in place either shorter term or longer term hedges. In the event that caps have been sold against these assets as a requirement of the financing obligations, the change to 5-minute settlement may invoke a renegotiation of the contract, due to some form of change of market pricing clause. Given our analysis that most of the fast start generators will not be able to physically back the same volume of caps, then this is likely to lead to one of two outcomes:

- The sale of a lower volume of 5 minute caps which, unless the premiums increase substantially, will result in a lower level of revenue for the generator, and leave the buyer of the caps with less volume than they originally executed. This lower level of revenue is likely to be a concern for the banks as it may render the assets financially unviable. In such an instance, the banks will either refuse to finance the assets or charge a higher interest rate to cover the risk. Throughout all this, additional costs will be incurred due to the movement away from the assets being able to effectively utilise caps to hedge their revenue streams due to the reduced ability to physically back the contracts.
- The generator taking on a higher level of risk, and continuing to sell the same level of 5 minute caps that it had under a 30-minute settled market. Due to their reduced ability to capture pricing >$300/MWh, this will ultimately lead to diminished returns for the generator which they will likely try to rectify by passing through to the buyer increased premiums (if the market will pay additional pricing rather than look at alternative avenues to mitigate the risk), or will result in a diminished financial outcome. If the latter is the case, this could lead to write-downs of asset values and bank debt write-offs, and possibly the sale of such assets at reduced prices to companies that can utilise them differently within a portfolio.

6.3.3 Accounting and/or corporate governance arrangements

Under the current accounting standard AASB 139, the sale of caps is not considered an ‘effective hedge’ from an accounting perspective, and therefore the change in market value of the instruments must be reflected in the Profit and Loss Statement on a regular basis. From 1 July 2018, a new standard AASB 9 will replace AASB 139, which is a little more accommodating for recognising the effectiveness of certain hedge products. In any case, the use of 30 minute versus 5 minute caps will unlikely change the consideration of this, although further examination of the new standard is worthwhile, given it is not the subject of this paper.

6.3.4 Reopening of any contract referencing spot price

Existing hedge contracts, long term offtake agreements, and any contract that references spot market price has the potential for a reopening of the contract based on a change in market price clause. For a number of these agreements, this should be a fairly straightforward adjustment to change the reference price. However, it poses the following problems:

- Reopening of any contract arrangements could provide an opportunity for one party to renege on the contract, particularly if it is out of the money, or there are other circumstances that are causing grievances.
- Where these contracts relate to affected contract types, e.g. caps, floors, load-following swaps, whole of generation meter swaps etc., there is going to have to be a repricing of the transactions to reflect the change in the settlement basis. This could result in disputes and in the extreme potentially cancellations of these types of agreements.

6.4 Role of gas in renewable energy transition

The analysis presented concludes that gas-fired generators are likely to be one of the asset classes affected by the change to 5-minute settlement, with potential for reduced income through lower cap sales and the reduced ability to capture high price events. Depending on the eventual severity of this reduction in revenue and whether asset write-downs are required, there may be a disincentive for new gas-fired power stations to be built.

Due to the move up in gas pricing in recent times in Australia, and due to the variability in spot electricity pricing where renewable energy generation penetration is high, it has/is becoming uneconomical for CCGTs to run in a baseload configuration, which has led to the mothballing or reduced operation of several CCGT plants across the NEM (e.g. 385MW Swanbank E (refer Figure 39), 480MW Pelican Point (refer Figure 40), 460MW Tallawarra (refer Figure 41).

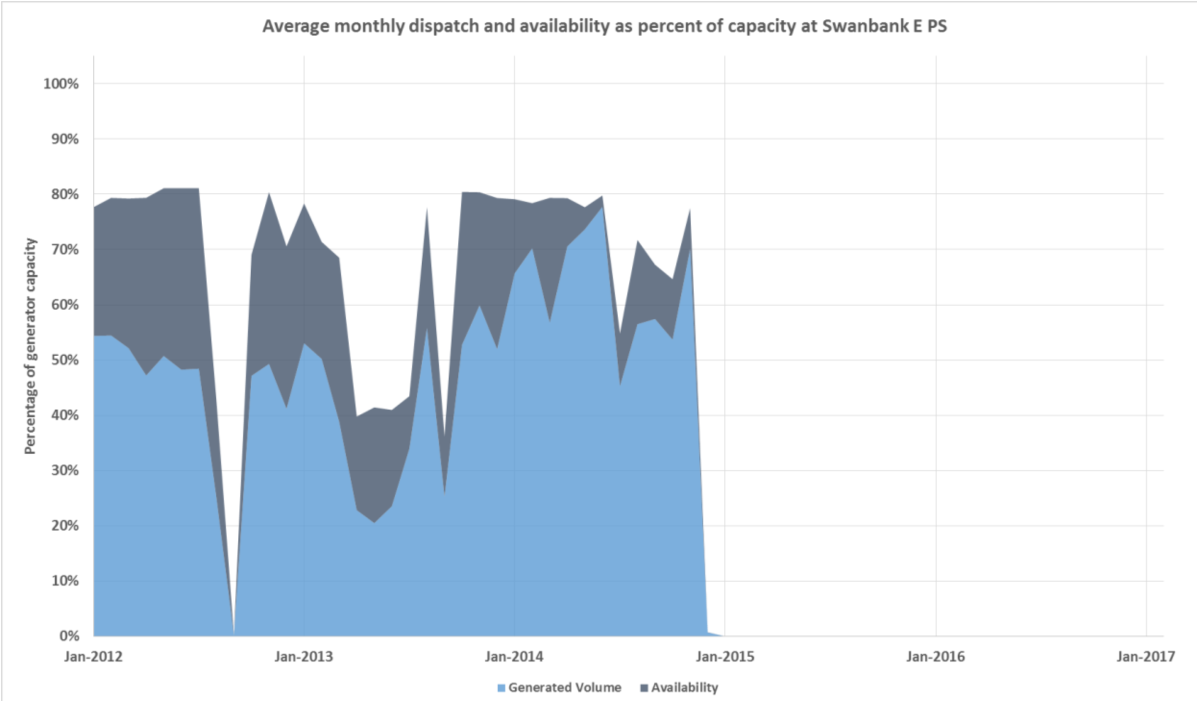

Figure 39 - Monthly availability and dispatch of Swanbank E CCGT

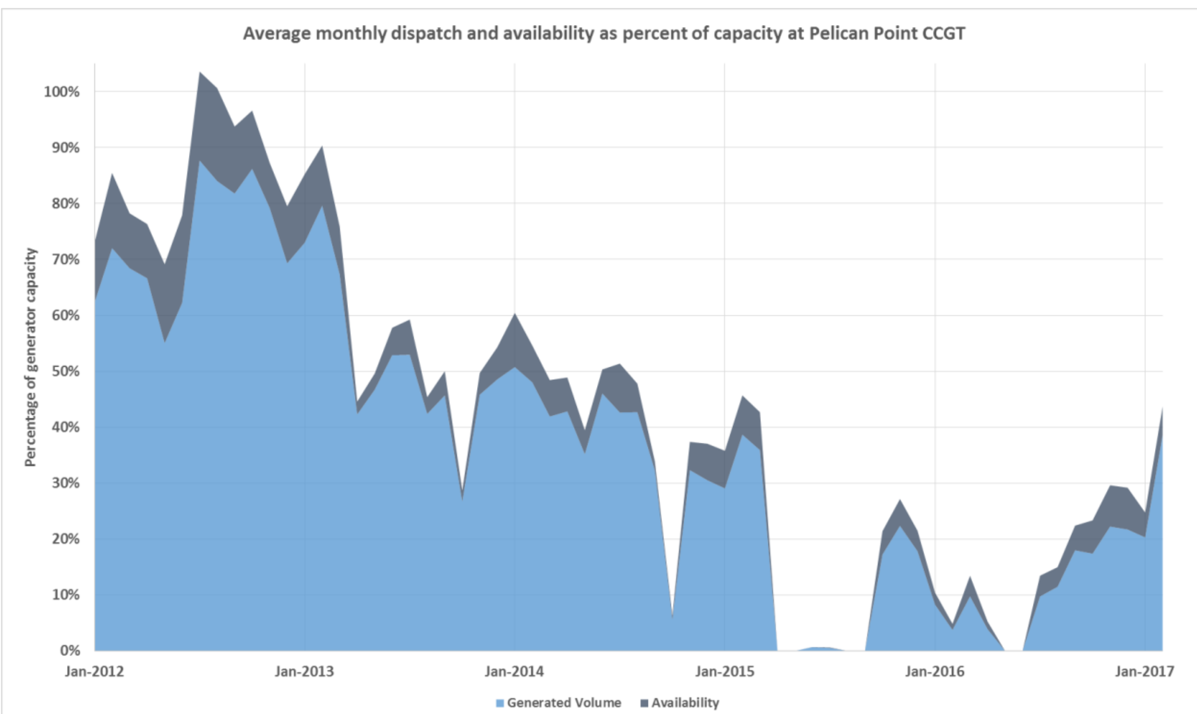

Figure 40 - Monthly availability and dispatch of Pelican Point CCGT

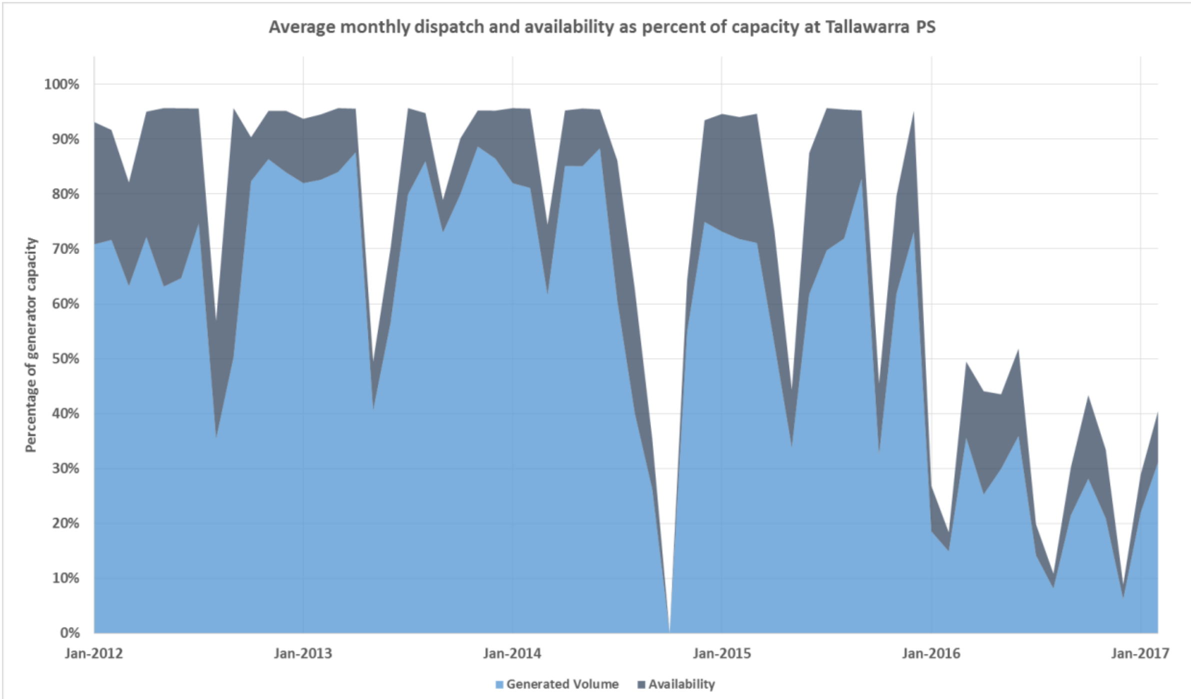

Figure 41 - Monthly availability and dispatch of Tallawarra CCGT

The potential rule change in combination with the higher cost of gas could severely limit the incentive for new investment in gas-fired power stations, particularly OCGTs. Furthermore, it has the potential to bring on the exit of gas-fired power generation due to the unsuitability of such assets to capture value. In the move towards increasing renewable energy generation in Australia over the next 20 years, the ideal sequence would be to have less efficient coal fired generation exiting the market in the first instance with lower emissions gas-fired generation being used as the transitional fuel as renewable energy generation increases its capacity in conjunction with other technologies such as storage to create a more stable energy supply.

6.5 Pumped storage hydro and batteries as net energy users

In the AEMC's working papers there is mention of some of the technologies that it expects to be able to respond to price events under a 5-minute settlement market. While some of the technologies are unclear or untested at this stage, batteries are one of the technologies that are mentioned regularly. It would be logical that batteries may fill part of the void caused by the reduction in cap sales by fast start generators.

However, another useful source of fast start generation is pumped hydro generation. Dr Alan Finkel, Australia's Chief Scientist, has advised that pumped storage is about 25 times cheaper on a lifetime basis than batteries at present, as they are five times cheaper per MWh of energy storage, with a lifetime approximately five times as long as batteries[4]. He

[4] "Future grid has batteries, renewables and software – Finkel", Australian Financial Review, 8 February 2017.

has suggested that of the two alternatives, pumped hydro would be the more economical form of storage for at least two decades. This would suggest that it is the most feasible alternative to provide the very fast generation that a five-minute settled market would incentivise.

However, it should be noted that pumped storage, together with batteries, are net energy users, as they utilise more energy in the pumping of the water to the storage area than they produce when the water flows through the turbines. For Australia's pumped hydro generators this is approximately 1.2 – 1.4 times. (Batteries are also a net user of energy due to losses in storage). Whilst this can be overcome from a financial viewpoint through the pumping of water at times of low spot electricity price and the generation of electricity at times of high spot electricity price, the deficit of energy that these units create will need to be generated by other units in the grid. This will either require harder running of existing baseload assets (generally coal), or the building of new generation.

If the change to 5-minute settlement disincentivises any new investment in open cycle gas-fired generation, and high gas pricing precludes generation from, and investment in, open cycle generation, then this additional energy will need to come from either coal or renewable energy sources.

6.6 Timing Considerations

In considering the timing of implementation for the proposed rule change, there are a number of items for the AEMC to consider. However, for the purposes of this paper we have focussed only on those that will affect the derivative market. These are:

- The length of affected contracts (e.g. caps, floors, half hourly collars, load following instruments etc.) that currently exist in the market.
- The period into the future that ASX cap contracts have been listed.
- The typical length of offtake agreements that will be affected.
- The timing of potential upgrades that would improve the speed of data flow to participants as speed of data would become highly critical.
- The timing of the development of alternative very fast start generation assets that are likely to be required to fill the void of cap sellers in the financial market.

Our analysis concludes that the proposed change to 5-minute settlement will have impacts on some participants that will be permanent. However, to minimise the impact on the reminder of the market, we consider the timeframes of other factors that will come into play. In general, the shorter the timeframe, the more disruption will be caused to the participants in the market.

6.6.1 Length of affected contracts

Due to the opaqueness of the OTC market, it is unknown what length of contracts may have been executed. In general, the more liquid end of the curve is up to 3 years forward. This is replicated on the ASX where in some regions futures contracts have traded 3 ½ years forward, and cap contracts 3 years forward at the time of writing. In respect of commonly traded affected instruments, the implementation of the proposed rule change 3 – 4 years forward of the rule being made is likely to cause the least impact.

Having said this, longer term cap contracts that have been sold as part of bank financing arrangements typically are for 10 – 15 years. Whilst a number of these arrangements may be more than half way through, the reopening of these may possibly involve some form of refinancing exercise particularly for those assets that will have reduced effectiveness of capturing 5-minute price spikes. Without knowing the details of these contracts, it is hard to know exactly what tenor such contracts have left, and therefore specify a period that would ensure they were not impacted. However, if the impact is to be minimal for such arrangements a period of more than five years will certainly be necessary.

6.6.2 ASX listing timelines

The ASX lists its products a minimum of 3 ¾ years forward and the traded products terms are defined at the point of listing. Therefore, caps that are listed on the ASX at present (out until the end of 2020) are defined as referencing the 30-minute spot price in calculating their payoff. These products cannot, under ASX Rules, be changed once listed. Due to the majority of derivative trading taking place on the ASX, it is recommended that the rule change not be implemented sooner than 4 years forward to avoid the situation of the ASX listing products that do not cover participants' underlying exposure and consequently becoming an ineffective and illiquid product.

6.6.3 Offtake Agreements

Longer term offtake agreements over assets that sell variable volume contracts (e.g. renewable energy assets) typically have terms of 10 – 15 years, but can be longer. As these types of agreements have been executed recently, and continue to be negotiated now, it is inevitable that the proposed 5-minute settlement change will impact these agreements, regardless of when it is implemented.

6.6.4 Upgrades to data transmission speed

With a move to 5-minute settlement, the timing of receipt of data from AEMO will become multiple times more critical. Whereas dispatch pricing now can take up to 50 seconds to be received, under a 5-minute settlement market, that equates to 14% of the period being elapsed before a participant is even aware of the price in order to make a decision whether to turn on or ramp up. In respect of a peaking generation unit trying to back a cap contract, that lost time equates to lost value and increased risk. Therefore, it is will be highly critical that data transmission times be increased to allow participants to react with more haste to a spike in pricing.

It is outside our area of expertise to estimate when and how this increased speed of data flow could take place, but is it worth highlighting the need for this.

6.6.5 Installation of large scale very fast start assets into the grid

If the 5-minute settlement results in the reduction in the supply of cap contracts, then it is suggested that batteries and other technologies be installed to fill this void. However, we would suggest that such assets are in place prior to the implementation of the proposed rule change to ensure that the market is not left with a shortage of cap contracts that will result in retailers potentially having to manage their load flex with instruments that either increase price or increase risk.

On this front, we would suggest that the AEMC consider the lead times associated with the construction of sufficient additional very fast start generation assets (e.g. pumped hydro, batteries or other technologies) when determining the timing of when the proposed rule change should become effective. Additionally, such consideration should include analysis of the timing around when certain technologies become economically viable to operate on a large scale. Currently Pump Storage Hydro are very economic from a feasibility study perspective but other restrictions particularly associated with environmental and land holder issues create substantial lead times and adversely impact their ability to be part of the solution without supportive policy and regulatory changes.

Dr Alan Finkel has recently advised that the price of batteries is falling by about three-quarters every 10 years, meaning that after a bit more than 20 years "grid-scale batteries could be price competitive with pumped hydro"[5]. Whilst a range of large scale battery solutions are starting to emerge around the world they require heavy levels of subsidy in order to be viable. Ignoring economic issues large scale battery solutions can deliver energy constraint solutions quite quickly. However, they do not address energy constraint issues and in the short to medium term it is expected that they will only alleviate a small portion of the estimated reduction in supply of caps, and either directly or indirectly there will be cost consequences for the consumer.

6.6.6 Uncertainty surrounding proposed rule change

Anecdotally, the uncertainty surrounding this proposed rule change is starting to have an impact on the liquidity of longer dated caps in the market. We have been advised that a number of market participants are reluctant to sell much cap volume until after the decision surrounding this rule change takes place and the timings of the effective implementation are known. This is an indication to us that participants are expecting that the proposed change will impact their portfolios and further consideration will be required before they enter too much additional volume.

6.7 System costs of the change

This report has focused on the implications to contract trading for a change in market rules to 5/5 settlements.

Although not directly in scope, we provide the AEMC with a comment that the costs of system changes to moving to 5/5 market settlements will be very large, and estimated to be in the tens of millions of dollars.

For physical and financial players, the following systems are a subset of those employed to manage financial risks and implement trading strategies. Each of these systems is a multi-million dollar capital investment which will require replacement or significant enhancements or recalibration upon a change to market. With the move to 5 minute settlement periods from 30 minutes, most will be required to handle six times as much data. The types of affected systems include:

- Settlement systems;
- Risk and compliance systems;
- Mark-to-market and hedge accounting systems;
- Contract pricing and valuation systems;
- Position monitoring;
- Limit monitoring;
- Market and Portfolio Reporting; and
- Forecasting Systems.

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[5] "Future grid has batteries, renewables and software – Finkel", Australian Financial Review, 8 February 2017.

7 Appendix 1 – Scope of Works

The AEMC has engaged Energy Edge to provide a report covering the following aspects relating to the proposed rule change.

1. A summary of the different types of financial instruments used in the NEM, noting which ones would be affected by the proposed rule change (with respect to the more granular settlement interval and proposed demand side optionality).
2. Detail on the contract type that would be most affected by the rule change. We expect this to be 'cap' contracts. This should include:
    a. how and why the contract type would be affected by the rule change (with respect to the more granular settlement interval and the proposed demand side optionality);
    b. identifying natural sellers of the contracts;
    c. how they are priced;
    d. applications and strategies in which they are used;
    e. historical estimates of volumes sold, segmented by fuel type, NEM region and/or corporation;
    f. historical prices; and
    g. any other information about the contract type that the consultant considers to be relevant.
3. Discussion of alternative hedging and operational strategies that could be used by market participants if 5-minute settlement is introduced. This should include:
    a. changed operational strategies that could be used at individual power stations to sell contracts referencing a 5-minute price;
    b. ability of market participants to use other assets in their portfolios for similar risk management outcomes;
    c. other types of financial instruments that could be sold;
    d. factors that may hinder participants in using alternative strategies (e.g. external constraints, such as the price and availability of gas); and
    e. factors that may assist participants in using alternative strategies (e.g. emerging technologies).
4. Discussion of other factors relevant to the AEMC's decision making, such as the potential impact of the proposed rule change on:
    a. competition in markets for financial risk management instruments;
    b. financial intermediaries; and
    c. participants' risk management policies, banking obligations, accounting and/or corporate governance arrangements.

Final Page Disclaimer:

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