AEMC

RULE CHANGE

Australian Energy Market Commission

DRAFT RULE DETERMINATION

National Electricity Amendment (Five Minute Settlement) Rule 2017

Rule Proponent

Sun Metals Corporation Pty Ltd

5 September 2017

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Australian Energy Market Commission, *Five Minute Settlement*, draft determination, 5 September 2017, Sydney.

About the AEMC

The AEMC reports to the Council of Australian Governments (COAG) through the COAG Energy Council. We have two functions. We make and amend the national electricity, gas and energy retail rules and conduct independent reviews for the COAG Energy Council.

Summary

The Australian Energy Market Commission (AEMC, or Commission) has made a draft rule, which is a more preferable rule, to align operational dispatch and financial settlement at five minutes. This will reduce the time interval for financial settlement in the national electricity market (NEM) from 30 minutes to five minutes. The draft rule provides a transition period of three years and seven months. The Commission believes this is the shortest timeframe possible to implement the required changes, while managing the considerable practical challenges, risks and costs the change presents. Further, the draft rule:

- sets out the metering requirements needed to provide five minute resolution data for settlement
- changes the resolution for bidding and offering into central dispatch from a 30 minute to a five minute basis.

Background

A physical requirement of power systems is that demand and supply must always be instantaneously balanced. Ideally, as demand and supply vary continuously, the price signal would also vary continuously. A market where the price signals provide incentives to respond to supply and demand changes over the shortest timeframe practicable, will provide more efficient wholesale market outcomes.

At the inception of the NEM in the 1990s the five minute dispatch price was considered to be the shortest timeframe practicable. However, the decision was made to adopt different periods for dispatch and settlement based on limitations in metering and data processing in the 1990s. These technical limitations no longer exist today.

The NEM is currently undergoing a significant transition involving the adoption of generation technologies such as wind and solar at the same time as age-based retirement of existing thermal generation. Flexible technologies are playing an increasingly important role in supporting the intermittent output of wind and solar generators. Supply side flexibility is currently provided by hydro, gas peaking, and diesel fuel generators and to some extent by coal-fired generators. There is also increasing demand side participation by consumers, which at the commercial and residential level is being enabled by the adoption of solar, battery and other technologies.

The generation mix will change further as technology advancements improve the economics of faster and more flexible demand and supply solutions. Wholesale prices directly influence the type, scale and location of technology installed, in response to changing power system conditions. They also provide a signal for the efficient consumption of electricity and efficient investment in generation and demand side technologies. Given the change underway, it is increasingly important that the NEM market design provides efficient price signals for operation and investment decisions.

The rule change request

The draft rule has been made with respect to a rule change request received from Sun Metals Corporation Pty Ltd (Sun Metals) in December 2015. Sun Metals proposed that the time interval for financial settlement in the NEM be reduced to five minutes so as to align financial settlement with operational dispatch.

Sun Metals submitted that the mismatch between the dispatch and settlement intervals leads to inefficiencies in the operation and generation mix of the market. Specifically, it:

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

Benefits of five minute settlement

The Commission considers that aligning dispatch and settlement at five minutes would have the following significant enduring benefits relative to the current arrangements:

1. improved price signals for more efficient generation and use of electricity
2. improved price signals for more efficient investment in capacity and demand response technologies to balance supply and demand
3. improved bidding incentives.

By aligning the financial incentives for participants with the physical operation of the market, five minute settlement will more accurately reward those who can deliver supply or demand side responses when they are needed by the power system. In contrast, 30 minute settlement provides an incentive to respond to expected 30 minute prices, rather than the five minute dispatch price. This pricing distortion leads to generator and demand responses that can occur up to 25 minutes after they are required by the power system.

Aligning dispatch and settlement at five minutes and creating an improved price signal also provides the right incentives for innovation and investment. In particular, efficient investment and innovation in an appropriate amount of flexible generation and demand side technologies. The expected result over time is a more efficient mix of generation assets and demand response technologies leading to lower supply costs. This will benefit consumers as reduced wholesale electricity costs flow through to lower retail prices.

Data shows that the differences between five minute dispatch prices and 30 minute settlement prices has become greater over the past few years, with the largest differences observed in South Australia and Queensland. The distortion due to 30 minute settlement is expected to increase in the future; hence the benefits of the improved price signal under five minute settlement are likely to become greater over time. The Commission expects that it will result in materially more efficient operation and investment decisions relative to 30 minute settlement.

Effects of five minute settlement on hedging and risk management

Market participants and intermediaries enter into contracts external to the NEM physical market to manage the risks associated with volatile demand and supply conditions and hence wholesale spot prices. The contract market plays a crucial role in reducing price uncertainty for generators, retailers, major industry and consumers of electricity. It allows generators to manage risk, secure finance and provides signals for on-going investment in generation capacity. Contracts enable generators to receive payments for having capacity available, even when they are not providing energy to the market. For retailers, contracts provide the wholesale purchase cost stability necessary to deliver price stability for consumers, and allows them to secure financing for their own operations.

Given the importance of liquidity in the contract market, it is vital that disruption is minimised. The Commission would be concerned if five minute settlement adversely affected the ability of market participants to manage risk through these contracts. In particular, concerns have been raised that five minute settlement would potentially result in a reduction in the supply of 'cap' contracts, a risk management product. Retailers and large energy users use caps as protection against high spot prices, and to underpin the finance of much of the existing fast response generation technology. Stakeholders have indicated uncertainty as to whether gas peaking generators will be able to defend contracts and offer the same contract volume the market. This could damage competition in the retail market and lead to higher prices for consumers.

The Commission acknowledges there are potentially risks to the contract market associated with moving to five minute settlement. However, analysis suggests that five minute settlement will still allow for hedging and risk management. The Commission's view is that participants will be able to effectively manage wholesale market risks and generators will have strong incentives to continue selling the same, or similar, contracts to what they currently offer.

To the extent that there is a reduction in contract volumes from existing peaking generators, there appear to be a range of alternatives risk management options available that could be developed given sufficient lead time. These include new and emerging storage and demand response technologies that can be utilised to achieve similar risk management outcomes. Other potential sellers of 'cap' contracts include thermal generators and financial intermediaries.

Effects of five minute settlement on system security and reliability

Some stakeholders raised concerns that the rule, if made, would:

- encourage greater volumes of fast ramping capability (e.g. batteries) that is invisible to the Australian Energy Market Operator (AEMO), making it harder for AEMO to manage system security
- impact the ability of gas peaking generator to offer caps and remain financially viable, causing them to exit the market, reducing both system security and reliability.

The Commission recognises there are potential risks to system security and reliability with the introduction of five minute settlement. However, given the large amount of work currently being undertaken to address system security and reliability issues, and the developments in the market, the Commission is satisfied that there is no direct threat to system security or reliability from making the rule change. In particular:

- Work is underway exploring the creation of a market for the supply of inertia services – this may in future offer additional revenue streams to support existing synchronous generation.

- Work is also underway examining changes that will promote the effective and efficient integration of technologies offering fast frequency response into the NEM. AEMO recently published changes to its exemption and classification guideline to require storage facilities larger than 5 MW to be classified as scheduled loads.

- Recent gas generation and energy storage commitments and investment decisions highlight the speed with which new technologies can be implemented in the face of emerging supply shortfalls.

Additionally, if the Commission makes a final rule that reflects the draft rule, the transition period of three years and seven months prior to five minute settlement commencing will provide time for system security issues to be further addressed or resolved.

Implementation

The Commission's position is that the contribution of five minute settlement to achieving the national electricity objective (NEO) and its benefits will be maximised by:

- having mandatory five minute settlement for all wholesale market participants, rather than optional demand side participation in five minute settlement on a permanent basis

- using revenue metering data, rather than supervisory control and data acquisition (SCADA) data, which while involving lower implementation costs, are less accurate and not widely available for all market participants.

The draft rule reflects this position and its key features are as follows:

- If the Commission makes a final rule that reflects the draft rule, it will commence on Thursday, 1 July 2021. This would be a transition period of three years and seven months.

- Five minute settlement is implemented in the NEM by amending the definition of a trading interval from a 30 minute period to a 5 minute period. Bidding and offering into the NEM, the online dispatch process, settlement, intervention pricing, the calculation of trading amounts, the calculation of the cumulative price threshold, and periodic energy metering are done on a 5 minute trading interval basis.

- The provisions applicable to spot price determination are amended so that a spot price is now determined for each five minute trading interval. The spot price is no longer the time-weighted averaging of dispatch prices across a 30 minute timeframe.

- A new definition of 30 minute period is created to be a 30 minute period ending on the hour or on the half-hour, and comprising six consecutive trading intervals. This new definition is applied to provisions in the national electricity rules (NER) which should continue to operate on a 30 minute basis. For example, in relation to the projected assessment of system adequacy (PASA) processes, AEMO is required to prepare and publish information for each 30 minute period. AEMO is also required to calculate and publish 30 minute spot prices (calculated in the same way that the current spot price is calculated).

- Types 1, 2 and 3 meters will need to record and store five minute data from the commencement date of the rule.

- Type 4 meters at a transmission network connection point or distribution network connection point where the relevant financially responsible Market Participant is a Market Generator or Small Generation Aggregator will need to record and store five minute data from the commencement date of the rule.

- The draft rule does *not* require all other types 4, 5 and 6 meters that are already installed to provide five minute data at the commencement date. The data from these meters will be profiled to five minute trading intervals by AEMO using net system load profiles.

- From 1 December 2018, all new and replacement type 4 metering installations will need to record and store five minute data.

- Existing meters that generate five minute data are prevented from being replaced with a meter of a lower functionality.

- AEMO can exempt a Metering Provider from complying with the data *storage* requirements for types 1, 2, 3, and 4 metering installations installed prior to 1 July 2021 where it is reasonably satisfied that the Metering Provider will be able to otherwise meet the requirements of the NER.

During the transition period, NEM participants will update metering (if required) and information technology (IT) systems to implement five minute settlement. It is also expected that most existing hedging contracts will have rolled off and new contracts will accommodate a future implementation of five minute settlement. AEMO will update its systems during this time and is expected to provide a test environment for participants to trial five minute bidding and five minute settlement.

Costs and challenges of implementing five minute settlement

The 30 minute settlement arrangements have been in place for nearly two decades. All existing IT systems, metering infrastructure, and financial contracts have been designed with reference to 30 minute settlement. Consequently, there will be significant practical challenges and risks associated with implementing five minute settlement, non-trivial one-off costs, and some ongoing costs.

The Commission acknowledges the concerns of market participants in relation to both the magnitude of the costs and the timeliness within which the required changes to support the implementation of five minute settlement can be made. These arise from the upgrades required to IT systems and metering, and the disruption to current contract arrangements. The one-off disruption to contracts and potential need for renegotiation is separate to the potential structural issue related to the impact of five minute settlement on the cap contract market.

The implementation of five minute settlement will result in what are largely significant one-off costs. While these costs appear large, they are relatively small when compared with the ongoing annual NEM transactions, which were $16.6 billion in 2016/17, and the expected medium term generation investment of up to $90 billion required in the NEM over the medium term. Given the size of these transactions and the enduring nature of the benefits of adopting five minute settlement, only minor operational and investment changes arising from the improved price signal is required to outweigh the implementation costs. For example, if improved price signals resulted in as little as a $0.50/MWh reduction in average wholesale prices, this would represent a nearly $100 million per year saving in energy costs, resulting in lower retail prices for consumers.

The view of the Commission is that the enduring benefits of the proposed rule change to align dispatch and settlement at five minutes will quickly outweigh the one-off and any ongoing costs. It will therefore contribute to the achievement of the NEO by promoting the efficient operation and use of, and investment in electricity services for the long term interests of consumers.

To address concerns raised about the costs and risks of implementation, the draft rule has set a transition period of three years and seven months. This reflects the shortest time that the Commission believes is possible to enable market participants and AEMO to manage the significant implementation issues, such as the large IT system changes. If the Commission makes a final rule that reflects the draft rule, it is recommended that market participants begin implementation as soon as possible. The transition period also provides a timeframe within which new generation could be built if required, and solutions to system security and reliability issues are likely to be developed.

Consultation

The Commission welcomes submissions on this draft determination and the more preferable draft rule by **17 October 2017**. There will be limited capacity to accommodate late submissions.

Contents

1 Sun Metals' rule change request

1.1 The rule change request

On 4 December 2015, Sun Metals submitted a rule change request to the Australian Energy Market Commission (AEMC). The rule change request seeks to amend the national electricity rules (NER) to address the mismatch between the time intervals for operational dispatch and financial settlement in the national electricity market (NEM).

1.1.1 Rationale for the rule change request

Sun Metals submitted that the mismatch between the dispatch and settlement intervals leads to inefficiencies in the operation and generation mix of the market. Specifically, this aspect of the market design:

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

Sun Metals noted that batteries, some loads and some transmission systems are capable of responding in a single five minute dispatch interval. It submitted that the capability of these technologies is not appropriately recompensed under the current arrangements and will therefore not be properly utilised.

Sun Metals provided two examples in support of its view that there is little incentive for fast response technologies to enter the market. These are summarised as follows:

- A fast start generator being dispatched for one dispatch interval in response to a high five minute price. Through averaging, the 30 minute average price received by the generator would be less than the five minute price at the time that the generator was producing.
- Loads, such as Sun Metals, having to restrict consumption over the whole 30 minute trading interval, to avoid high price events that may only last for a single five minute dispatch interval. This may be more disruptive for a load than a five minute response.

Sun Metals submitted that the average price may not be sufficient for investment in fast start generation, or for the operation of existing generation capacity. It also considered that the requirement for it to reduce consumption for a full half hour is disproportionately disruptive to the production of zinc and its associated economic benefit.

1.1.2 Solution proposed in the rule change request

To address the issues identified, Sun Metals proposed a five minute settlement regime which is compulsory for generators,[1] scheduled loads and market network service providers (MNSPs), and optional for other wholesale market participants.

Generators, scheduled loads and MNSPs would be settled on a five minute basis using:

- existing five minute prices calculated by AEMO; and
- energy from existing revenue meters, allocated to the five minute periods within a half hour using operational data from supervisory control and data acquisition (SCADA) systems.

SCADA systems are used to monitor and control industrial process, such as power station generating units.[2]

Sun Metals proposed that other wholesale market participants, including retailers and large consumers, could choose to be settled on either a five or 30 minute basis. All participants may choose, at their own cost, to install metering equipment capable of accurately measuring energy on a five minute basis.

Under Sun Metals' proposal, five minute settlement would be optional for non-scheduled loads. Therefore AEMO would need to operate concurrent five and 30 minute settlement for different participants. This arrangement would create an imbalance between the money earned by supply side participants settled on a five minute basis and the money paid by demand side participants, who could be settled on either a five or 30 minute basis.

Sun Metals proposed a new mechanism to correct the imbalance. The imbalance amount, which could be positive or negative, would be recovered entirely from those demand side participants who continue to be settled on a 30 minute basis.

The rule change request did not include a proposed rule, but noted that changes to Chapter 3 of the NER would be necessary to implement the proposed solution.

1.2 Current arrangements

This section provides an explanation of the existing arrangements for dispatch, settlement, financial markets, metering and IT systems.

1 The five minute settlement regime would be compulsory for scheduled, semi-scheduled and non-scheduled market generators that sell electricity into the spot market at the spot price.

2 The proposed use of SCADA data and the differences between SCADA and existing metering for revenue purposes are discussed in section 5.2.1 of the consultation paper and section 2.2 of the December 2016 working group paper.

1.2.1 Dispatch

The NEM dispatch interval is currently five minutes.[3]

The Australian Energy Market Operator (AEMO) balances instantaneous supply and demand through:

- a central dispatch algorithm that is run for every dispatch interval
- ancillary service markets that correct for deviations within dispatch intervals.

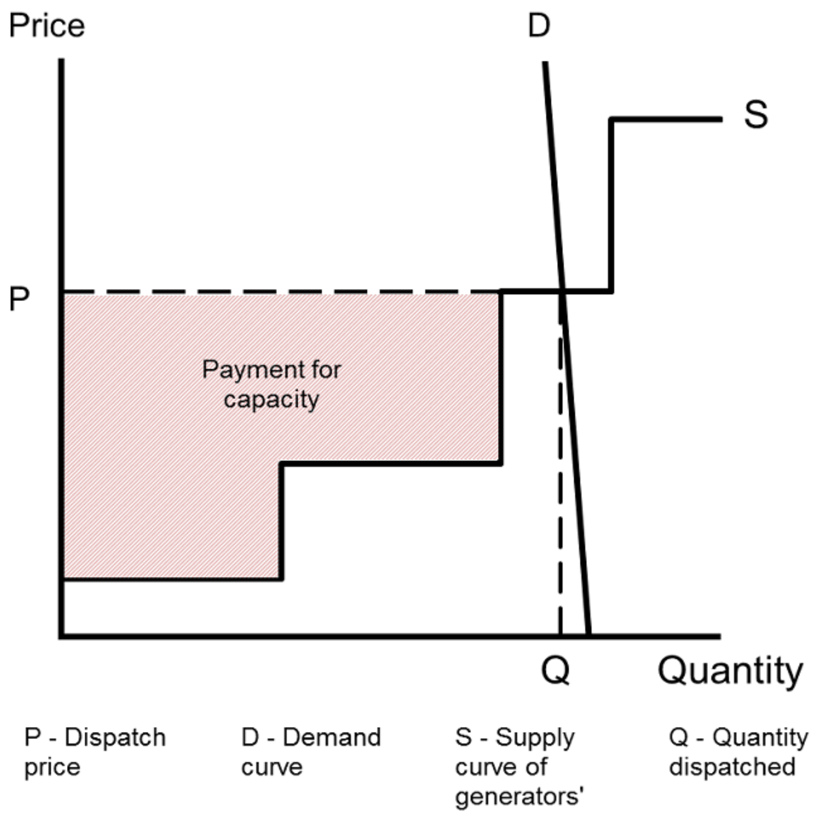
Scheduled and semi-scheduled generators, scheduled loads and MNSPs submit bids or offers to AEMO, signalling their willingness to generate, consume or transport electricity. Currently, bids and offers are submitted in 30 minute blocks. A generator may revise its offer up until the start of the relevant dispatch interval through rebids to shift the quantities of electricity offered between different price bands.

The central dispatch algorithm orders generators' offers from least to most expensive to determine which participants to dispatch to meet expected demand for electricity in each five minute period. Generators that have their bid accepted are generally paid the price of the highest bidder that was dispatched for the dispatch interval. This provides an incentive to generators to bid in at their short run marginal cost of generation, or the marginal cost of the generator that they expect to be next in the bid stack. This process is depicted in Figure 1.1.

The stepped supply curve in Figure 1.1 represents the quantity of capacity, Q, that generators are willing to provide to the market at nominated prices, P. Assuming that generators bid in at, or near, their short-run marginal cost, the gap between the price, P, and the supply curve, S, represented by the shaded area in Figure 1.1, is the effective payment for generation capacity. That is, prices above the short run marginal cost allow a generator over time to recover the capital costs associated with the significant investment in generation capacity.

3 NER, c. 3.8.21(a1)

Figure 1.1 Stylised process of setting dispatch price



1.2.2 Settlement

The settlement process involves:

- generators being paid for the energy they supply to the NEM
- retailers being billed for the energy they purchase on behalf of consumers
- wholesale customers being billed for the energy they purchase directly from the pool.

While currently a dispatch price is determined for each five minute dispatch interval, settlement is calculated on a 30 minute basis. The settlement price is the time-weighted average of the six dispatch prices that occurred during any given half-hour trading interval.[4] Participants are settled on the basis of the half hourly settlement price and their aggregate production or consumption during the respective half hour.

The 30 minute settlement interval reflects limitations in the technology available in the 1990s. It was acknowledged that a five minute settlement interval would be efficient, however it was thought to require significant additional computational resources to

4 Where the dispatch price is represented by D1 for 12:05pm, D2 for 12:10pm, et cetera, and the settlement price for 12:30pm by S, S = (D1+D2+D3+D4+D5+D6) / 6.

implement, and metering equipment was not sophisticated enough to handle any finer detail than half hourly pricing.[5]

1.2.3 Forward contracting

As a gross pool market, all electricity generation and consumption in the NEM is settled through the wholesale market at the spot price. Importantly, spot prices provide the basis for forward contracting to manage risk.

The contract market plays a crucial role in allowing parties to manage their exposure to price volatility and uncertainty associated with the wholesale spot market outcomes. Generators have an incentive to enter into contracts that fix price above their short run marginal cost to increase the likelihood of recovering their capital costs. This highlights that in the NEM, generation capacity is effectively paid for through contracts.

Forward contracting provides a market-based mechanism to support efficient investment over time in generation capacity. It enables generators to obtain a degree of revenue certainty and secure project finance. Retailers are able to deliver price stability for consumers and secure financing for their own operations.

There are different types of hedge contracts that can provide greater price certainty. Generators and consumers in the same market region are well suited to contract with each other since, for a fixed volume of energy, the costs incurred by consumers are inversely related to the returns to generators. In the most simple form of forward contracting, a consumer and a generator may enter into contracts to:

- agree a fixed price for a specified volume of energy (known as a ‘swap’ contract), or
- limit the price to which the consumer can be exposed (known as a ‘cap’ contract).

1.2.4 Metering and IT systems

When settling the market, AEMO currently takes account of the 30 minute price and the aggregate production or consumption of individual participants during each half hour. The latter is provided by metering equipment, which is installed at the connection points of individual participants. Consistent with the 30 minute settlement interval, metering data is provided to AEMO for each 30 minute period or is determined by AEMO via a profiling process.

In accordance with s. 7.3.4 and Schedule 7.2 of the National Electricity Rules (NER), metering installations must comply with the National Measurement Act and applicable specifications or guidelines specified by the National Measurement Institute. Under the Act, it is an offence to use a revenue meter in such a way that it gives an inaccurate measurement, or tamper with a revenue meter, causing it to give inaccurate information.

5 ACCC, *Applications for authorisation - National Electricity Code*, 10 December 1997, p. 60.

Many modern interval meters are already capable of measuring energy at intervals shorter than 30 minutes.

Rule 7.3.1(a)(10) of the NER requires interval meters to locally store 35 days' worth of data.[6] Interval meters typically have significantly more data storage capacity than is required for 35 days of history. The extra space is used for discretionary features, such as multi-part tariffs, calendars and power quality.

1.3 The rule making process

On 19 May 2016, the Commission published a notice advising of its commencement of the rule making process and consultation in respect of the rule change request.[7] A consultation paper identifying specific issues for consultation was also published. Submissions to the consultation paper closed on 16 June 2016. The Commission received 29 submissions as part of the first round of consultation.

In June 2016, having considered the submissions it received in response to its consultation paper, the Commission identified that the rule change request raised multiple issues that were sufficiently complex that it would be necessary to extend the timeframes for making a draft determination in relation to this project. Accordingly, in July 2016 the Commission extended the time for making the draft determination by seven months, under section 107 of the National Electricity Law (NEL).

To inform its work on the rule change, the Commission established a working group comprising of generators, retailers, industrial and residential consumers, new technology companies, financial institutions, a community group and market institutions. The working group met once in September 2016 and once in December 2016. Two working papers were prepared to stimulate discussion at the meetings, and these papers have been published.

On 24 January 2017, the Commission decided to further extend the period of time for the making of a draft determination to 6 July 2017 to allow for additional consultation and analysis to be undertaken by the Commission. As part of the consultation the Commission, on 11 April 2017, published a directions paper. This provided more detail on the design of a potential five minute settlement regime and the Commission's preliminary assessment on the cost and benefits of a move to five minute settlement. This additional detail had been requested by a number of stakeholders to enable them to more accurately assess the impacts to them. The Commission held a public forum to discuss the directions paper on 4 May 2017 in Sydney. Submissions to the directions paper closed on 18 May 2017. The Commission received 43 submissions as part of the second round of consultation. Around half the submissions were submitted late, with a number of submissions received in mid to late June.

6 The 35-day requirement is for meter types 1, 2, 3 and 4. Type 5 meters are interval meters but are required to locally store 200 days' worth of data because they are manually read.

7 This notice was published under section. 95 of the National Electricity Law (NEL).

On 4 July 2017, the Commission gave notice of another extension under section 107 of the National Electricity Law, to 5 September 2017. This was in order to consider substantive new matters raised by stakeholders in their submissions to the directions paper.

In making this draft rule determination, the Commission has considered all issues raised by stakeholders in the first and second round of submissions, and at the public forum. Issues raised in submissions are discussed and responded to throughout this draft rule determination.

Issues that are not addressed in the body of this document are set out and addressed in Appendix A.

1.4 Structure of the draft rule determination

This draft rule determination is set out as follows:

- Chapter 2 provides an overview of the Commission's draft rule determination, including its assessment framework and summary of reasons for making the draft rule. It also sets out the key features of the draft rule
- Chapter 3 identifies the in-principle benefits of five minute settlement
- Chapter 4 analyses the potential effect of five minute settlement on hedging and risk management
- Chapter 5 assesses any system security and reliability impacts from five minute settlement
- Chapter 6 sets out the reasons for the Commission's policy settings required to implement five minute settlement, including mandatory five minute settlement for both supply and demand side, metering, bidding and pre-dispatch
- Chapter 7 considers whether an appropriate transition period could mitigate the costs and risks of introducing five minute settlement
- Appendix A provides the Commission's response to stakeholder comments that are not addressed elsewhere in the draft rule determination
- Appendix B sets out the relevant legal requirements under the NEL for the Commission to make this draft rule determination
- Appendix C provides supplementary material for Chapter 4.

1.5 Consultation on draft rule determination

The Commission invites submissions on this draft rule determination, and accompanying more preferable draft rule, by 17 October 2017. There will be limited capacity to accommodate late submissions.

Any person or body may request that the Commission hold a hearing in relation to the draft rule determination. Any request for a hearing must be made in writing and must be received by the Commission no later than 12 September 2017.

Submissions and requests for a hearing should quote project number "ERC0201" and may be lodged online at www.aemc.gov.au or by mail to:

Australian Energy Market Commission
PO Box A2449
SYDNEY SOUTH NSW 1235

2 Draft rule determination

The Commission's draft rule determination is to make a draft rule that is a more preferable draft rule. The more preferable draft rule aligns operational dispatch and financial settlement at five minutes by reducing the time interval for financial settlement in the NEM from 30 minutes to five minutes. The draft rule also:

- changes the resolution for bidding and offering into the NEM from a 30 minute to a 5 minute trading interval basis
- sets out the metering requirements needed to provide five minute resolution data for settlement, and
- provides for a transition period to implement the changes necessary to achieve five minute settlement and reduce the costs of the change.

This chapter outlines:

- the key features of the draft rule
- the rule making test for changes to the NER
- the more preferable rule making test
- the assessment framework for considering the rule change request
- the Commission's consideration of the draft rule against the national electricity objective.

Further information on the legal requirements for making this draft rule determination is set out in Appendix B.

2.1 The Commission's draft rule determination

The more preferable draft rule made by the Commission is attached to and published with this draft rule determination. If the Commission makes a final rule that reflects the draft rule, it will commence on Thursday, 1 July 2021. The key features of the draft rule are set out below. The draft rule:

Implementation of five minute settlement:

- Implements five minute settlement in the NEM by amending the definition of a trading interval from a 30 minute period ending on the hour or half hour, to a 5 minute period ending on the hour and each continuous period of five minutes thereafter. Bidding and offering into the NEM, the online dispatch process, settlement, intervention pricing, the calculation of trading amounts, the calculation of the cumulative price threshold, and periodic energy metering are now all done on a 5 minute trading interval basis.

- Amends the provisions applicable to *spot price* determination so that a *spot price* is now determined for each five minute *trading interval*. The spot price is no longer the time-weighted averaging of dispatch prices across a 30 minute timeframe.

- Removes the definition of *dispatch price*. Amending the trading intervals to be a five minute period, and changing the meaning of *spot price* causes the dispatch price to become the same as the *spot price*. Only one definition is required.

- Removes the definition of *dispatch interval*. This is because a *trading interval* becomes equivalent to a dispatch interval and only one definition is required. Therefore the draft rule replaces instances where '*dispatch interval*' is used in the NER that relate to areas that need to operate on a five minute basis with '*trading interval*'. For example, in relation to generating unit offers in clause 3.8.6 of the NER, *dispatch offers* will now be made in relation to each of the 288 (instead of 48) trading intervals in the trading day.

Forecasting, monitoring, reporting and compliance

- Creates a new definition of *30-minute period* as being a 30 minute period ending on the hour or on the half-hour, and comprising six consecutive trading intervals. This new definition is applied to provisions in the NER which should continue to operate on a 30 minute basis, and should not be done on a trading interval basis. For example, in relation to the PASA processes, AEMO is required to prepare and publish information for each 30 minute period.

- Introduces a requirement that the pre-dispatch schedule published by AEMO (which covers each trading interval commencing from the next trading interval after the current one up to and including the final trading interval of the last trading day for which bids and offers have been received in accordance with the timetable) is to have two resolutions. One will be for a 30 minute period, and one for a five minute period. The five minute period will only be in relation to the 60 minute period before the time that the relevant pre dispatch schedule is published by AEMO.

- Introduces an obligation on AEMO to publish a 30 minute price (calculated in the same way that the current spot price is calculated) for a *regional reference node* for each *30-minute period* in addition to publishing the *spot price* for each *regional reference node*.

- Changes the *late rebidding period* from 15 minutes to 30 minutes before the start of each five minute trading interval. This provides the Australian Energy RegulatorAER with a similar period of time compared to the current period for which the AER can request contemporaneous records in relation to the late rebid.

- Maintains the $5,000/MWh price threshold over which the AER reports on high price events, but applies this threshold to the average spot price over rolling 30 minute periods rather than to a *trading interval*.

Metering:

- Requires the *Metering Provider* to ensure that type 1, 2 and 3 *metering installations* prepare and record five minute interval data from the commencement date.
- Requires the *Metering Provider* to ensure that any type 4 *metering installations* at a *transmission network connection point* or *distribution network connection point* where the relevant *financially responsible Market Participant* is a *Market Generator* or *Small Generation Aggregator* prepare and record five minute data from the commencement date.
- Introduces an obligation on the *Metering Coordinator* at a connection point to ensure that all new and replacement *metering installations* prepare and record five minute data.
- Prevents existing meters that generate five minute data from being replaced with a meter of a lower functionality.
- Enables AEMO to profile 30 minute interval data from some type 4 *metering installations* and type 5 *metering installations* into five minute *trading intervals* in accordance with the metrology procedure.
- Empowers AEMO to exempt a *Metering Provider* from complying with the data storage requirements for types 1, 2, 3, and 4 *metering installations* installed prior to 1 July 2021 where it is reasonably satisfied that the Metering Provider will be able to otherwise meet the requirements of the NER.

Transitional rules:

- Introduces an obligation on AEMO to amend and publish its relevant procedures to apply from the commencement date by 1 December 2020.
- Introduces an obligation on the AER to amend and publish its relevant procedures to apply from the commencement date by 1 December 2020.
- Exempts type 4 *metering installations* installed prior to 1 December 2018 from providing five minute data until they are replaced.
- Requires new or replaced type 4 *metering installations* to prepare and record five minute data from 1 December 2018.
- Introduces an obligation on AEMO to publish a procedure setting out the requirements for applying for an exemption from complying with the data storage requirements for types 1, 2, 3, and 4 *metering installations* installed prior to 1 July 2021 by 1 December 2020.
- Provides for default offers and bids submitted to AEMO prior to the commencement date to be deemed to be six equal offers or bids submitted in respect of the six consecutive *trading intervals* within the relevant *30-minute period* until such time as the offer or bid is resubmitted.

2.2 Rule making test

2.2.1 Achieving the national electricity objective

The Commission may only make a rule if it is satisfied that the rule will, or is likely to, contribute to the achievement of the national electricity objective (NEO).[8] This is the decision making framework that the Commission must apply.

The NEO is:[9]

> "to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:
>
> (a) price, quality, safety, reliability and security of supply of electricity; and
>
> (b) the reliability, safety and security of the national electricity system."

2.2.2 Making a more preferable rule

Under section 91A of the NEL, the Commission may make a rule that is different (including materially different) to a proposed rule (a more preferable rule) if it is satisfied that, having regard to the issue or issues raised in the rule change request, the more preferable rule will or is likely to better contribute to the achievement of the NEO.

Having regard to the issues raised in the rule change request and during consultation, the Commission is satisfied that the more preferable draft rule will, or is likely to, better contribute to the achievement of the NEO for the following reasons:

- the draft rule requires mandatory five minute settlement for all wholesale market participants, rather than optional demand side participation as proposed by Sun Metals in its rule change request. This approach is more efficient because it:
  - strengthens the long term incentives to respond to the physical requirements of the power system
  - prevents the creation of a new settlement residue from the misalignment of generators being settled on a five minute basis and load being settled on a 30 minute basis
  - minimises administrative burden and complexity

8 Section 88 of the NEL.

9 Section 7 of the NEL.

- the draft rule prescribes that revenue metering data should be used rather than SCADA data as proposed by Sun Metals. This is because revenue metering data is more accurate and is widely available.

2.3 Assessment framework

In assessing the rule change request against the NEO the Commission has considered the following principles:

- **Prices that reflect the marginal cost of supply and value of its use.** To promote efficient outcomes in the electricity market, spot prices should generally reflect the marginal cost of supply and value of consuming electricity. When supply and or demand conditions change frequently, a shorter settlement interval is likely to lead to prices that more accurately reflect the value of supplying or consuming electricity at different times.

- **Valuing generation and demand response flexibility.** Price signals also signal the physical value of when a demand or supply response is needed by the power system. They should enable the market to deliver enough generation or demand response to meet the demand and supply balance at the time when it is physically needed by the power system. Correct price signals will also facilitate investment decisions into the right kind of technology to respond flexibly.

- **Technology neutral:** Arrangements should be designed to take into account the full range of potential market and network solutions. They should not be targeted at a particular technology, or be designed with a particular set of technologies in mind. Technologies are changing rapidly and, to the extent possible, a change in technology should not require a change in arrangements. The design of the market should enable the market to choose the least cost technology for supply or the technology that is most valued by consumers. Technology neutrality is therefore important in that it enables an efficient mix of generation and consumption market responses in the short term and an optimum mix of supply side and demand side investment in the longer term. This minimises the costs of supply over time.

- **Management of price risk exposure.** All electricity generated and consumed in the NEM is transacted at the spot price. Generators can physically manage their exposure through bidding at or above the cost of supply, so as to avoid being dispatched if losses would be incurred. The mismatch between dispatch and settlement may create undue risks for participants, as the ability of participants to respond to changes in the market (via the dispatch process) is not well aligned with financial outcomes (settlement). Aligning dispatch and settlement would improve the ability of market participants to manage their price risk exposure.

- **Efficient risk allocation via contracting.** Participants can financially manage their exposure to spot prices by entering into contractual agreements that provide greater price certainty. These arrangements can involve the buyer of a contract paying the seller to take on some or all of the price risk to which the buyer is exposed. While these arrangements occur outside of the NEM, hedge contracts play a significant role in allowing participants to manage wholesale market volatility and creating incentives for the efficient operation of and investment in generation capacity. The Commission acknowledges that changes to the NEM market design would impact on the incentives for participants to buy and sell hedging contracts.

- **Supply and demand side competition.** A more accurate NEM spot price may provide clear incentives for demand side participation, such as consumers deciding to curtail consumption, delay consumption, or install their own generation capacity. These responses have the potential to reduce price spikes and average prices. More accurate spot prices may also encourage efficient supply side competition with generators entering the market that are able to take advantage of spot price variability or existing participants investing in additional flexibility.

- **Regulatory and administrative burden.** The costs associated with the proposed changes would involve once-off costs associated with the transition and potential on-going costs associated with the new regime.

2.4 Summary of reasons

As described in more detail in Chapter 3, the Commission considers that the draft rule provides a number of benefits relative to current market arrangements. The key benefits of the draft rules can be summarised as follows:

- **Improved price signals for more efficient generation and use of electricity.** As a result of five minute settlement, wholesale spot prices will more accurately reflect the operating costs of supplying and benefits of consuming electricity. Prices will be more aligned with the physical supply and demand conditions in the market. This improved efficiency is likely to manifest in reduced wholesale market costs, putting downward pressure on the wholesale cost components of consumers' electricity bills. Wholesale costs currently account for just under a third of the customers' bills.

- **Improved bidding incentives.** Five minute settlement removes the potential for the 30 minute trading interval to play a coordination role in generators' bidding strategies. Evidence suggests that, at times, generators' bidding behaviours lead to high price events and artificially increased price volatility that cannot be explained by the underlying physical condition of the market. These price events invite generation and consumption patterns where market participants 'pile in' to take advantage of the high prices. Given that these price events and subsequent generation and consumption decisions are independent of the power system's need, they are inefficient. Five minute settlement will better align generator's bidding strategies with the efficient outcome of the market. Reduced incentives to induce high prices and volatility is likely to lead to reduced hedging costs for retailers and will lead to reduced costs for consumers.

- **More efficient demand side participation.** Five minute settlement will sharpen the price signals for demand response and align the timing of such response with the physical need of the power system. Given that the majority of the demand side currently does not participate in central dispatch, providing more accurate signals regarding the timing of the need for demand response is crucial. Five minute settlement will better ensure that demand response occurs within the dispatch interval when it is needed and consumers are appropriately rewarded for their ability and willingness to provide the service. More targeted demand response is expected to put a direct downward pressure on wholesale prices.

- **More efficient signals for investment in capacity.** The expectations around the spot price form the basis on which contracts are entered into for the supply of quantities of electricity. Contracts also provide the basis for which generators invest in capacity. As five minute settlement provides an improved wholesale price signal, this will result in more efficient investment in generation capacity and also demand response technologies. In particular, investment in more flexible generation capacity and demand response technologies, that can respond within the five minute interval when it is needed by the power system.

- **More efficient signals of the value of generation and demand side flexibility to balance supply and demand.** Five minute settlement will provide more granular information about the need to balance supply and demand at short time interval, which is particularly important in the context of the rapid technological change taking place in the NEM. Due to the penetration of intermittent generators, there is already a greater physical variation on the supply side. With the introduction of competition in metering, and the increasing penetration of behind the meter distributed energy resources, further physical variation is expected on the demand side. Consequently, the value provided by technologies that are capable of short term supply-demand balancing is expected to increase. Ensuring the electricity market signals the need for and rewards the provision of flexible technology is of paramount importance. Five minute settlement provides an improved, stronger financial signal for flexible generation technologies when compared with 30 minute settlement.

- **Reduced barriers to entry for new technology.** There is already some level of investment in fast response technology – such as aggregating distributed battery storage, next generation gas peaking plants and faster start demand response. Five minute settlement will enable efficient investment to be directed towards generation and demand side technologies that represent the optimal path to balance supply and demand over time. The capital costs of new technologies – such as utility-scale battery storage – have been decreasing and investors' expectation of wholesale market revenues are increasingly becoming a key decisive factor in their uptake. In this context, it is important that the market design features such as settlement processes do not inadvertently create artificial barriers for efficient new generation and demand response technologies to enter the market.

- **Technology neutrality.** Fast response, flexible generators can more easily align their generation output with the physical needs of the market and generate at times when prices are high. Thirty minute settlement pricing mutes their incentives to do so. Some of the revenues they could earn under five minute pricing is redistributed to less flexible generators that take advantage of the price event after it has happened and cannot respond at the time it is needed by the power system. The consequence is that 30 minute settlement rewards slower, less flexible technologies at the expense of more flexible alternatives that are able to deliver the response when it is required. Five minute pricing better aligns generators' financial rewards and the value their technologies deliver to the market. Over time, five minute settlement will result in a more efficient generation mix where customers will ultimately pay less for electricity than under 30 minute settlement.

The key benefits described demonstrate a strong efficiency argument for the alignment of the dispatch and settlement periods at five minutes. There are now new technologies emerging and rolling out commercially in much shorter timeframes. The need for efficient price signals is becoming increasingly important in the NEM as it is faced with, for example, age-based retirements, and increasing levels of generation and demand side participation by consumers. Price signals will directly influence the type of technology installed, and the scale and location of investments responding to changing power system conditions. In this environment, the materiality of the problem of 30 minute settlement will be greater. Conversely, the benefits of aligning dispatch and settlement at five minutes and providing an improved price signal, will be more significant.

The Commission acknowledges there are potential risks to the contract market associated with moving to five minute settlement. However, analysis done suggests that five minute settlement will still allow for satisfactory hedging and risk management outcomes (see chapter 4). The Commission's view is that participants will be able to effectively manage wholesale market risks and generators will have strong incentives to continue selling the same, or similar, contracts to what they currently offer.

The Commission recognises there are potential risks to system security and reliability with the introduction of five minute settlement from impacts on existing peaking generators and the increased uptake of fast ramping technologies (see chapter 5). However, given the large amount of work currently being undertaken to address system security and reliability issues, and the developments in the market, the Commission is satisfied that there is no direct threat to system security or reliability from making the rule change.

Implementing five minute settlement will involve large changes to existing arrangements, given that 30 minute settlement has been in place for nearly two decades. There will significant practical challenges and large one-off costs incurred due to the changes required to financial contracts, metering and IT systems (see chapter 7). These costs though appear small when compared with the benefits derived from even a small improvement in efficiency in the annual NEM transaction process and future investment in the sector. The view of the Commission is that the enduring benefits from the proposed rule change to align dispatch and settlement at five minutes will quickly outweigh the largely one-off costs. It will therefore contribute to the achievement of the NEO, and promote the efficient operation and use and investment in electricity services for the long term interests of consumers. The Commission is also of the view that a three year and seven month transition period is required to mitigate the costs and risks associated with implementation. This reflects the shortest time that the Commission believes is possible to enable market participants and AEMO to manage the significant implementation risks.

2.5 Strategic priority

This rule change request relates to the AEMC's strategic priority relating to markets and networks.[10]

This strategic priority relates to the flexibility and resilience of energy market frameworks to respond to changes in technology and new business models. Given the changes in technology, and the emergence of new business models, energy market arrangements need to be flexible and resilient enough to respond to this change. The need for efficient price signals, such as improved price signals from the alignment of the dispatch and settlement periods, becomes increasingly important in the NEM as large synchronous generators retire and levels of generation and demand side participation by consumers increase.

10 AEMC, *Strategic priorities*, available at: http://www.aemc.gov.au/Major-Pages/Strategic-priorities

3 Benefits of five minute settlement

This chapter explores the theoretical and practical benefits from a move to five minute settlement. It considers the potential benefits from five minute settlement on the efficiency of operation and consumption decisions, reducing barriers to demand side participation, improving innovation and investment decisions, valuing demand and supply side flexibility, and maintaining technology neutrality.

3.1 Sun Metals' view

Sun Metals was of the view that the current arrangements:

- accentuate strategic late rebidding, where generators have been observed to withdraw generation capacity in order to influence price outcomes
- impede market entry for fast response generation and demand side response.

In providing this view, Sun Metals did not undertake any analysis or quantification of the materiality of the problem associated with the existing 30 minute settlement framework, nor the benefit of moving to five minute settlement.

3.2 Stakeholder views

The majority of the submissions to both the consultation paper and directions paper broadly acknowledged that there was a theoretical problem with having a misalignment between the dispatch and settlement periods.[11] CS Energy, ENGIE, ERM Power and Origin Energy noted that as dispatch and settlement timing nears being instantaneous, the market would be increasingly efficient, however the technical, physical and economic costs of achieving this outcome needed to be recognised.[12] Many of those who expressed support for the theory behind five minute settlement also indicated strong opposition to the change going ahead.[13]

Stakeholders submissions commented on potential benefits in terms of improved investment signals, valuing flexibility, demand side response incentives, technology neutrality and bidding incentives. These views are summarised below.

Investment signals

There was also wide recognition among stakeholders that a move to five minute settlement would provide stronger investment signals for new and emerging

11 Consultation paper submissions: Australian Energy Storage Alliance, p. 4; The Australia Institute, p. 2; Clean Energy Council, p. 3; Ecoult, p. 4; Genex Power, p. 1; Melbourne Energy Institute, p. 8; Reposit Power, p. 1; UnitingCare Australia, p.10; Wärtsilä, p. 9; ZEN Energy, p. 2. and Directions paper submissions: AEMO, p. 2.; ENA, p.1; EnergyAustralia, p. 1.

12 Consultation paper submissions: CS Energy, p.1.; ENGIE, pp. 2-3; ERM Power, p. 4; Origin Energy, p. 1.

13 E.g. Directions paper submissions: Energy Queensland, p. 1; Origin Energy, p. 4.

technologies and thus would incentivise the wide-scale investment in different fast response and instantaneous energy supply solutions.[14] Ecoult noted that the proposed rule change would likely increase applications where energy storage is the most cost-effective solution to managing grid variability and peak pricing.[15] Tesla considered that the current 30 minute settlement did not provide an appropriate investment signal for flexible technology capable of quickly responding to fluctuations in demand and "meeting the requirements of our modern electricity system".[16]

AGL Energy and Tesla considered that moving to five minute settlement was an inevitable market development that would help to more effectively harness increased demand response capability, battery storage opportunities and a greater renewables-based generation profile.[17] The Public Interest Advocacy Centre (PIAC) and Tasmanian Council of Social Service (TasCOSS) considered that by providing greater certainty over the price for electricity generated or consumed in a given dispatch interval, five minute settlement would lead to more efficient price signals, encourage more efficient participation in the wholesale markets by new technologies such as storage, and thus would improve efficiency in the wholesale market.[18]

Valuing flexibility

Wärtsilä noted that despite higher accuracy forecasting tools and better scheduling, increased renewable energy increases the probability of a sudden change in generation, which adds to the volatility of the system. As a result, getting a price signal that values flexible response is becoming increasingly important.[19] Tesla also commented that five minute settlement would provide vital investment signals to support the increased uptake of flexible technology which would play a necessary role in supporting increased renewable energy penetration.[20]

The South Australian and Victorian Governments supported the introduction of five minute settlement. They considered it would better enable electricity supply and demand to be balanced, resulting in a more efficient mix of generation and demand response.[21]

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14 See, for example, Directions paper submissions: PIAC, p.1; TasCOSS, p. 3.; Future Business Council, p. 1.; AGL Energy, p. 1.; United Energy, p. 1.

15 Ecoult, consultation paper submission, p. 1.

16 Tesla, directions paper submission, p. 1.

17 Directions paper submissions: AGL Energy, p. 1.; ASEA/Tesla, p. 3

18 Directions paper submissions: PIAC, p. 1.; TasCOSS, p. 3.

19 Wärtsilä, consultation paper submission, p. 5.

20 AESA/Tesla, directions paper submission, p. 3.

21 Directions paper submissions: SA Department of Premier and Cabinet, p. 1; DELWP, p. 1.

Demand side participation

Stakeholders were divided as to whether five minute settlement would be advantageous for those engaging in demand side response.[22] Meridian and Powershop considered that it would encourage commercial and industrial demand response because some services such as air conditioning and freezers could be switched off for five minutes without any impact on the operations. However, it noted that some commercial industrial loads may not be able to execute demand response on a five minute basis.[23] It was observed that workplace practices and processes might not be sufficiently flexible for larger energy users to provide a rapid response of short durations.[24]

Similarly, the Australian Energy Council (AEC), ERM Power, Major Energy Users, and Snowy Hydro asserted that most demand response activities required more than five minutes to implement. Consequently, changing to a five minute settlement regime would reduce incentives to undertake demand response activities.[25]

Other stakeholders, including the Australian Energy Storage Alliance considered that five minute settlement would be beneficial for those seeking to engage in demand response as it would send stronger signals about the value of adopting new energy services, such as direct demand control and demand response.[26] Energy Consumers Australia submitted that a dynamic services market is firmly in the long term interests of energy consumers.[27]

EnerNOC and Flow Power submitted that five minute settlement would provide the right price signals to incentivise efficient consumption of energy. A greater proportion of demand response would occur within the right dispatch interval as price signals would be un-muted. This would provide increased incentives for technological advances, and new, innovative business models from retailers and independent service providers.[28]

Technology neutrality

Some stakeholders considered that five minute settlement would be more technology neutral than the current arrangements, however others considered that this characterisation was inaccurate.

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22 This could involve, for example, load curtailment, load cycling, fuel substitution and switching to on-site generation.

23 Meridian Energy and Powershop, directions paper submission, p. 2.

24 Meridian Energy and Powershop, directions paper submission, p. 2; EnergyAustralia, consultation paper submission, p. 2.

25 Directions paper submissions: ERM Power, pp. 5-8.; Major Energy Users, p.12; Australian Energy Council, p.2;

26 Consultation paper submission: Australian Energy Storage Alliance, p. 4.; The Australia Institute, p. 1.; Intelligent Energy Systems, p. 2.; Energy Consumers Australia, p. 4.

27 Energy Consumers Australia, directions paper submission, p. 4.

28 Directions paper submission: Flow Power, p. 1; EnerNOC, p. 3.

Flow Power and Energy Consumers Australia considered that five minute settlement would be more technology neutral; Energy Consumers Australia commented that the current rules are framed around the way the existing technology operates.[29] The Clean Energy Council was of a similar view. It commented that:

> "…a competitive energy market must move away from incumbency privileges, with 30 minute settlement an example of these privileges."[30]

In contrast, EnergyAustralia argued that implementing the rule change would have a significant detriment on gas powered generators and these disadvantages would be much larger than the disadvantages that batteries were subject to under current arrangements.[31] Arrow Energy and the Major Energy Users were of the opinion that given that five minute settlement was likely to promote new technology over existing generation, it was not consistent with a technology neutral approach.[32]

Bidding incentives

Stakeholders who commented on the issue of bidding incentives fell in two groups: those who thought that the Bidding in good faith rule change had already addressed strategic bidding issues, and those who considered that bidding issues will exist. Stakeholders in both groups generally considered that bidding behaviour would continue to change under five minute settlement.

A range of stakeholders thought that, despite the Bidding in good faith rule change, strategic rebidding remained a problem in the market.[33] ZEN Energy submitted that the current market rules were flawed as they provided incentives for generators to act in ways that could destabilise the market.[34] Reposit Power considered that the move to five minute settlements would reduce the opportunity for price manipulation, resulting in a more efficient price.[35]

In contrast, Origin Energy suggested that the concerns around the materiality of strategic bidding and misalignment were overstated.[36] Stanwell and Major Energy Users both suggested that the problem this rule change aimed to address was immaterial in light of other inefficiencies in the market.[37] Arrow Energy did not

29 Directions paper submissions: Clean Energy Council, p. 5; Flow Power, p. 2.

30 Clean Energy Council, directions paper submission, p. 3.

31 EnergyAustralia, directions paper submission, p. 6.

32 Directions paper submissions: Arrow Energy, p. 3; Major Energy Users, p. 19.

33 Consultation paper submissions: Intelligent Energy Systems, p. 7; Liquid Capital Markets, p. 1; Melbourne Energy Institute, p. 5; Wärtsilä, p. 4. Future Business Council, directions paper submission, p. 1.

34 ZEN Energy, consultation paper submission, p. 2.

35 Reposit Power, consultation paper submission, p. 1.

36 Origin Energy, consultation paper submission, p. 2.

37 Consultation paper submissions: Major Energy Users, pp. 8-9; Stanwell, p. 5.

believe there were material efficiencies to be achieved as the strategic late rebidding issue has been addressed.[38]

Stakeholders agreed, that bidding strategies would change under five minute settlement. However, the extent to which this would address existing issues or create new ones was unclear.[39] The Australian Financial Markets Association (AFMA) noted that although there would be efficiency gains from improved bidding behaviour in the wholesale market, the actual magnitude of the benefits would depend on participants' behaviour once five minute settlement was implemented.[40] Energy Consumers Australia indicated that the increased wholesale market rigor and improvements in the efficiency of generator behaviour would be in the long term interests of consumers.[41] Major Energy Users considered that while generators would implement bidding strategies to maximise the return on their investments, consumers would not have the same flexibility to change their strategies as these were dependent on consumer products, operations, and delivery commitments.[42]

3.3 Analysis

3.3.1 The role of electricity markets in promoting efficiency

The Commission considers that the role of markets in electricity supply is to provide reliable power at the lowest cost to consumers. Efficient outcomes are achieved in the short term by making sure that:

- electricity is produced by those generators that can produce electricity at the lowest cost (productive efficiency)
- electricity is consumed by those that value it most highly (allocative efficiency).

To achieve efficient outcomes in the long term (dynamic efficiency), it is necessary for there to be:

- sufficient and timely investment in generation capacity and demand side technologies
- investment in the types of generation and demand side technologies that deliver the greatest value over time.

These concepts are discussed further below.

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38 Arrow Energy, directions paper submission, p. 1.

39 Directions paper submissions: SACOSS, slides 5, 10-16, 24; Infigen, p. 3; Stanwell, p. 21.

40 Directions paper submissions: AFMA, p. 1-2; Origin Energy, p. 12; Energy Consumers Australia, p. 4-6.

41 Energy Consumers Australia, consultation paper submission, p. 3.

42 Major Energy Users, directions paper submission, p. 31.

Short term (static) efficiency

In the short term, the objective of the market design is to provide reliable power at the lowest cost by optimising the existing generation and consumption assets. In the NEM, and many international electricity markets, this optimisation is based on the principle of security-constrained economic dispatch. This involves dispatching those generators with the lowest bid costs ahead of those with higher bid costs, unless there are physical or technical limits that prevent this from occurring. The process is designed to minimise the costs of production, incentivising and promoting productive efficiency.

As mentioned in section 1.2, the NEM central dispatch algorithm is run for every five minute period based on the bids and offers submitted by scheduled generators, loads and MNSPs, and expected demand in each region. There are then ancillary service markets that correct for deviations from expected demand and supply levels that occur within the dispatch interval. The resolution of the dispatch interval is important: as supply and demand change, wholesale prices reflect the time at which physical change in demand and supply occurred. A relatively granular dispatch period, such as five minutes,[43] can provide information on the rate of changes in supply and demand, and frequency with which these changes occur.

Given that the five minute dispatch interval captures the key physical features of the power system for that time interval, five minute prices are expected to provide signals for the efficient operation of, and investment in, generation and load.

The other component of short term efficiency is allocative efficiency, which relates to the consumption decisions of small and large consumers. Large commercial and industrial customers are often exposed to wholesale market prices 'at the margin' even if they use financial instruments to hedge some or all of their exposure. The wholesale electricity market pricing outcomes are an important consideration in achieving allocative efficiency for these end users.

Small customers, however, purchase their electricity through the retail market and it is retailers that are exposed to the wholesale electricity prices. While allocative efficiency for retail customers is ultimately guided by retail tariffs, distortions in wholesale market prices 'carry over' into retail markets. For example, the wholesale price signal may influence decisions by retailers on whether to offer demand response payments or other innovative retail offerings to their customers. To the extent that the wholesale market is relatively less efficient and prices are higher than they otherwise would be, these higher prices would also flow through to retail prices.

43 Internationally there are examples of electricity markets that dispatch at 60, 30, five and one minute intervals, though five minute dispatch is much more common that one minute. Five minute dispatch is used in the New Zealand Electricity Market and all major US electricity markets (PJM, NYISO, CAISO, ERCOT, MISO, SPP and ISO-NE).

Bidding incentives

The NEM operates on the basis of a uniform clearing price. Generators that have their bid accepted are generally paid the price of the highest bidder that was dispatched for the dispatch interval. This provides an incentive for generators to offer their capacity at their short run marginal cost (SRMC) of generation. Bidding higher than their SRMC creates risks that a generator is not dispatched when it would have been profitable to do so, whereas bidding below the SRMC creates risks that the generator is dispatched at a clearing price that results in a financial loss.

Over time, positive differences between a generator's SRMC and the uniform clearing price allow for the recovery of capital costs associated with the significant investment in generation capacity.

In practice, generators typically split their offered capacity between high and low prices in a process known as 'bid shading'. This is explained in Box 3.1 below.

Box 3.1 Bid shading in single-unit and multi-unit clearing price auctions

The NEM energy market design is known in academic literature as a multi-unit clearing price auction as generators can offer different quantities of their capacity in multiple (up to ten) price bands. Through 'bid shading', generators maintain some low priced capacity, but also allocate some capacity to high price bands.

Bid shading can be explained by comparing single-unit and multi-unit clearing price auctions. In the former, the seller has a single unit for sale and can benefit from others' higher offers. If a seller tries to influence the price in a single-unit auction, it can only do so at the risk of missing out on the sale if the clearing price ends up below its offer price. Contrary to this, in a multi-unit clearing price auction, sellers can attempt to influence the uniform price using some small offers in high price bands without risking the sale of the units that are offered in the low price bands.

Also in practice, generators will offer their capacity in a way that reflects their forward contract position. Section 1.2 made note of the risk management benefits of forward contracting for generators, retailers and consumers. Contracts promote the efficient operation of and investment in generation, and provide price certainty for consumers. A subsequent benefit is that forward contracting leads to generators having a reduced incentive to exercise market power. When contracting takes place, there should therefore be less price volatility compared to the scenario in which it did not.

Potential for price coordination

In a repeated auction, participants typically learn about the strategies of others over time and strategies that are jointly beneficial for multiple participants are more likely to emerge. The success of price coordination is particularly high when:

- market participants have a common shared history and understanding of the market rules
- the products of the firms are indistinguishable from each other
- the market or auction is repeated multiple times.[44]

Price coordination behaviour can be difficult to regulate as rules that restrict bidder's flexibility might generate inefficiencies without being fully effective. Eliminating the sources of such strategic behaviour may be more effective than mandating behaviour that is in line with competition.

Long term (dynamic) efficiency

Dynamic efficiency requires that prices signal the value of additional capacity and also the technology that is most valuable in light of expected supply and demand conditions. Static and dynamic efficiency are inherently interlinked: if price signals distort productive and allocative efficiency in the short term, the ability to achieve dynamic efficiency over time is reduced as the price signals that would guide long term investment decisions are also distorted. Dynamically efficient outcomes effectively involve the achievement of allocative and productive efficiency over time.

Information such as long term demand forecasts, plant retirement decisions and long term historical average wholesale electricity prices is directly helpful in making decisions about the required investments in additional capacity. However, more granular information is needed to support investment decisions in the kind of technology that is best suited for the market, especially in the face of the increasing penetration of wind and solar generation as is occurring across the NEM. To support efficient investment in this future NEM it is essential that the market frameworks signal the value of investing in supporting equipment that can provide short term balancing capabilities.

When demand is gradually increasing and this is occurring at times consistent with historical patterns, most generators and demand response providers can ready themselves to provide a response. However, when there are more rapid changes – perhaps due to variation in the output of wind and solar generators, or binding transmission constraints – the wholesale prices need to reflect not just the marginal costs of the additional electricity, but also the cost of the technical capability of participants to provide responses within a short time. That is, the cost of adjusting to abrupt changes at the margin. When prices are sufficiently granular, those with the kind of technology that can better take advantage of high prices will earn more revenue during high price events. This means that when high prices are due to a tight supply-demand balance, generators that are able to provide generation at the time when it is needed by the power system are rewarded with higher prices.

44 For further details see, Klemperer, P. (2002) What Really Matters in Auction Design, Journal of Economic Perspectives, 16 (1), 169-190. And Fabra, N. (2003) Tacit Collusion in Repeated Auctions: Uniform versus Discriminatory, Journal of Industrial Economics, 51 (3), 271-293.

This does not mean that every resource must be highly flexible. Rather, there will be some optimal level given the physical needs of the power system. In an efficient market, the physical need for supply and the financial rewards of providing it are aligned through prices, which provide an incentive to invest in the technologies that are valued most highly.

3.3.2 Efficient operation and consumption decisions

As discussed above, productive and allocative efficiency is concerned with the efficient operation of generation fleet together with consumption decisions. This relies upon access to accurate prices that reflect the marginal costs of generating and benefits of using electricity.

Price spikes that are an outcome of supply-demand conditions are important indicators of the physical condition of the market. The more closely prices reflect the physical condition of the market, the more efficient the price signals. The following section assesses the ability of 30 minute average prices compared to five minute prices to signal the physical needs of the market.

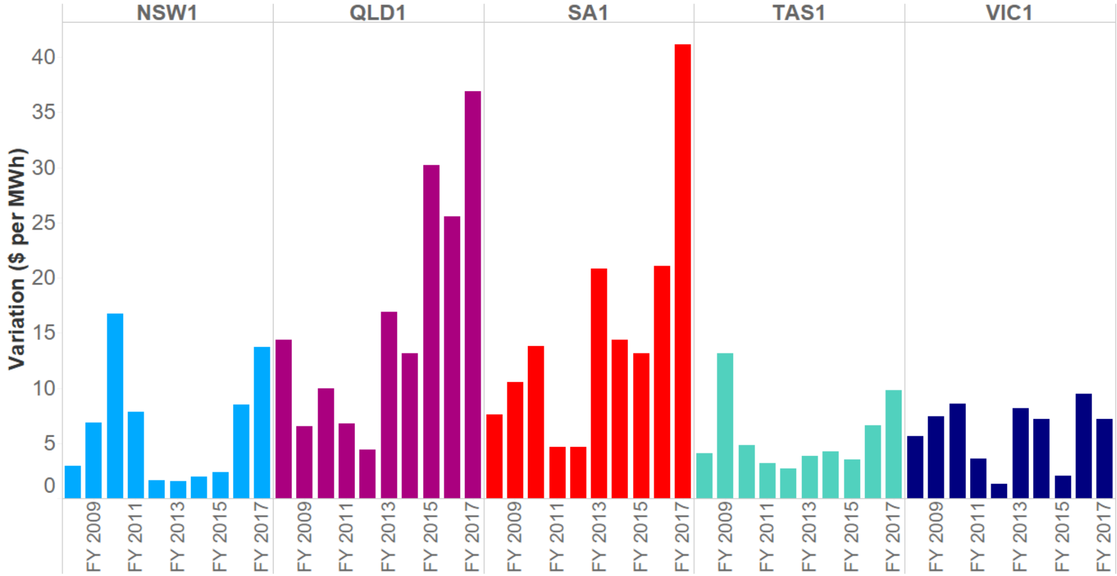
Distortions in electricity wholesale price signals

The directions paper highlighted evidence of variation between the settlement price and the individual dispatch interval prices.[45] The directions paper analysis has been modified to reflect volume weighted average prices as shown in Figure 3.1.

Figure 3.1 shows the annual average of the volume-weighted absolute difference between the five minute dispatch prices and corresponding 30 minute settlement trading prices. This difference provides an indication of whether, at any point in time, the five minute dispatch interval offer price reflects the 30 minute settlement price that participants actually receive. In financial year 2017 the variation between dispatch interval offer price and settlement price ranges from $8 MWh in Victoria to about $40 MWh in South Australia.

45 AEMC, *Five Minute Settlement*, directions paper, 11 April 2017, section 3.3.2.

Figure 3.1 Absolute average annual volume-weighted variation by region (2009 to 2017)



Data source: AEMO.

Conceptually, in the above figure, very small absolute differences suggest that the 30 minute trading price is providing incentives consistent with what is required given the power system is dispatched on a five minute basis. Alternatively, larger differences signal that the trading price associated with the 30 minute settlement outcome does not provide a good indication of what is required on a five minute basis. Large differences suggest that 30 minute settlement is distorting the price signal for the efficient operation, use and investment in generation and demand response technologies in the NEM.

Price distortions relative to average prices

Figure 3.1 shows that:

- there are interregional differences between how effective the 30 minute trading price is as a signal compared to a five minute basis
- across the NEM since 2012 there has generally been an increasing trend of greater variation between the 30 minute trading price and the five minute dispatch price
- the increase in variation over time is greatest in Queensland and South Australia.

Table 3.1 highlights the variations between five minute dispatch and 30 minute settlement prices in the South Australia and Queensland regions in 2015/16 and 2016/17.[46]

46 Average regional prices sourced from: AER, *State of the Energy Market*, May 2017, p. 52.

Table 3.1 Absolute variation as percentage of average regional price

Region and year	Absolute variation ($/MWh)	Average regional price ($/MWh)	Percentage variation
SA 2015/16	21.1	67	31%
SA 2016/17	41.1	108	38%
QLD 2015/16	25.6	64	40%
QLD 2016/17	36.9	93	40%

This table shows that the variation between five minute and 30 minute prices has increased in both states, peaking at around 30 and 41 per cent of the average regional price in South Australia and Queensland respectively. That is, on average the price signal provided by 30 minute settlement can be expected to vary by 30 to 40 per cent compared to the five minute price, degrading the underlying price signal.

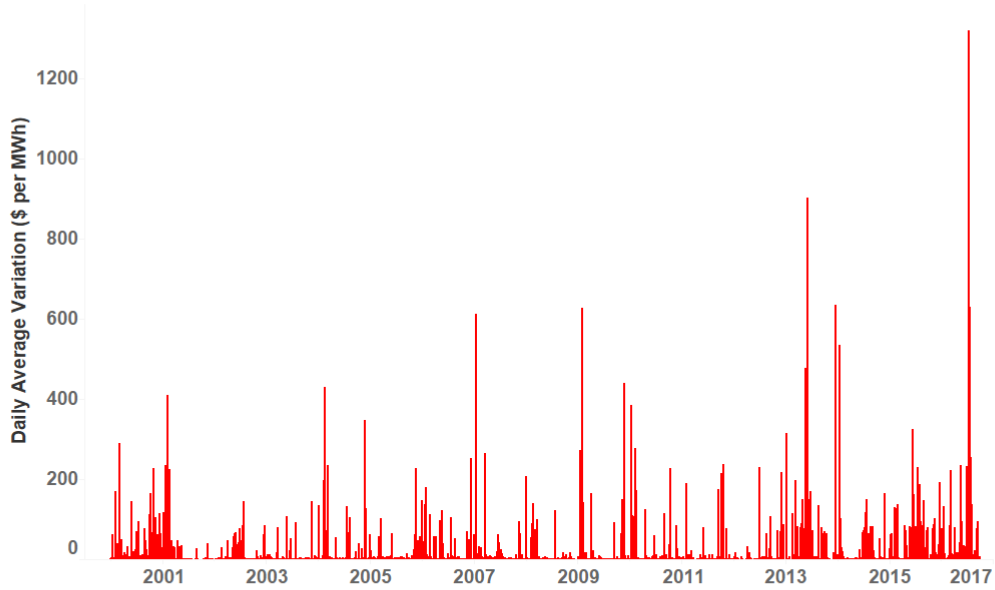
Distortions to daily prices

The annual averaging used in the graphs in Figure 3.1 suppresses the magnitude of the variation that can be seen on a daily basis. Figure 3.2 reproduced from the directions paper, examines South Australia more closely, which is the state along with Queensland that exhibits the greatest variation over time.[47]

Figure 3.2 highlights the magnitude of the average daily variation for South Australia and how it has increased over time. The chart removes the smoothing impact of the annual averaging in Figure 3.1 and shows that the daily average variation can be extremely high. For example, the maximum daily average variation is over $1,200/MWh. There are also many instances where the daily variation is above $100/MWh.

47 AEMC, *Five Minute Settlement*, directions paper, 11 April 2017, p. 43.

Figure 3.2 Daily average variation (SA, 2000 to 2016)



Effect of pricing distortions

Dispatch prices are set subject to the physical limits and condition of the market, and in the absence of strategic bidding, reflect the supply-demand balance. The key problem with the misalignment between dispatch and settlement is that the benefits of the relatively granular dispatch interval price signal is lost due to the market settling over 30 minutes. The 30 minute price becomes 'detached' from the underlying physical supply and demand conditions leading to an erosion of market efficiency.

When prices no longer reflect the marginal cost of generation and benefits of use, price signals distort generation and consumption decisions, and also create perverse bidding incentives. The issue of distorted bidding (and strategic bidding incentives) can be demonstrated through analysis of the dispatch interval prices within the 30 minute trading interval, as discussed in the next section.

Perverse bidding behaviour

Without strategic bidding, we would expect to see price spikes uniformly distributed within the trading intervals as they would be driven by supply and demand conditions which are, except for some notable exceptions, independent of the trading intervals.[48] The Commission considers that where price spikes are more likely to occur in the first and the last dispatch intervals, these spikes cannot easily be explained without consideration of strategic bidding behaviour.

48 An example when demand is 'coordinated' with the commencement of a trading interval includes the definition of peak time in retail contracts which has led to an increase in demand exactly at 11pm as customers have the tendency to set their appliances on timers. Similarly, in South Australia, hot water heaters tend to turn on at 11pm. Some wholesale price impact due to changes in demand at the beginning or the end of the retail peak time intervals would be in line with the expectations for a competitive market.

As discussed above, generators face mixed incentives. They want to achieve high sales and high prices. Two ways in which these incentives play out under 30 minute settlement are:

1. Late price spike: A generator that has achieved high sales volume by being dispatched early in a 30 minute trading interval could then shift its capacity to high price bands in an attempt to spike the price in dispatch interval five or six, and thereby achieve a high average price for the half hour.

2. Early price spike: Once a price spike has occurred, then generators have an incentive to shift capacity to low prices to maximise their sales volume for the half hour, which will be compensated at the high average price.

As generators will seek to achieve high sales volumes and high prices the first and the last dispatch intervals are increasingly likely to fulfil the role of a common strategic reference point in generators' bidding strategies. This behaviour is directly attributable to the mismatch between five minute dispatch and 30 minute settlement. It is important to note, that explicit collusion or communication is not required, as generators' common understanding of the preferred strategic outcome can be enough to achieve a desired price outcome.

Late rebidding strategic behaviour was the subject of the Bidding in good faith rule change in 2016.[49] Snowy Hydro, Arrow Energy and Major Energy Users stated in their submissions that the Bidding in good faith rule provisions already prohibited generators from making false or misleading offers and this already prevented such (alleged) behaviour to occur. As a result, stakeholders considered, high prices occurred less frequently in the later dispatch intervals.[50]

Analysis by the Commission suggests that since the Bidding in good faith rule was made, this specific behaviour, while still present, is less dominant. However, other types of behaviour however appear to have emerged. The following sections summarise these outcomes.

Persistent late and early price spikes

In the NEM, generators are required to submit their offers for 30 minute intervals. They can rebid these offers during the trading interval to adjust for changes from one five minute dispatch interval to the next. However, when they do so, the adjustment is effectively uniform for the 'remainder of the trading interval'.

Early price spikes within a trading interval increase the certainty of a settlement price that is above the operating cost of the plant. Under these conditions, selling more

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49 Introduced in July 2016, the Bidding in good faith rule change was designed to curb the incentive to create late spikes through rebidding behaviour. The rule change introduced new information recording requirements for rebids that are made within the late rebidding period. The late rebidding period is defined to begin 15 minutes before the commencement of the trading interval to which the rebid applies, and ends at the end of that trading interval. AEMC, *Bidding in Good Faith*, final determination, 10 December 2015.

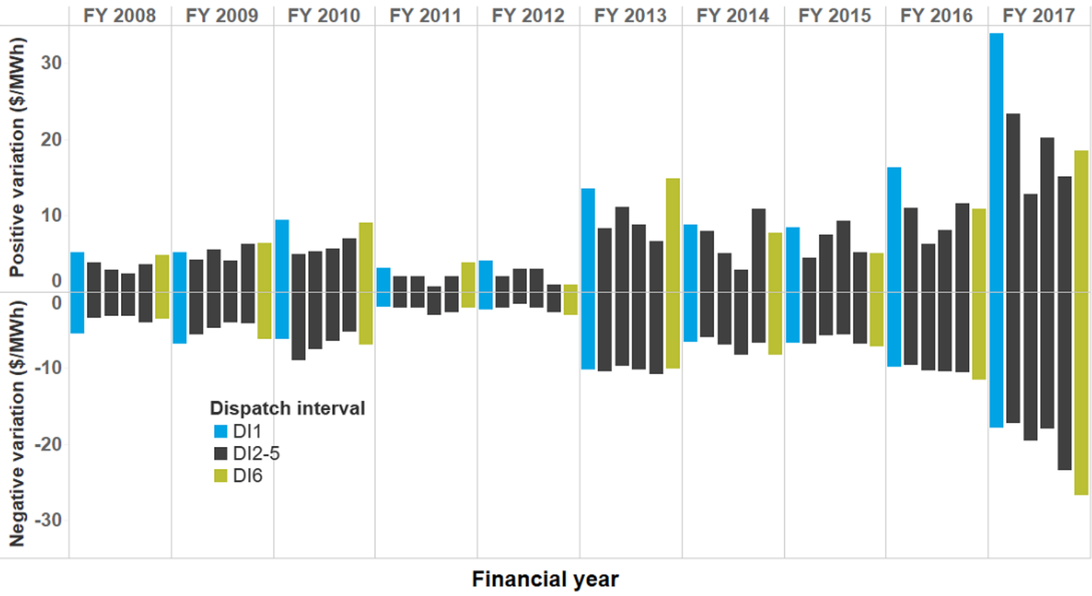
50 Directions paper submissions: Snowy Hydro, p. 2; Arrow Energy, p. 2; Major Energy Users, p. 7.

volume in the subsequent dispatch intervals within the trading interval becomes the strategic priority by rebidding to shift more MW quantities into the *lower* price bands.

Generators' rebidding strategies once a price spike occurs are in line with the expectations of competitive market outcomes. However, a systematic occurrence of early price spikes may indicate that current market arrangements provide common reference points for generators.

Figure 3.3 shows the average annual volume weighted variations between the five minute prices relative to the 30 minute prices in each dispatch interval since 2008 for South Australia. This figure is based on a similar methodology to Figure 3.1 above, though in this case the average variation between 30 and five minute prices has been split into positive (five minute > 30 minute) and negative (5 minute < 30 minute). Figure 3.3 demonstrates that historical price spikes occurred more frequently in the first and last dispatch intervals that the other dispatch intervals. As highlighted in working paper 1, this trend is present in all regions in the NEM and most distinct in Queensland and South Australia.[51]

Figure 3.3 South Australia variations between five minute and 30 minute price per dispatch interval



Data source: AEMO.

The above figure highlights that since the introduction of the Bidding in good faith rule change on 1 July 2016 the variations in the first dispatch intervals have outgrown the variations in the last dispatch interval. Generators appear to have shifted the emphasis of their bidding to the first dispatch intervals within the 30 minute trading intervals.

The analysis presented by Seed Advisory and attached to the submission by Origin Energy also found that late price spikes continued to persist after the implementation

51 Five Minute Settlement Working paper 1, pp. 18; 37.

of the rule change.[52] Seed Advisory also found no easily observable relationships between underlying demand or supply changes and high price in the last dispatch interval. This was even when the last dispatch interval sample was restricted to very high price events. Their finding suggested that – while there were some regional, seasonal and time of day effects – the price spikes were not the result of sudden changes in demand or supply.[53]

'Piling in'

Where a price spike occurs in the first dispatch interval, under 30 minute settlement any generation that occurs in the trading interval containing that dispatch interval will share the benefit of the price spike.[54] This provides an incentive for those generators that can respond within the 30 minute period, to alter their bids to attempt to increase the level at which they are dispatched. In doing so, generators are likely to bid prices well below the short run marginal cost of generation to be dispatched.[55]

During such piling in, large levels of generation are offered at prices that could be below costs and at a time when it is not necessarily needed by the power system. In fact, generation may occur up to 25 minutes after prices signalled that it was required by the power system through five minute prices. To maximise the share of the trading interval settlement value, generators are no longer responding to the signal provided by the five minute dispatch price, but their expectation of the price outcome for the 30 minute settlement period.

The mismatch between dispatch and settlement prices has been identified as a contributing factor to generator rebidding in the AER's reporting on spot price events above $5,000/MWh. For example, on 10 February 2017, Snowy Hydro, Callide Power, Arrow Energy, and ERM Power all rebid significant capacities – ranging from 15 MW for Arrow Energy to 480 MW for Snowy Hydro – from price bands close to the market price cap to the lowest price bands close to the market floor price.[56] In all instances of rebids consistent with piling in, the reason indicated by generators was the discrepancy they observed between five minute dispatch and 30 minute settlement prices. While the Commission considers that this behaviour is commercially reasonable, the overall outcomes are not in line with the efficient operation of the market.

The price uncertainty associated with piling in also impacts generators that could respond within the five minute dispatch interval. The uncertainty surrounding 30 minute settlement prices potentially creates the incentive to avoid being dispatched, even though the dispatch price indicates that their generation is physically valued by

52 Seed Advisory, *The Five Minute Settlement Rule Change Proposal – Review of the Australian Energy Market Commission's Directions Paper*, 29 May 2017, p. 45.

53 *Ibid*, p. 38.

54 AEMC, *Five Minute Settlement*, directions paper, pp. 17-18 and 34-35.

55 This is further discussed in the Commission's directions paper, p. 36.

56 AER, *Electricity spot prices above $5000/MWh – New South Wales & Queensland*, 10 February 2017, published 5 May 2017.

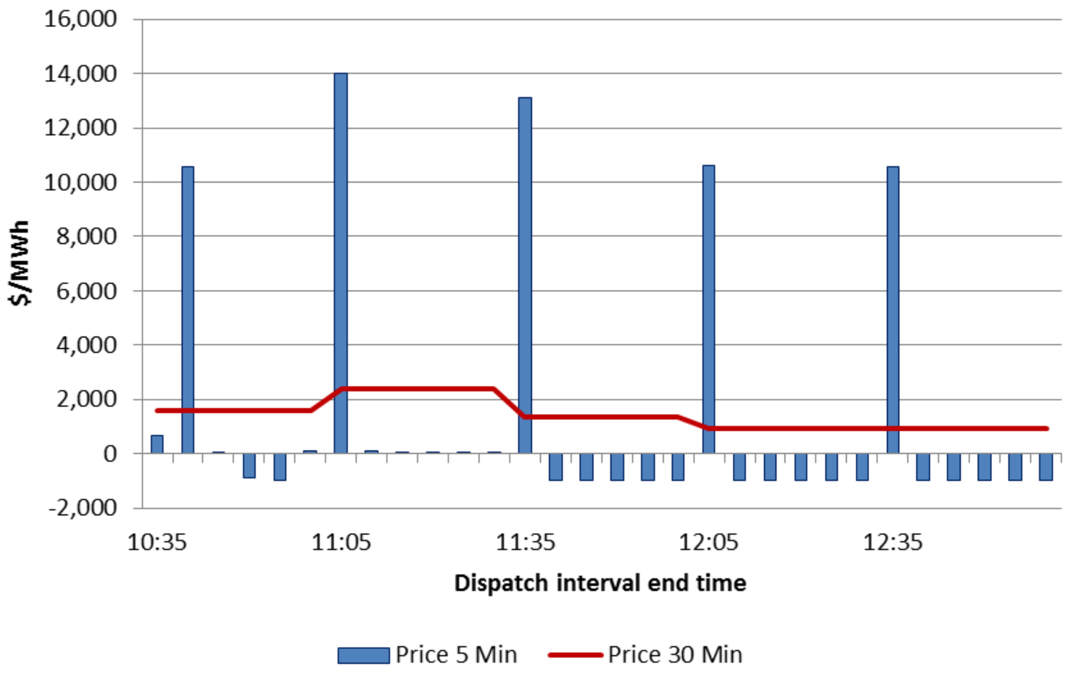
the power system in that interval. This has the potential to create risks for the ongoing operation and financial viability of flexible and fast response technologies.

Furthermore, 30 minute settlement provides perverse incentives by encouraging generators to maximise their share of the benefits of a price spike in the first dispatch interval by:

- non-conformance with dispatch instructions, to generate more when there is an early price spike
- presenting themselves as being less flexible than they are to avoid being ramped down.

Figure 3.4 below illustrates the type of incentives that arise from the distorted price signal that the mismatch of dispatch and settlement creates. The chart compares the five trading intervals from 10.30am to 1.00pm on Tuesday 21 March 2017 in South Australia. It demonstrates how high prices in the first or second dispatch interval can lead to rebidding at a low or negative price (below short run marginal cost), and highlights the substantial difference between five minute and 30 minute prices over the five half hour trading intervals.

Figure 3.4 South Australia five minute and 30 minute prices – 21 March 2017



Data source: AEMO.

Some stakeholders asserted that events such as these are due to regional factors in South Australia and Queensland and should not be used to justify a change to the whole market.[57] While the Commission acknowledges that regional factors have contributed to historical price outcomes, it also sees the potential for the conditions to South Australia (e.g. high penetrations of wind and solar generators, retirements of thermal generators) to be replicated in other regions to varying degrees. With this rule, there is the potential to introduce a more efficient price signal before such issues become more prevalent.

Russ Skelton & Associates (RSA) suggested that piling in was prudent risk management to defend sold contracts.[58] If this behaviour occurred in one trading interval only, it may be considered in line with RSA's assertions. However, in the 21 March 2017 example depicted above, price spikes and piling in occurred over five consecutive trading intervals. Once the pattern had started, the subsequent price spikes appear to have been reasonably foreseeable. That generators only rebid for the current trading interval and not future periods, which could have avoided the price spikes occurring, suggests that they were not fully contracted and hence able to benefit from high prices.

The initial price spikes followed by low – or negative – prices have also been perceived by some stakeholders as serving the interests of customers. For example, the Major Energy Users were concerned that five minute settlement would cause high prices to persist for longer than they do now as "increased competition" in the intervals after a price spike may not occur. The Major Energy Users noted that, "the fact there is little carryover in the high price…shows the benefits to consumers of the 30 minute settlement".[59]

However, the Commission considers that the more pertinent question is why the prices spikes occurred in the first place, rather than what happen in the remainder of the trading interval. The fact that the level of competition appears to fluctuate within the trading interval is not due to physical market conditions, but attributable to the incentives created by 30 minute settlement. The Commission is of the view that competition among generators should be expected to put downward pressure on wholesale prices in all dispatch intervals.

Generators' bidding strategies under 30 minute pricing undermine the electricity wholesale market's role of achieving productive efficiency as wholesale spot prices can become detached from the physical needs of the market. When generators' offers are decoupled from the cost of its generation, there is also an increased probability that high cost generators with costs above the clearing price will be dispatched, while low cost generators will not be.

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57 Directions paper submissions: Arrow Energy, p. 6; Infigen Energy, p.2; SA Water, p. 2; Snowy Hydro, p. 8.

58 Russ Skelton & Associates, *Materiality of problem or magnitude of benefits*, Five Minute Settlement Public Forum, May 2017, p. 6.

59 Major Energy Users, directions paper submission, pp. 13-14.

Artificial volatility and price risk

The Commission considers that the existing framework is incentivising behaviour that may also be contributing to a degree of artificial volatility in the market. This volatility is not a function of underlying uncertainty, market risk or system need. Rather, it is driven by the price bidding behaviour of participants. This increased price risk affects generators as well as those loads that are spot exposed. To the extent that there is an increase in risk, this would also increase the cost of supply and retail prices for consumers.

The Commission expects that the historic volatility associated with five minute dispatch under 30 minute settlement is not expected to continue in the presence of five minute settlement. Price spikes under five minute settlement are more likely to be a result of changes in supply and demand and reflective of the physical conditions of the power system and the network.

With five minute settlement it would be expected that incentives would change, resulting in different bidding strategies and responses by generators. This is an outcome that stakeholders have indicated is likely.[60] Energy Consumers Australia asserted that the increased wholesale market rigor and improvements in the efficiency of generator behaviour associated with five minute settlement would be in the long term interests of consumers.

The Commission considers that the provisions introduced as a result of the Bidding in good faith rule will result in less instances of price spikes caused by generators rebidding capacity to higher price bands very close to dispatch. However, there remains sufficient evidence to suggest there are still issues with rebidding. Distortions in price signals from 30 minute settlement can be material and appear to be increasing. The failure to align settlement and dispatch will therefore continue to provide an ongoing incentive for perverse behaviour and may result in the physical needs of the market being detached from the financial incentives provided through prices.

The Commission also considers that five minute settlement removes the potential for the 30 minute trading interval to play a coordination role in generators' bidding strategies. By better aligning generators' bidding strategies with the efficient outcome of the market, there are reduced incentives to engage in bidding behaviour to create high prices and volatility. This in turn would reduce hedging costs for retailers and costs for consumers.[61]

How five minute settlement may reduce distortions to demand side participation by customers is further discussed below.

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60 For example see directions paper submissions: SACOSS, slides 5, 10-16, 24; Infigen, p. 3; Stanwell, p. 21.

61 Energy Consumers Australia, consultation paper submission, p. 3.

Distortions to demand response

As discussed above, stakeholders' views generally differed regarding the level of demand response that would be expected under five minute settlement relative to 30 minute settlement.

Similar to the 'piling in' phenomena, 30 minute settlement may result in demand responses up to 25 minutes after the dispatch interval where a high price signalled it was needed by the power system. Responses to 30 minute rather than 5 minute prices as a result of the 30 settlement regime, incentivises allocatively inefficient consumption decisions on the demand side. For example, where loads face an unexpected thirty minute price that is below their willingness to pay, it is allocatively inefficient for them to have limited their consumption.

This highlights that the uncertainty surrounding the 30 minute settlement price also has the potential to create confusion, resulting in demand response not taking place or taking place at the wrong time. In general, a market where the price provides signals and incentives for demand to be responsive over the shortest timeframe practicable, will result in demand response in line with the physical requirements of the power system. In support of this view, EnerNOC considered that when price signals are clear this provides incentives to consumers to participate in the market and for innovation with technology and operational processes and service providers' business models.[62]

For large commercial and industrial customers’ that are in some way exposed to wholesale market prices, the wholesale electricity market pricing outcomes directly affects allocative efficiency.[63] Small customers, however, purchase their electricity through the retail market and it is retailers that are exposed to the wholesale electricity prices. An important component of the retail bill is the wholesale cost of electricity, which in the NEM is linked to product prices in the contract market.

As noted in section 3.3.1, allocative efficiency for retail customers is ultimately guided by the retail tariffs customers face. However, distortions in wholesale market prices can flow through into retail markets. For example, retailers may as a result of distorted wholesale market outcomes created by 30 minute settlement choose not to offer a demand response as part of its retail offerings, despite it being efficient to do so. Critically, when retailers face sharper and more accurate price signals, such as would occur in the move from 30 minute to five minute settlement, their decision whether to offer demand response payments to their customers will be more aligned with the supply-demand condition of the wholesale market.

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62 EnerNOC, directions paper submission, p. 3.

63 This is even the case where they use financial instruments to hedge some or all of their exposure. Financial instruments used by large customers provide them with compensation for high price events independent of their actual electricity use at the time. This means that even if these instruments help customers manage their price risks, the contracts themselves do not cancel or dampen their incentives to respond to prices when these are above their willingness-to-pay. When willingness-to-pay is above the market price cap, customers will not respond and this is also efficient.

The Commission considers that five minute settlement would incentivise demand response to occur within the dispatch interval when it is needed and consumers will be more appropriately rewarded for their ability and willingness to provide the response. Any distortion created by 30 minute settlement is likely to become increasingly significant given the take up of behind the meter technologies, such as solar, energy storage, electric vehicles and smart thermostats, which give consumers the capability to respond dynamically to retail and wholesale price signals.

3.3.3 Innovation and investment decisions over time

Structural change is underway

In the NEM, the value of electricity settlements were around $16 billion in the 2016-17 financial year,[64] while the estimated replacement cost of the current 45 GW of NEM generation assets are estimated to be in the order of $130 billion.[65]

Critically, in the next decade over 45 per cent of the existing electricity thermal generation plants in the NEM will be at least 40 years old. It is likely that significant new investment, in the order of $10-$90 billion, will be required in the short-to-medium term to either upgrade or replace this infrastructure. Given this, the signal the wholesale price provides for efficient investment becomes increasingly important.

This investment required is also occurring at a time when the nature of the market is changing, in particular the potential for variation in supply and demand. There is greater physical variation already on the supply side, due to, for example, the penetration of intermittent generators. With the introduction of metering competition and the increased uptake of distributed energy resources, further physical variation is expected on the demand side.[66]

New technologies are emerging and rolling out commercially in much shorter timeframes. Consequently, the value provided by technologies that are capable of short term supply-demand balancing is expected to increase. Enabling the wholesale price to signal the efficient need for such flexible technology is critical.

The value of fast response and flexible generation technologies

The increasing penetration of intermittent generators and the recent black system events in South Australia have highlighted the requirements for more generation flexibility. Specifically, generation that can respond in the timeframe and to the extent

64 AEMO, *National electricity market fact sheet*, 2017, p. 1.

65 This estimate is based on 45GW of capacity with an average replacement cost of $2.9 million/MW. Taken together with the network replacement costs, total replacement cost for NEM assets is estimated at a quarter of a trillion dollars or over $10,000 for every person in Australia.

66 For example, the uptake of household solar photovoltaic (PV) systems continues to grow. It currently amounts to nearly 6 GW of intermittent renewable capacity across Australia. Solar PV installations found at http://pv-map.apvi.org.au/analyses.

necessary to address short term energy imbalances due to wind and solar variability, and unforeseen outages.

The potential problems in rewarding generation flexibility are exacerbated by 30 minute settlement as it dampens the incentives for generators to respond within a short timeframe. The outcome of this is that 30 minute settlement prices currently do not adequately signal the need for, and the value of, flexible response. Currently, all generators that provide output during a half hour trading interval are rewarded by the same MWh price, regardless of how flexibly they responded to the price signal.

Traditionally, it has been assumed that when short term high prices occur, they signal a potential opportunity for investments in peaking generation or demand side management. Conversely, if there is a sustained increase in the wholesale prices without an increase in volatility, this sends a signal that investment in additional baseload capacity may be required.

While in the past these price signals have worked well to attract sufficient and timely investment in generation capacity, in the future this is unlikely to be adequate to attract the type of generation that efficiently meets short term fluctuations in demand and supply.

The Commission considers that five minute settlement would provide more granular information about the need to balance supply and demand over short time intervals. This is particularly important in the context of the technology change that is taking place in the NEM. Consequently, the value provided by technologies that are capable of short term supply-demand balancing is expected to increase. In respect of these technologies, five minute settlement would provide an improved signal for investment when compared with 30 minute settlement.

The Commission expects that five minute settlement would lead to marginal changes in investment decisions. It would change the relative value of different technologies, such as gas and diesel-fired generation, energy storage, and demand response, by more accurately valuing flexible responses.[67] Five minute settlement would provide a greater incentive for:

- more flexible generation unit choice and configurations of gas-fired generation
- more automation of demand response activities, so that a faster response can be provided
- investment in battery storage technologies, especially utility-scale storage
- aggregation and control of behind the meter energy storage resources.

Over the coming decades, maintaining the misalignment of dispatch and settlement could create the potential for slower response technologies being favoured by investors over those with greater flexibility.

67 A range of examples were provided in Section 4.5 of the Commission's directions paper.

Price signals will influence the amount and the type of technology installed, the timing of any installation, and the scale and location of investments responding to changing market conditions. In this environment the materiality of the problem of 30 minute settlement will be greater. Conversely, the benefits of aligning dispatch and settlement at five minutes and providing an improved price signal, will be more significant.

Distortion in investment incentives and barriers to entry

The NEM will face a major transformation in the coming decade, as it moves away from a reliance on traditional generation technologies and the thermal generation fleet ages. The removal of any barriers to efficient participation for prospective competitors will be an important step to facilitate greater competition in the long term.

In the directions paper, the Commission demonstrated through several examples, how 30 minute settlement favours slower, less flexible technologies at the expense of more flexible alternatives. For example, 30 minute settlement creates the potential for:

- relatively slow generators requiring 15 to 20 minutes to respond from rest to benefit from a price spike even though the conditions that caused the spike may have already passed
- very fast resources that would provide energy for a single five minute period being discouraged from doing so by the fact that it will be paid the average price for the half hour.

In this way, 30 minute settlement benefits technologies capable of providing a response in 15 to 20 minutes while disadvantaging technologies that can provide an instantaneous response. Over time, this will likely result in a generation mix where, relative to five minute settlement, the latter is under-represented and the former is over-represented. Similar considerations apply to demand response technologies.

Newer fast response technologies offer more flexible performance. Currently they have relatively high costs, although their economics is continually improving. A worst case scenario of the existing framework would be where the misalignment of dispatch and settlement creates incentives to invest in slower response technologies in future that are not only less valued by consumers in a particular five minute interval, but also involve a higher cost of supply.

For example, this could arise due to the higher ancillary service requirements associated with operating the market with relatively inflexible plant. This dynamic inefficiency from a distorted generation mix will have a more enduring effect, as downstream retail customers in the longer term will pay higher prices for electricity than they otherwise should over a sustained period of time.

Incentives for energy storage

A point of contention in stakeholder submissions has been whether 30 minute settlement impedes the efficient entry of energy storage technologies. In discussing this, the Commission notes that there are different incentives for investments in behind the meter storage (i.e. residential and commercial) compared to utility-scale projects. Retail customers respond to retail prices whereas utility-scale storage would participate directly in the wholesale market, responding to wholesale prices. Potentially, there would be more of an impact on the investment decisions in utility-scale storage than investments in behind the meter energy storage.[68]

Utility-scale energy storage investments will be made on the basis of opportunities presented by wholesale prices, and other revenue streams (such as frequency control and network support). Under five minute settlement it would be much more feasible for large scale storage to respond to five minute prices. For example, a battery could discharge for a single five minute period to capture or suppress a price spike, rather than having to discharge for a whole half hour in order to do so.

Essentially, this means that under five minute settlement it would be possible to capture more revenue with the same sized battery, or the same amount of revenue with a smaller battery (potentially, up to one-sixth the size). It is therefore likely that there would be more investment in utility-scale storage under five minute settlement than there would be under 30 minute settlement.

However, the implications of such investment is that the presence of fast response storage would of itself reduce volatility as storage providers look for energy price arbitrage opportunities. This implies the benefit to large storage would not be as significant as analysis of historical pricing data (without accounting for changes in participant behaviour) would suggest. The net effect of these factors is difficult to estimate. To the extent that participants take advantage of the arbitrage opportunities under five minute settlement, the Commission expects this would result in reduced price volatility.

Another unknown factor is the impact of aggregation of behind the meter energy storage and how these may be more actively used in the wholesale market. It is possible there is less of an incentive for aggregation under 30 minute settlement. How the choice of settlement pricing may influence investment decisions is further considered through an example below.

Example of difference in settlement outcomes and investment recovery for battery storage

While capital costs of battery storage investments have been high, these costs are decreasing. Several utility-scale battery storage investments are currently under consideration across the NEM. Besides participating in the energy market, battery

68 For retail customers, the rationale to install a battery is generally to maximise the value of energy that is generated from solar PV systems. Residential retail prices are typically around 20-30 c/kWh, while retailers may compensate households at a rate of 6 c/kWh for energy that is exported. There is therefore value in using a battery to store energy generated from the PV system, using it to offset consumption at 20-30 c/kWh rather than exported it for 6 c/kWh, or possibly less. Investment in behind the meter storage will therefore largely be a function of retail prices, tariffs structures and the prices that retailers pay for exported energy. As energy storage costs decline, the Commission expects that there will be significant investment in behind the meter storage irrespective of whether five minute settlement is implemented.

storage technologies may also concurrently provide services in network support or frequency control markets.

The stylised example presented below analyses how the choice of settlement pricing in the energy market may impact the investment decisions for battery storage, using NEM pricing data from 2010-17. As potential frequency control ancillary service (FCAS) revenues are being ignored, the energy trading value of a battery in this example depends entirely on the difference between the revenue received for electricity output at times of high prices (net of round trip efficiency losses) and the cost of electricity purchases at times when it is at its cheapest.

Capital costs in this example use data from Bloomberg New Energy Finance.[69] They estimate that the capital cost of a lithium-ion battery is around $1 million per MWh in Australian dollars, based on a battery configured to produce its maximum output for thirty minutes (e.g. 1 MW/0.5 MWh). Assuming that the battery would operate 1 charge/discharge cycle every day for 10 years with 90 per cent roundtrip efficiency,[70] and for simplicity ignoring project financing costs, the per cycle capital cost of the battery storage equates to around $300/MWh.[71]

For each day, the net arbitrage revenue is calculated for both five minute and 30 minute settlement and the average daily arbitrage values calculated for each year between 2012 and 2017. This analysis has been done for South Australia and Queensland, which as highlighted in section 3.3.2, exhibit the greatest absolute variation between five minute and 30 minute settlement prices, and New South Wales, which is representative of a region with low variation.

Figures 3.5 and 3.6 depict the net arbitrage values under five minute and 30 minute settlement in Queensland and South Australia, respectively. They also include a line at $300/MWh representing an indicative breakeven point for capital recovery. If the net arbitrage value in the charge exceeds the breakeven line, then the investment in battery storage is financially viable. The use of a constant capital cost line is simplistic, given it excludes such things as financing costs. It is therefore likely to understate current costs, but will overstate future costs given the ongoing decline in battery costs.

The graphs show that in 2016 in Queensland and 2017 in South Australia, the choice of five minute or 30 minute settlement would have had a significant impact on a battery storage capital investment decision. Both Queensland and South Australia face volatile

69 Bloomberg New Energy Finance, *Storage System Costs: More than Just a Battery*, 23 June 2017, p. 4. The average survey costs for a grid-scale energy storage system with a power to energy ratio of 1:0.5 was US$802.

70 To model a 90% roundtrip efficiency, it was assumed that the battery's would generate full power but its generation time would be reduced to represent an overall 90% discharge relative to charge. For example, if the battery charged for 2 hours (4 half-hours), it would discharge at full power for 3 half-hours and then only 60% of the energy in the final half-hour such that the energy discharged was 25%, 25%, 25% and 15% in each half-hour, totalling 90% in aggregate.

71 This assumes that the battery is charges and discharged once every day for 10 years. Roundtrip efficiency is expected to decrease over the course of the 10 years but this is not considered in the current analysis.

wholesale electricity prices and, not surprisingly, these regions offer higher returns for battery storage looking to take advantage of energy arbitrage.

Figure 3.5 Battery net arbitrage value – Queensland 2012-2017

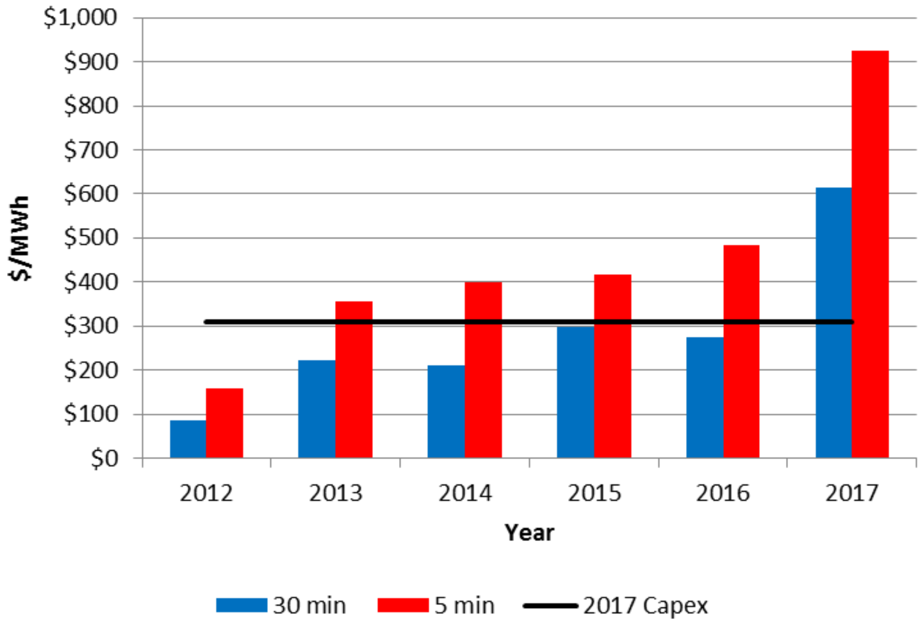


Figure 3.6 Battery net arbitrage value – South Australia 2012-2017

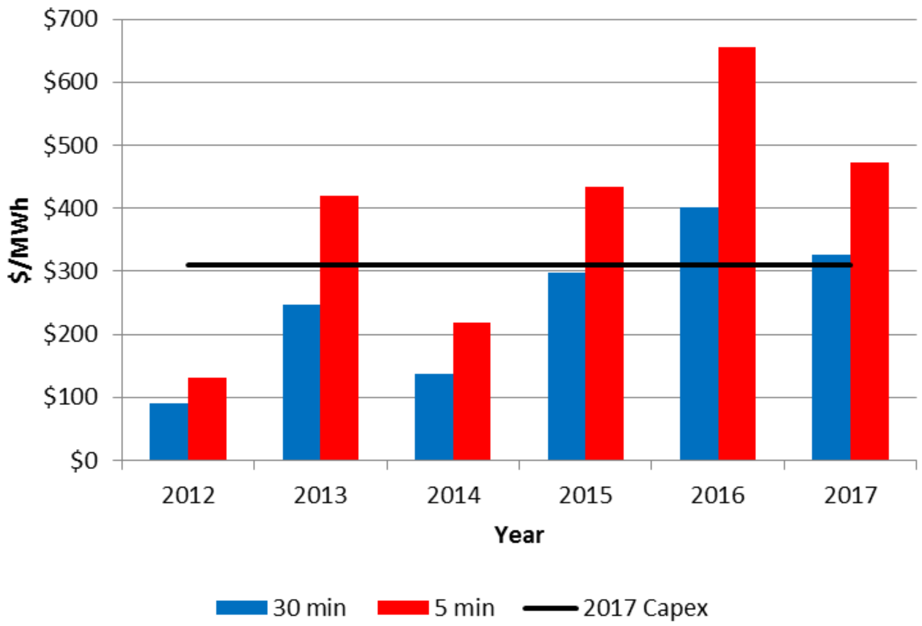
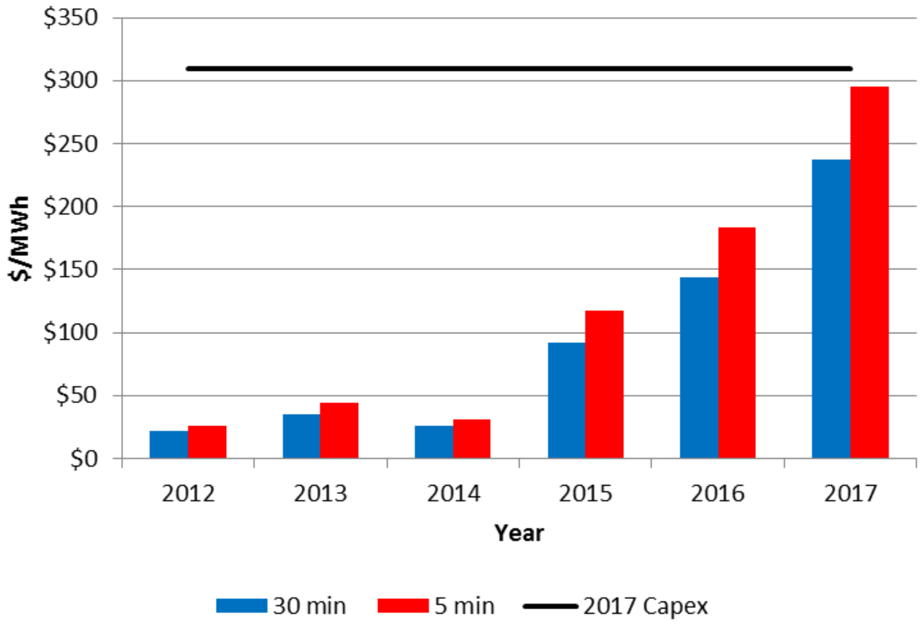


Figure 3.7 shows the same information for the New South Wales region. It demonstrate that even in a region with relatively low price volatility, the choice of five minute or 30 minute settlement would be a relevant factor for those considering capital investments in battery storage.

Figure 3.7 Battery net arbitrage value – New South Wales 2012-2017



In Queensland and South Australia, the difference between the five minute and 30 minute settlement arbitrage value seems to be increasing over time. The trend is inconclusive in New South Wales. Across all three regions though, the gap between energy market arbitrage and capital costs is declining over time due to ongoing reductions in the capital costs of energy storage technologies. This demonstrates that the distortion in investment decisions as a result of 30 minute pricing is becoming more significant.

Gas-fired generation

The Commission considers it likely that five minute settlement would increase the incentives to select more flexible options where investment in gas fired generation is being considered. The change in incentives to invest could be different for open cycle gas turbines (OCGT) and combined cycle gas turbines (CCGT).

For a new OCGT investment, there would be a strong incentive to deploy aero derivative turbines rather than frame industrial units. In the NEM historically there has been a clear preference for less flexible frame units. This may reflect their lower capital cost compared to aero derivative units and the low gas prices through to the end of 2010. The presence of 30 minute settlement may have also reduced the financial incentive for investing in more flexible aero derivative OCGTs.

Further, the presence of 30 minute settlement may affect investments in CCGT plant at the margin. For example, it means there is less of an incentive for having greater operational flexibility such as including a bypass capability between the gas turbine and steam boiler, which would allow the gas turbine to operate independently as an OCGT.[72]

Five minute settlement would change the relative value of gas-fired generation versus energy storage technologies, by more accurately valuing flexible responses. Five minute settlement may result in less OCGT generation being built in future, as it may be more economical to use different, more flexible technologies.

There is already some level of investment in fast response technology – such as aggregating distributed battery storage, next generation gas peaking plants and faster start demand response. A number of stakeholders have suggested that this investment means that five minute settlement is not required.[73] The Commission does not consider this to be a strong indicator of whether 30 minute settlement distorts investment decisions. The relevant comparison is between a potential future with five minute settlement, and a continuation of the current market design. With this in mind, the Commission considers that five minute settlement is likely to more effectively promote investment in generation and demand side technologies to efficiently balance supply and demand in the face of increasing renewable generation and changing demand patterns.

The capital costs of new technologies – such as utility-scale battery storage – have been decreasing and investors' expectation of wholesale market revenues are increasingly becoming a key factor in their uptake. In this context, the Commission considers it to be important that market design features such as settlement processes do not inadvertently create barriers for any efficient new generation and demand response technologies to enter the market.

Demand side technology investment

As discussed in section 3.3.2, demand response is of reduced societal value if it takes place after it was needed by the power system. It may be the case that, as a result of the introduction of five minute settlement, the amount of slow demand response would decline and the amount of fast demand response would increase. In some cases this may be due to business in the former category making changes so that a faster response is possible. To the extent that this outcome is in line with the needs of the power system, this trade-off would be efficient.

From the point of view of efficient outcomes, it is important that the incentives customers and demand side service providers face are in line with the needs of the power system. This requires that customers or service providers are able to receive the

72 It is the Commission's understanding that the majority of the existing CCGT generators in the NEM do not have this functionality. In the absence of this feature, the start sequence of the gas turbine is constrained by the requirements of the steam turbine (e.g. the plant may be held at set points while steam conditions are managed). A CCGT with bypass would provide the option to operate either as a less flexible but more thermally efficient CCGT, or provide a faster response in OCGT mode, depending on expected wholesale price movements.

73 Directions paper submissions: Australian Energy Council, p. 3; Energy Queensland, p. 5; ENGIE, p. 4; Major Energy Users, pp. 6; 26; Snowy Hydro, p. 7.

full reward for the value and services they provide to the market. The Commission considers that five minute settlement better aligns customers' and the power system's interest and hence it is likely to better promote efficient investments in demand side technology over time.

3.3.4 Technology neutrality

The market design principles in clause 3.1.4(3) of the NER state that, technology neutrality requires "the avoidance of any special treatment in respect of different technologies used by market participants". The Commission considers this to be an important guiding principle.

The impact of five minute settlement on technology neutrality is related to the existing distortion the misalignment of dispatch and settlement currently creates. That is, 30 minute settlement results in generators responding to a 30 minute price, rather than the more efficient five minute dispatch price. In doing so, the market design favours slower, less flexible technologies at the expense of more flexible alternatives. These flexible and fast response technologies could more efficiently respond to the five minute price and the emerging system conditions in the power system.

In that sense, the Commission considers that five minute settlement provides an improved price signal that would be more technology neutral. Over time, five minute settlement will result in a more efficient generation mix and lower cost to consumers.

3.4 Commission's position

The Commission considers that aligning dispatch and settlement at five minutes would have the following significant enduring benefits relative to current arrangements:

1. improved price signals for more efficient generation and use of electricity
2. improved price signals for more efficient investment in capacity and demand response technologies to balance supply and demand
3. improved bidding incentives.

By aligning the financial incentives for participants with the physical operation of the market, five minute settlement will more accurately reward those who can deliver supply or demand side responses when they are needed by the power system. In contrast, 30 minute settlement provides an incentive to respond to expected 30 minute prices, rather than the five minute dispatch price. This pricing distortion leads to generator and demand responses that can occur up to 25 minutes after they are required by the power system.

Aligning dispatch and settlement at five minutes and creating an improved price signal also provides the right incentives for innovation and investment. In particular, efficient investment and innovation in an appropriate amount of flexible generation and demand side technologies. The expected result over time is a more efficient mix of generation assets and demand response technologies leading to lower supply costs. This will benefit consumers as reduced wholesale electricity costs flow through to lower retail prices.

Data shows that the differences between five minute dispatch prices and 30 minute prices has become greater over the past few years, with the largest differences observed in South Australia and Queensland. The distortion due to 30 minute settlement is expected to increase in the future; hence the benefits of the improved price signal under five minute settlement are likely to become greater over time. The Commission expects that it will result in materially more efficient operation and investment decisions relative to 30 minute settlement.

4 Impact on electricity contracts market

The Commission has considered whether five minute settlement will allow for hedging and risk management outcomes as part of its assessment of this rule change. As noted in Chapters 1 and 3, market participants and intermediaries enter into contractual arrangements external to the NEM physical market to manage the risks associated with volatile wholesale prices. As a result, the prices that retailers offer via retail electricity contracts will depend on their hedging arrangements, including the type, volume and prices of the contracts that they have purchased.

The Commission would be concerned if a move to five minute settlement affected the ability of market participants to manage risk through the wholesale contract market, as this could damage competition in the retail market and lead to higher prices for consumers.

4.1 Stakeholder views

A key concern of some stakeholders is the potential impact of five minute settlement on the contracts market that participants use to manage their exposure to risks in the NEM physical market. This issue has been raised throughout the rule change process, including in submissions to both the consultation[74] and directions papers.

In the last round of submissions, some stakeholders continued to be of the view that the availability of hedging contracts and therefore market liquidity would be reduced by a move to five minute settlement.[75] This would lead to the remaining contracts costing more. Some stakeholders also expected that there would be greater demand for contracts due to the reduced effectiveness of assets in vertically-integrated portfolios and because five minute demand can be higher than 30 minute demand.[76] The biggest impact would be on 'cap' contracts, although 'swap' contracts would also be affected, submitters said.[77]

The argument put forward in relation to cap contracts was that peaking generators – the typical sellers of these contracts – mostly require longer than five minutes to physically respond to changes in the market if they are at rest. They would therefore not be able to defend a contract settled on five minute prices.[78] Alongside the directions paper the Commission published a consultant report by Energy Edge that

74 For a summary of these submissions see pp. 38-42 of the directions paper.

75 Directions paper submissions: AFMA, pp. 3-6; Hydro Tasmania, pp. 1-2; Infigen Energy, p. 3; Arrow Energy, p.10; Origin Energy, p.2; Snowy Hydro, pp. 1-2; Aurora Energy, p. 4; Major Energy Users, p. 34.

76 Stanwell, directions paper submission, p. 12.

77 An explanation of the different types of hedging contracts was provided in the AEMC's directions paper, with further details available in the Energy Edge report. A brief summary of the most common contract types, swaps and caps, is provided in Box 4.1 at the end of this section.

78 Directions paper submissions: Arrow Energy, p. 2; Flow Power, p. 2; Major Energy Users, p. 20; Origin Energy, p. 10.

estimated an annual reduction in the volume of traded cap contracts of 23 per cent, or 625 MW.[79] Stakeholders were generally of the view that the Energy Edge analysis was conservative and had underestimated the actual impact on cap volumes.[80] Snowy Hydro and Marsden Jacobs (in a report commissioned by Snowy Hydro) provided competing analysis that five minute settlement would cause a 4,200 MW reduction in the volume of caps, including a 2,640 MW reduction from Snowy Hydro.[81]

There was a view put forward that prices would be higher and more volatile due to uncontracted generators seeking revenue through the spot market (as opposed to receiving cap contract payments).[82] Conversely, the Australian Energy Council (AEC) thought that there could be more price volatility due to peaking generators being unwilling to respond to price spikes.[83]

In relation to swaps, AFMA noted that the directions paper contained limited comment on the impact on swaps. AFMA considered that, "the potential effect on swaps and futures is just as important [as caps] and potentially will involve additional costs". A few stakeholders noted that an increase in the price of caps would be reflected in the pricing of swaps due to the interaction between the products.[84] ERM Power and Stanwell thought that there would be a decrease in the volume of swaps sold due to the risk of a unit trip or load rejection.[85]

A common concern was that the reduction in the liquidity of contracts would be detrimental for smaller, second tier retailers.[86] Proponents of this view considered that it would be more difficult for second tier retailers to compete with their vertically-integrated competitors who have alternative means to manage risk, aside from purchasing cap contracts.

Incumbent participants voiced uncertainty and doubt about the ability of new technologies to compensate for a reduction in the availability of hedging contracts for existing plant.[87] For example, Energy Queensland submitted that batteries are small-scale and offered as non-firm demand response, so their potential to replace hedge cover is minimal.[88]

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79 Energy Edge, *Effect of 5 Minute Settlement on the Financial Market*, March 2017.

80 Directions paper submissions: Snowy Hydro, p. 11; Origin Energy, p.2; Energy Queensland, p. 3; ERM Power, pp. 2, 11; EnergyAustralia, p. 9.

81 Directions paper submissions: Snowy Hydro, p. 11; Marsden Jacobs, pp. 36-37.

82 Directions paper submissions: Snowy Hydro, p. 18; Arrow Energy, p. 2; Major Energy Users, p. 27.

83 AEC, directions paper submission, p. 2.

84 Directions paper submissions: Origin Energy, p. 10; Infigen Energy, p. 3; Marsden Jacobs, p. 35.

85 Directions paper submissions: ERM Power, p. 10; Stanwell, pp. 8-9.

86 Directions paper submissions: Hydro Tasmania, p. 10; ERM Power, p. 10; Stanwell, p. 13; Origin Energy, p. 2; Snowy Hydro, p. 2; AEC, p. 3; Meridian/Powershop, p. 2.

87 Directions paper submissions: AFMA, p. 4; Energy Queensland, pp. 10-11; Infigen Energy, pp. 6-7; Origin Energy, p. 2; Snowy Hydro, p. 19.

88 Energy Queensland, directions paper submission, pp. 10-11.

A range of other stakeholders provided a contrasting view. The Clean Energy Council and Energy Consumers Australia thought that participants would be able to adapt to the change.[89] Tesla submitted that batteries (utility scale and residential) can be used within the cap market.[90] Wärtsilä submitted that its internal combustion engines can respond from standby mode to full output within five minutes and can provide an effective physical hedge for sold cap contracts.[91]

EnerNOC noted that businesses can use controllable resources behind the meter to offset the need to buy caps. It also thought that with five minute settlement, fast-responding customers would have more confidence to be exposed to spot prices which would reduce the demand for hedging contracts.[92] Mojo Power, Meridian Energy Australia and the South Australian Government also thought that behind the meter resources could be used for risk management purposes.[93]

89 Directions paper submissions: Clean Energy Council, p. 4; Energy Consumers Australia, p. 6.

90 Tesla, directions paper submission, p. 3.

91 Wärtsilä, directions paper submission, p. 2.

92 EnerNOC, directions paper submission, p. 4.

93 Directions paper submissions: Mojo Power, pp. 3-4; Meridian/Powershop, p. 2; South Australian Government, p. 1.

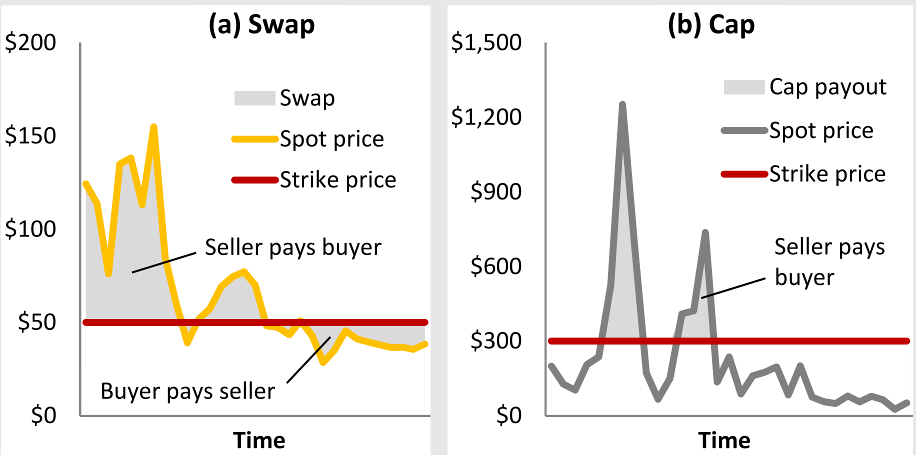
Box 4.1 Swap and cap contracts explained

The most common types of electricity derivatives are swaps (referred to as futures in ASX trades) and caps. In 2014/15, swaps accounted for 79 per cent of trading in electricity derivatives while caps accounted for 16 per cent of the volume.

These contracts operate as follows:

- **Swap:** A swap contract trades a given volume of energy during a fixed period for a fixed price (the strike price). The variable wholesale market spot price is, in effect, swapped for the fixed strike price. The contract is settled through payment between the counter-parties based on the difference between the spot price and the strike price. Figure 4.1(a) provides a stylised example of this arrangement. The natural seller of a swap is a baseload generator whereas the natural buyer is a retailer. For both parties, the swap is a hedge against spot price volatility. Retailers typically use swaps to hedge the average component of their customer load profile.
- **Cap:** A cap contract trades a fixed volume of energy for a fixed price when the spot price exceeds a specified price, which is typically $300/MWh. It provides the buyer of the contract with insurance against high prices. The seller of a cap is required to pay to the buyer the difference between the spot price and $300/MWh every time the spot price exceeds $300/MWh. Figure 4.1(b) provides a stylised example. The natural sellers of caps are peaking generators whereas the natural buyers of caps are retailers and large energy users. Caps are most suitable to hedge load that is variable or less certain.

Figure 4.1 Example of swap and cap contracts



4.2 Analysis

The Commission in the analysis that follows examines how swaps and caps operate, the price impact on a cap and a contract portfolio under five and 30 minute settlement, and the ability of existing peaking generators to continue to offer caps under five minute settlement. The Commission's consideration of the potential impact of five minute settlement on hedging and risk management is structured as follows:

- Hypothetical examples of how a retailer can hedge a retail load, to highlight the importance of swaps and caps (see swaps and caps explained in Box 4.1)
- An analysis of the difference in the intrinsic value of caps using historical five and 30 minute data, which is then applied to the hypothetical examples to assess portfolio costs
- An analysis of the ability of peaking generators to sell caps under five minute settlement
- A summary of alternative risk management options.

4.2.1 Hypothetical examples of hedging with swaps and caps

This section presents hypothetical examples of how a retailer can use swap and cap contracts to hedge a retail portfolio, the indicative hedging costs and the impact on the retailer's cash flow volatility (or risk).

While each business will have its own policies for and flexibility around hedging, a typical strategy[94] to hedge a retail load will be to:

- Purchase swap contracts such that the average net exposure is zero i.e. volume of base load swap contracts = average base load consumption.
- Purchase peak load swap contracts such that the average net peak load exposure is zero, i.e. the volume of peak load swap contracts = average peak load consumption.
- Purchase cap cover above the swap contracted level to hedge for load flex, up to a predetermined level, such as 10 per cent probability of exceedance (PoE), or expected maximum demand level.[95]

In order to highlight the likely hedging costs and risk reduction benefits, our analysis was to:

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94 Energy Edge, *Ibid*, p. 10.

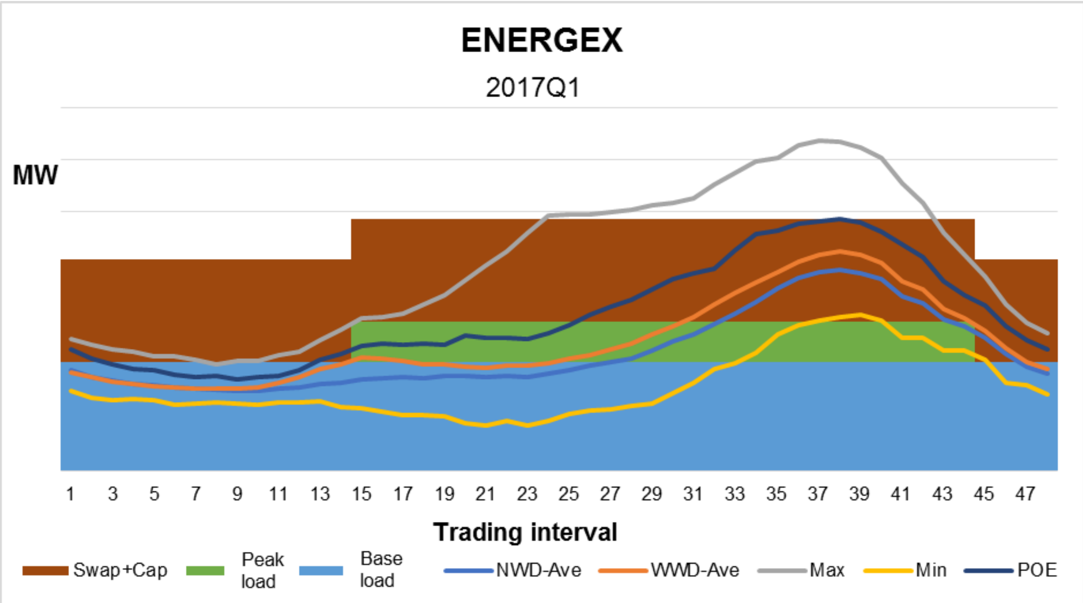
95 Caps are classified as an "ineffective hedge" as per IAS39 (International Accounting Standard for Financial Instruments: Recognition and Measurement) and may be an excluded risk management product for this reason.

1. Model the contracting requirements of a typical customer portfolio based upon the net system load profile (NSLP). The NSLP is representative of households and small businesses with accumulation metering.[96] The NSLP data was used to calculate the average peak load, average base load and 10 per cent PoE level for each network region by quarter.

2. Overlay the corresponding regional spot prices and daily closing prices for ASX caps, peak and base load futures contracts to determine the cost of hedging the portfolios. The data source was ASX Energy.

Figure 4.2 and Figure 4.3 illustrate the hedging strategy for the south east Queensland (SEQ) for Q1 2017 and ACT for Q3 2016 based on the typical strategy described above. Respectively, these show extremes for summer and winter load profiles.

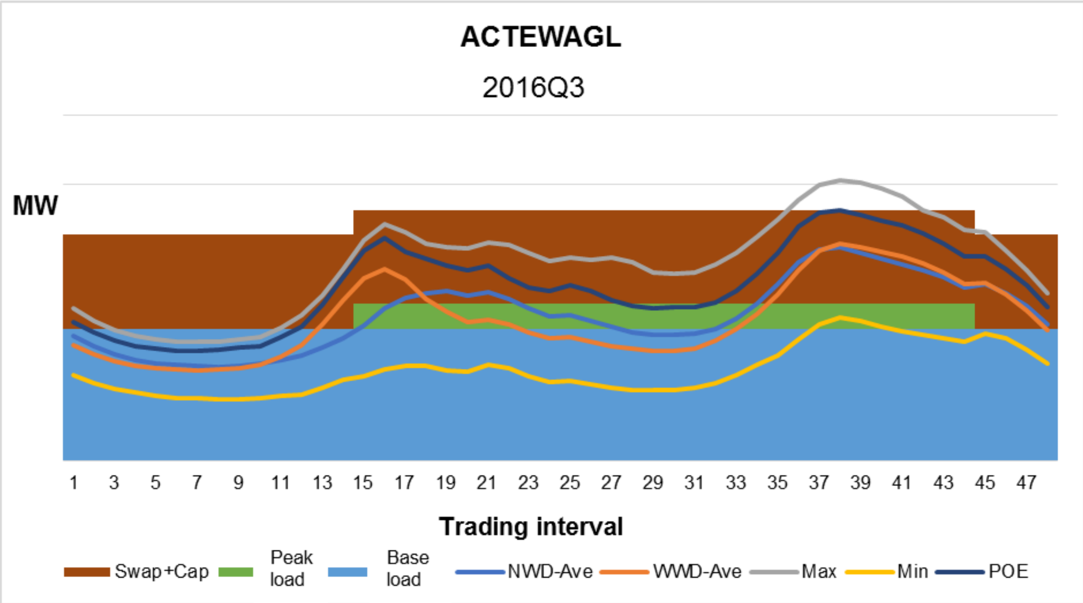
Figure 4.2 SEQ NSLP hypothetical hedging strategy for 1st quarter 2017



Note: NWD-Ave=Non-Working Day average half-hourly load. WWD-Ave=Working Week Day average half-hourly load. Max=Maximum half-hourly load. Min=Minimum half-hourly load. POE=Probability of Exceedance load (10%), where the load only exceeds this half-hourly load 10% of the time.

96 More information on the settlement-by-difference and NSLP arrangements are discussed in section 6.3.3.

Figure 4.3 ACT NSLP and hypothetical hedging strategy for 3rd quarter 2016



To capture the way in which hedges are used, and their cost, it was assumed that each calendar year was contracted three months prior, i.e. as close as possible to the first of October. This was done so that the analysis is not influenced by 'last minute' purchasing, whilst also ensuring that there would be adequate levels of market liquidity. As the analysis uses actual demand data for each quarter, it effectively assumes that the retailer has 'perfect foresight' over its future load.

The quarterly data was aggregated to provide a comparison of the portfolio costs. In Figure 4.4 and Figure 4.5 below:

- column 1 is the average price for the retail portfolio, in the absence of any hedging contracts
- column 2 is the average price for the retailer when it buys peak load and base load swaps to cover average peak load and base load, but load flex beyond this is unhedged
- caps are added in column 3.

The remaining columns show the standard deviation of daily prices. An increase in price or volatility using swap or cap hedging products is highlighted in red, whilst a reduction is highlighted in green.

Figure 4.4 ACT retail portfolio costs Q1 2015 to Q1 2017

Quarter	(1) LWAP	(2) LWAP-SWAP	(3) LWAP-SWAP-CAP	LWAP (s.d)	LWAP-SWAP (s.d)	LWAP-SWAP-CAP (s.d)
2015Q1	$36.04	$39.28	$42.50	38%	17%	16%
2015Q2	$37.77	$35.27	$36.37	25%	13%	16%
2015Q3	$48.20	$39.30	$37.85	152%	49%	39%
2015Q4	$46.51	$39.31	$40.06	55%	28%	17%
2016Q1	$47.31	$42.97	$47.18	46%	21%	18%
2016Q2	$89.29	$46.83	$49.75	38%	37%	33%
2016Q3	$59.22	$44.15	$46.12	45%	18%	17%
2016Q4	$65.64	$39.81	$40.21	87%	17%	103%
2017Q1	$161.46	$87.14	$77.78	146%	154%	66%

Figure 4.5 SEQ retail portfolio costs Q1 2015 to Q1 2017

Quarter	(1) LWAP	(2) LWAP-SWAP	(3) LWAP-SWAP-CAP	LWAP (s.d)	LWAP-SWAP (s.d)	LWAP-SWAP-CAP (s.d)
2015Q1	$151.30	$101.87	$71.83	244%	183%	77%
2015Q2	$33.96	$35.28	$38.31	27%	17%	15%
2015Q3	$51.07	$44.39	$43.39	60%	34%	18%
2015Q4	$46.18	$48.75	$53.69	51%	25%	18%
2016Q1	$107.86	$116.46	$121.25	103%	47%	28%
2016Q2	$83.72	$51.54	$55.86	33%	17%	19%
2016Q3	$59.54	$52.21	$57.99	38%	14%	12%
2016Q4	$70.68	$65.52	$76.91	34%	22%	17%
2017Q1	$255.61	$173.95	$137.48	124%	95%	40%

Note: RRP: time-weighted average 30 minute regional reference price; LWAP: load-weighted average price; LWAP-SWAP: load weighted average price net of swap contracts (energy spot purchases +/- difference payments from swaps); LWAP-SWAP-CAP: load weighted average price net of swap contracts and cap contracts (energy spot purchases +/- difference payments from swaps – cap premium + cap payout); LWAP(s.d), LWAP-SWAP(s.d) and LWAP-SWAP-CAP(s.d): standard deviation of daily LWAP/ LWAP-SWAP/ LWAP-SWAP-CAP, a measure of the volatility of outgoing cash flows for the retailer.

For example, in Q1 2017 for SEQ, the unhedged average price for the portfolio is $256/MWh, with a standard deviation of the daily outgoing cash flows of 124 per cent. Purchasing swaps reduces the price to $174 and standard deviation to 95 per cent. Purchasing both swaps and caps further reduced both average price and volatility.

Although it is impossible to predict whether or not contracting will increase or decrease the load-weighted average price of the portfolio, in most cases it should reduce the volatility in the outgoing cash flows for the retailer. This is the prime motivation for a retailer to contract; hedging provides for more consistent cash flows that are better aligned with income received from customers billed at a fixed price per MWh. In these examples for retail load in SEQ and ACT, hedging may increase or decrease the portfolio cost relative to paying the spot price.[97] However, it generally results in a reduction in the variability of outgoing cash flows.

4.2.2 Impact of increased intrinsic value of caps

The intrinsic value of a cap contract is the amount that a cap is worth (in $/MWh) based on the payout a buyer would receive due to spot prices being above $300/MWh. It is calculated as follows:

1. the sum of spot price minus $300 for all intervals when the price is above $300/MWh

2. divided by the number of intervals during the analysis period.[98]

This excludes the risk premium paid by the buyer of a contract to account for uncertainty.

Table 4.1 illustrates the method of calculating the intrinsic cap value using five and 30 minute data from New South Wales in 2015/16.

Table 4.1 Intrinsic value of caps in NSW for 2015/16

Step of calculation	30 minute prices	5 minute prices
Sum of prices above $300	$34,826.74	$221,541.70
Number of periods with prices above $300	10 (5 hours)	86 (14.3 hours)
Less $300 for each of these periods	$31,826.74	$195,741.70
Total number of periods (both above and below $300)	17,568	105,408
Intrinsic value of cap	$1.81/MWh	$1.86/MWh (+2.8%)

The table illustrates that in New South Wales in 2015/16, there were five hours' worth of 30 minute intervals when prices were over $300/MWh, compared to 14.3 hours' worth of five minute intervals. The intrinsic value of a cap contract settled against 30 minute prices was $1.81/MWh, while the value for the five minute settled cap was

97 Increase or decreases in hedged portfolio costs relative to an unhedged portfolio assume ceteris paribus. If retailers and loads do not contract with generators, then spot prices would typically be higher. This is discussed in Anderson et al. (2007). Forward contract in electricity markets: The Australian Experience, *Energy Policy*, 35(5), 3089-3103.

98 This is equivalent to first dividing the sum by two if the prices are 30 minute resolution, or six for five minute prices, then dividing by the number of hours in the analysis period to produce a $/MWh figure.

$1.86/MWh. This coincides with a 2.8 per cent increase in the intrinsic value of a cap under five minute settlement for the period described.

The Energy Edge report (commissioned by the AEMC) and the Russ Skelton & Associates (RSA) report (commissioned by the AEC) noted that, historically, the intrinsic value of caps would have been greater had they been settled against five minute rather than 30 minute prices.[99] The results from the respective reports are shown in Table 4.2 below. The difference in 30 minute and five minute outcomes arise due to the mathematical possibility that a cap contract settled against five minute prices can pay out more often than a half hourly cap.[100]

Table 4.2 Historical difference in intrinsic value of caps with five minute settlement

Region	Energy Edge report	RSA report
Queensland	$1.29 (+9.1%)	+41%
New South Wales	$0.06 (+4.2%)	+23%
Victoria	$0.10 (+14.2%)	+39%
South Australia	$4.91 (+46.5%)	+59%

Note: The period of the Energy Edge analysis is January 2015 to March 2017, while the RSA report covers 2012 to 2017.

Since the Energy Edge report was prepared in March 2017, AEMO revised its pricing for South Australia to account for the suspension of the market in the period after the Black System Event (29 Sept to 11 October 2016). Using the most recent prices for South Australia, the Commission calculates that the intrinsic value of caps would be around 10 per cent greater for South Australia in the equivalent period, rather than the 46 per cent difference originally calculated by Energy Edge.

As an extension of the analysis presented in section 4.2.1, the average portfolio costs for SEQ and ACT were recalculated assuming an increase in the intrinsic value of caps due to five minute settlement. The change in intrinsic value for contracts that would be purchased for ACT and SEQ supply areas respectively are shown in Table 4.3 below.

99 Energy Edge, *ibid*, pp. 40-42; Russ Skelton & Associates, p. 23.

100 If a 30 minute price is above a strike price of $300/MWh, then by definition there must have been at least one five minute period within the half hour with a price above $300/MWh. However, the opposite does not hold: if a 30 minute price is below $300/MWh, there may have been five minute periods within that half hour with prices above $300/MWh.

Table 4.3 Change in intrinsic value for settling on historical five minute prices

Quarter	New South Wales	Queensland
2015Q1	$0.01	$2.24
2015Q2	$0.16	$0.01
2015Q3	$0.03	$0.29
2015Q4	$0.10	$0.06
2016Q1	$0.04	$3.20
2016Q2	$0.01	$0.10
2016Q3	$0.00	$0.06
2016Q4	$0.14	$0.53
2017Q1	$0.27	$3.69
AVERAGE	$0.09	$1.13

For Table 4.4, it was assumed that the market reflects the change in value and there is an increase in the average price of the portfolio. The largest changes are observed for SEQ in Q1 2017. Relative to the portfolio costs presented in the tables above, the Q1 2017 changes are in the order of 5 per cent increases on LWAP-SWAP-CAP. In the ACT example, the increases are much smaller in both absolute and percentage terms (a 0.04 per cent increase for Q1 2017 is the largest during the period analysed).

Table 4.4 Change in portfolio costs due to changed intrinsic value of caps

Quarter	ACT	SEQ
2015Q1	$0.00	$1.99
2015Q2	$0.13	$0.01
2015Q3	$0.02	$0.37
2015Q4	$0.05	$0.06
2016Q1	$0.04	$2.62
2016Q2	$0.01	$0.10
2016Q3	$0.00	$0.07
2016Q4	$0.12	$0.53
2017Q1	$0.30	$3.36
AVERAGE	$0.08	$1.01

This historical analysis of five and 30 minute prices produces a limited increase in the intrinsic value of caps, translating to relatively minor increases in load-weighted average prices for a retail portfolio (assuming the full increase in value is passed through).

The Commission considers that these results are a worst case scenario representing the upper bound of the potential impact on average portfolio prices. The historical differences occur because there were instances of a five minute prices exceeding $300, but the corresponding 30 minute average price was below this threshold. Currently, sellers of half hourly caps are incentivised to keep 30 minute prices below $300; they are somewhat indifferent to whether five minute prices are above $300.

Under five minute settlement, cap sellers would be incentivised to keep five minute prices below $300. The Commission expects that with five minute settlement, five minute prices would be suppressed below $300 more than they have been historically. Therefore, the actual difference in the intrinsic value of caps should be smaller than calculated in this section.

4.2.3 Ability of peaking generators to sell caps

The physical capability of a plant determines the ability of the generator to defend caps. The Directions Paper provided extensive analysis on this topic, highlighting that there is plenty of existing capacity that can ramp up within five minutes from generators already on line. The analysis in the Directions paper is reproduced in Appendix C.

As mentioned in the summary in section 4.1, some stakeholders have concerns that moving to five minute settlement would limit the ability of existing peaking generators to sell cap contracts. The analysis presented by some stakeholders during the consultation process of this rule change has followed two methodologies:

1. The 'cold start' strategy: Assumes that peaking generators would only sell a volume of caps that it would be able to defend from an offline state. This strategy was identified by Snowy Hydro and a variation on this assumption was used in the Marsden Jacobs report. Marsden Jacobs calculated a 4,200 MW reduction in the volume of caps, while Snowy Hydro predicted a 2,640 MW reduction from its New South Wales hydro assets.

2. Historical behaviour: Energy Edge used historical generator output and regional prices to calculate the amount of generation that units achieved when prices were above $300/MWh. This analysis was performed on both a 30 minute and five minute basis. The 23 per cent, or 625 MW, reduction in cap volumes calculated in the report was derived from the differential between the amount of generation achieved in 30 minute periods >$300 versus five minute periods >$300.

Evaluation of the 'cold start' strategy

The Commission considers that the 'cold start' assumption utilised by Snowy Hydro and Marsden Jacobs does not provide an accurate representation of the volume of caps that would be sold under five minute settlement. The strategy assumes that, most of the time, price spikes are unexpected, which is unlikely to be the case. The analysis will also show that if this strategy was used by participants under the existing 30 minute settlement then there would likely be no change in cap contracting levels in a move to five minute settlement.

Price spikes are generally not unexpected

Prior studies have shown that:

- a single price spike usually influences the half hourly price
- there is inherent difficulty in forecasting which of the six dispatch intervals will have the highest price.

For example, the Energy Edge and RSA reports identified that, historically, contiguous dispatch intervals at prices above $300 or $1,000 have been uncommon. Energy Edge showed that in the period January 2015 to March 2017, just under 70 per cent of the hours containing dispatch prices above $1,000 involved only a single dispatch interval above this threshold.

The Commission recently analysed AEMO's demand and price forecasts during the Non-scheduled generation and load in central dispatch rule change.[101] It found that

101 AEMC, *Non-scheduled generation and load in central dispatch*, draft determination, 20 June 2017, Appendix D.

the demand forecasts are generally accurate. AEMO's price forecasts are not as accurate as the demand forecasts, though this it to be expected as the price forecasts are a price signalling mechanism. Energy Edge made observations about the incidence of 'false positive' and 'false negatives' in the five minute pre-dispatch schedule.

Notwithstanding this, the Commission considers that price spikes in the NEM are generally not unexpected. The Commission took five and a half years' worth of data from January 2012 up to and including July 2017 for the NEM states of New South Wales, Victoria, Queensland and South Australia and analysed the conditions present when the dispatch price was above $1,000/MWh.

The cap contract analysis was based on price events greater than $1,000/MWh. This threshold level was selected for a number of reasons including consistency with other analysis and in light of the fact that the vast majority of the payout on cap contracts is attributable to high price events where the price is greater than $1,000/MWh.[102]

Several observations are presented in Table 4.5.

Table 4.5 Percentage of observations matching criteria when five minute price >$1,000/MWh

Region	Percentage of time Price Spike when demand >80% of Quarterly Maximum	Price spike in peak time 7am-10pm	Price spikes in summer
NSW	94%	100%	62%
QLD	78%	86%	77%
VIC	98%	100%	58%
SA	52%	95%	38%

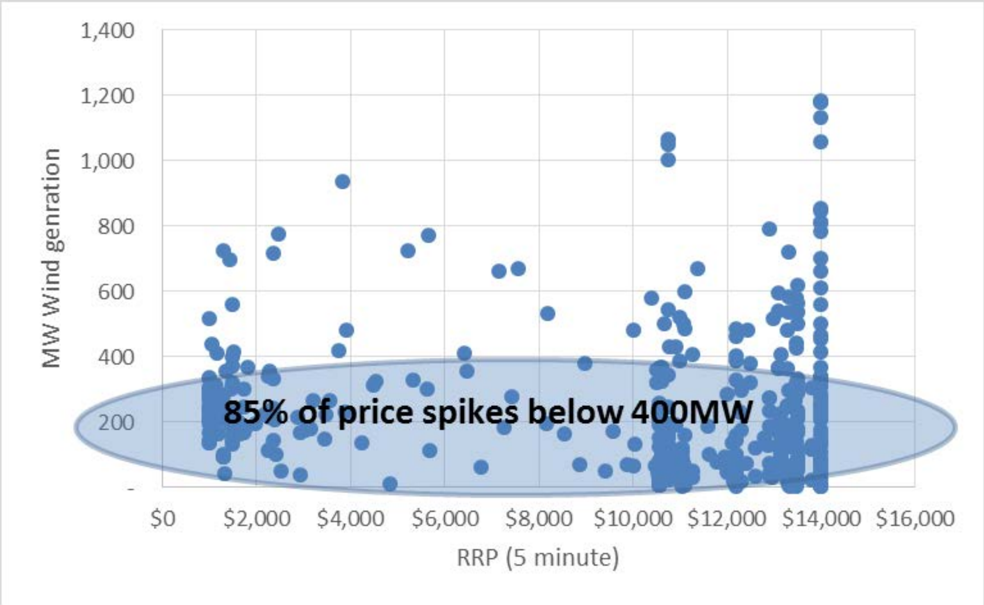
It can be observed that, in New South Wales, Queensland and Victoria, that price spikes are most likely to occur in peak times and when demand is expected to be at least 80 per cent of the maximum demand for that quarter.

South Australia appears to be more unpredictable using these metrics, which may be due to the relatively high penetration of wind and solar generation, as well as interconnector limits and outages. Figure 4.6 shows five minute regional prices plotted against the aggregate wind generation in South Australia. It shows that 85 per cent of

102 For example, in South Australia in financial year 2016/17, there were 410 trading intervals where the price was greater than $300/MWh and cap contracts would have paid out, with the total value of energy above $300/MWh being $715 million. Of these 410 high price trading intervals, some 105 had prices greater than $1,000/MWh. Of critical significance is the fact that these 105 trading intervals with prices above $1,000/MWh accounted for nearly 93% of the total cap payout value indicating that using a $1,000/MWh threshold is unlikely to materially impact the findings.

prices spikes above $1,000/MWh occur when wind farm output is below 400 MW, suggesting that low wind farm output is a potential predictor of high prices.[103]

Figure 4.6 South Australia wind generation versus five minute prices



The Commission understands that participants would desire to know the exact dispatch interval in which a price spike will occur. However, it considers that this level of precision is not necessarily required for participants to operate effectively. Uncertainty is normal and inevitable in the wholesale electricity market. Innate risks in the power system – transmission or power station outages, other participants' behaviour, unforeseen changes in demand – are reflected in price movements, particularly when these things move in a way that was unexpected. Being exposed to sudden price movements is therefore an inherent aspect of participating in the spot market and informs investment decisions.

The 'cold start' strategy under 30 minute settlement

One of the factors influencing a generator's willingness to sell contracts (including caps), is the physical ramp rate a unit can achieve.[104] The time a generator takes to ramp to its maximum output will vary depending on its technical characteristics and starting output level.

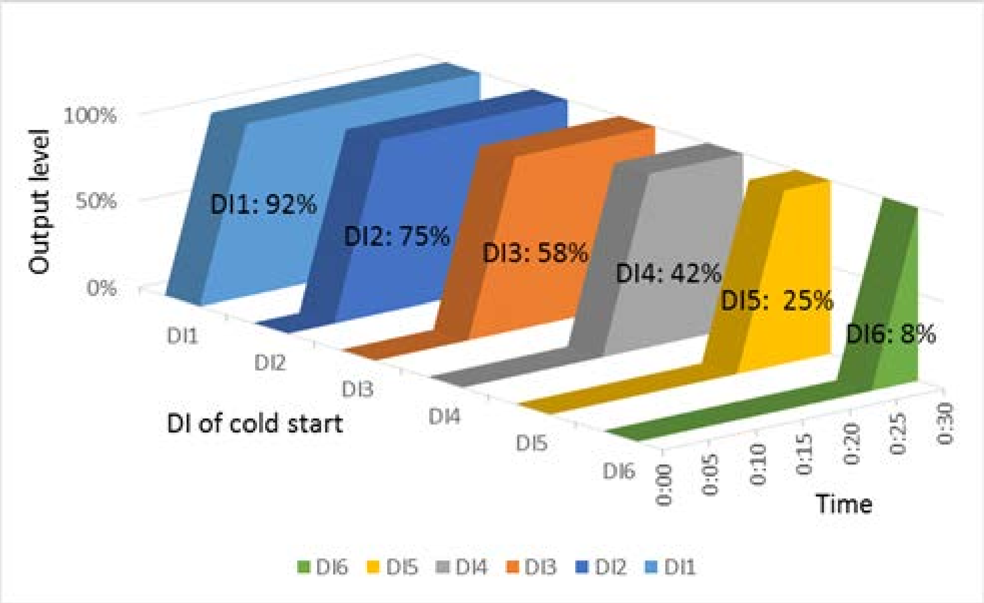
As explained below, if the 'cold start' (offline) assumption was applied to the current 30 minute settlement arrangement, there would potentially be no difference between 30 minute and five minute settlement contracting levels.

103 400 MW is approximately 25 per cent of the installed capacity. South Australia has 1,595MW of installed wind capacity as of June 2017.

104 Other factors that influence a generator's willingness to sell contracts, in no particular order, are: counterparty credit risk; perceptions about future spot prices; supply of gas/water or other energy source; fuel costs; running costs; reliability of plant; planned maintenance; number of individual generating units; competition from other generators; and start/stop times.

In the Marsden Jacobs analysis identifying a potential 4,300 MW reduction in cap volumes, it was conservatively assumed that non-operating peaking generators can supply 50 per cent of their full load energy within five minutes. This is equivalent to ramping linearly from 0 to 100 per cent output within five minutes. Figure 4.7 shows the energy delivered from a cold start by a generating unit that ramps linearly from 0 to 100 per cent within five minutes under six scenarios (that correspond to each dispatch interval).

Figure 4.7 Energy dispatched within a trading interval



The percentages represent the proportion of the generator's energy that would be delivered over a 30 minute trading interval, depending on the dispatch interval in which the unit starts. For example, if the generator starts at the beginning of DI1 and reaches full output within five minutes and sustains this output for the remainder of the half hour, then the electricity delivered would be 92 per cent of the energy that would have been provided had the generator been at full output for the whole half hour.

If it is assumed that price spikes can occur with equal probability across the trading interval, then the probability that the unit will need to undertake a cold start in any dispatch interval is one in six. The average amount of energy that could be delivered within a half hour would therefore be equivalent to the generator running at 50 per cent of its capacity rating for the whole trading interval.[105]

To summarise, this analysis shows that a generator that ramps from 0 to 100 per cent output within five minutes is able to deliver:

- 50 per cent of its full load energy within five minutes

105 Average amount of energy that could be delivered within a half hour = (92% + 75% + 58% + 42% + 25% + 8%)/6 = 50%.

- An average electricity delivery of 50 per cent of its full load energy within half an hour, if price spikes are assumed to be evenly distributed across a trading interval.[106]

If the amount of electricity that can be delivered from a 'cold start' within a settlement period is genuinely the limiting criteria to the level of caps sold, a move to five minute settlement would likely cause no change in contracting levels.

Energy Edge's historical behaviour analysis

Energy Edge's methodology addresses some of the shortcomings of the 'cold start' assumption as it reflects the actual ability of asset classes to capture high prices under 30 minute settlement.

To further understand the result, the Commission looked at the operating levels of generators at the start of every dispatch interval in 2016/17 when the price was over $1,000/MWh.

Figure 4.8 below shows the average operating level (expressed as a percentage of unit registered capacity) for all gas, hydro and liquid fuel generators in Queensland, New South Wales and South Australia.[107] It also shows the percentage of these $1,000/MWh intervals when the generator was not at zero output at the start of the interval. The analysis shows that peaking generators are often already operating at a high level of output at the start of these intervals and are unlikely to be offline. This is particularly true of generators in New South Wales and Queensland during this period.

106 If there was a systematic bias towards DI6 price spikes, then the average electricity delivery would be lower. Conversely, a bias towards DI1 spikes would suggest a higher average electricity delivery, using this methodology.

107 Victoria was excluded as there were only four dispatch intervals in 2016/17 where the prices was above $1,000/MWh.

Figure 4.8 Operating level at start of five minute intervals with prices >$1,000

Region	Station	Registered capacity (MW)	Average of Initial MW	Proportion of intervals when Initial MW > 0
NSW1	Blowering	80	86%	100%
NSW1	Colongra	724	12%	15%
NSW1	Guthega	60	73%	82%
NSW1	Hume NSW	29	134%	98%
NSW1	Shoalhaven	240	59%	98%
NSW1	Tallawarra	440	30%	35%
NSW1	Tumut3	1,500	114%	100%
NSW1	Upper Tumut	616	99%	100%
NSW1	Uranquinty	664	96%	100%
QLD1	Barcaldine	37	56%	59%
QLD1	Barron Gorge	60	89%	82%
QLD1	Braemar 2 Power	519	52%	64%
QLD1	Braemar Power	504	69%	79%
QLD1	Condamine A	144	90%	100%
QLD1	Darling Downs Power Station	644	84%	100%
QLD1	Kareeya	84	96%	97%
QLD1	Mackay GT	30	8%	19%
QLD1	Mt Stuart	419	51%	71%
QLD1	Oakey	282	80%	84%
QLD1	Roma	80	58%	85%
QLD1	Swanbank E	385	0%	0%
QLD1	Townsville GT	242	75%	84%
QLD1	Wivenhoe	500	10%	12%
QLD1	Yarwun Power Station	154	100%	100%
SA1	Angaston Power Station	50	42%	70%
SA1	Dry Creek	156	31%	52%
SA1	Hallett	180	59%	88%
SA1	Ladbroke Grove	80	82%	81%
SA1	Lonsdale Power Station	41	69%	76%
SA1	Mintaro	90	52%	61%
SA1	Osborne	180	83%	84%
SA1	Pelican Point	478	23%	52%
SA1	Port Lincoln	73	6%	15%
SA1	Port Stanvac Power Station 1	58	56%	65%
SA1	Quarantine	224	53%	65%
SA1	Snuggery	63	26%	50%
SA1	Torrens Island A	480	54%	65%
SA1	Torrens Island B	800	63%	79%

Note: Shows each unit's average operating level for 231 intervals in Queensland, 60 intervals in NSW, and 194 intervals in South Australia. Values above 100 per cent indicate that a unit was, on average, generating above its registered capacity.

This analysis suggests that peaking generators may be generating in anticipation of price spikes so that start-up times and ramp rates are less of a constraint. In its submission, Snowy Hydro indicated that a defendable cap position would be 260 MW from its New South Wales hydro assets (Tumut 3 and Upper Tumut), compared to a combined registered capacity of 2,116 MW. In 2016/17, these units were, on average, generating at or above their registered capacities at the start of five minute intervals when prices were above $1,000/MWh. The Commission therefore questions whether the 260 MW figure is an accurate representation of the volume of caps that would be sold under five minute settlement.

The results also show relatively high average loading levels for gas generators in Queensland. For example, 90 per cent for Condamine, 84 per cent for Darling Downs, 78-81 per cent for the Oakey units, and 61-71 per cent for six of the seven units at Braemar 1 and 2. The average loading levels during $1,000/MWh price spikes in South Australia in 2016/17 tended to be lower, including loading levels in the 60-70 per cent range for the Torrens Island which, as a baseload generator, would be expected to already be online when many price spikes occur.

This analysis indicates that peaking generators tend to already be online at the start of five minute intervals when prices are above $1,000/MWh. The Commission considers that the cap reduction calculated by Energy Edge is the upper bound of the potential reduction in volumes from five minute settlement. The historical data shows that existing generators are often highly effective at capturing five minute price spikes, even though they are not directly compensated for providing energy during these times.

In the same way that asset owners maximise their profits under 30 minute settlement, the Commission expects that asset owners will maximise profit under five minute settlement and would therefore be more effective at capturing five minute price spikes than the historical analysis would suggest. The Energy Edge analysis also effectively assumes that five minute settlement is implemented straight away, whereas in practice a transition period would be provided so that participants can prepare and adapt.

4.2.4 Alternative sources of cap contracts

In its directions paper, the Commission noted a range of alternative ways in which cap contracts could continue to be sold and options that participants could implement to offset their need for caps.

These options are summarised as follows:

1. New financial products could be developed that better match the physical capability of existing fast start generators. For example, Asian caps, or callable caps with a defined notice period (e.g. 12 or 24 hours in advance).
2. Baseload generators selling more caps. However, this would potentially be coupled with a reduction in the availability of swap contracts.
3. Investing in utility-scale energy storage and thermal plant technologies that are highly flexible and could operate effectively under a five minute settlement market design. This includes energy storage, internal combustion engines and aero-derivative gas turbines. A discussion on these technologies was provided in Chapter 4 of the directions paper.

4. Large energy users investing in fast-response demand management technologies to manage spot exposure or participating in the wholesale market via a retailer demand response program. This could enable large users and retailers to reduce the volume of caps that they need to buy.

5. Aggregation and control of storage devices located behind the meter at customers' premises. There are already examples of this occurring in the NEM.[108] This option could enable retailers to reduce the volume of caps that they need to buy.

6. Caps sold by financial intermediaries, if there is a sufficient differential between the implied intrinsic value of a cap and expected future spot market outcomes.

The Commission considers that, collectively, these options can likely compensate for a reduction in cap volumes from existing peaking generators, if a reduction is to occur. Notwithstanding this, most of these options would involve changes to risk management policies and physical infrastructure and may require multiple years to implement. This is one factor that has informed the length of the transition period for the implementation of the draft rule.

4.2.5 Thirty minute settlement as a way of risk management

Some stakeholders have suggested that 30 minute settlement is efficient because it allows participants to manage risk.[109] Energy Queensland stated that:

> "30 minute price signals are not inefficient as currently both fast start generation and demand side management are able to adequately respond to the 30 minute price signal."

For this reason, it was suggested that alignment at 15 minutes could be preferable to five minute settlement.[110] Snowy Hydro submitted that 15 minute alignment would have less adverse consequences due to the physical characteristics of the existing generation mix.

The Commission's view is that the existing 30 minute settlement, and the proposed 15 minute alternative, are indirect forms of risk management. Given the potential for price averaging to distort wholesale price signals, it is not an appropriate risk management feature.

The benefit that some stakeholders see in 30 minute settlement is that it can provide a level of assurance about the price that a generator will receive for future energy output. Specifically, if a price spike occurs at the beginning of a half hour trading interval, participants know that the 30 minute average price will be above a certain

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108 For example: AGL Energy's virtual power plant, Greensync, Reposit Power.

109 Directions paper submissions: Energy Queensland, p. 4; Hydro Tasmania, pp. 1-2; Snowy Hydro, p. 10; Stanwell, p. 24.

110 Directions paper submissions: Arrow Energy, p. 8; Major Energy Users, p. 3; Snowy Hydro, p. 3.

threshold.[111] In these situations, 30 minute settlement benefits fast start generators as they can commit to generate with the knowledge that they will receive revenue in excess of their fuel and start costs.

Stakeholders have also cited the inaccuracy of the pre-dispatch schedule as a reason that 30 minute settlement is needed to manage the risk of unexpected price spikes. This indicates that participants' abilities to manage risk, at least in part, depends on their ability to forecasts prices and, potentially, lock in a price and quantity of energy for future periods.

The Commission notes that there are a range of other market design options that exist in overseas electricity markets that could be explored to improve price visibility for risk management. The Commission is considering these options as part of the Reliability Frameworks Review and would welcome stakeholder comment as part of that process.[112] These options are outside the scope of the rule change request.

4.3 Commission's position

The Commission is of the view that participants will still be able to effectively manage wholesale market risks, because peaking generators will still have strong incentives to sell caps. Our analysis also suggests there is unlikely to be a significant increase in cap contract prices from five minute settlement.

To the extent that there is a reduction in cap volumes from existing peaking generators, there appear to be a range of alternatives that participants can use for risk management. These include applications involving new and emerging battery and demand response technologies that can be utilised to achieve similar risk management outcomes. Other potential sellers of caps contracts include baseload generators and financial intermediaries.

111 For example, if the prices spikes to $14,000/MWh for five minutes, the 30 minute price will be at least $1,500/MWh, multiple times the short run marginal cost of even the most expensive generators.

112 AEMC, *Reliability Frameworks Review*, issues paper, 22 August 2017, pp. 66-67.

5 System security and reliability

5.1 Stakeholder views

Submissions to the directions paper raised concerns that the Commission had not, in its directions paper, given sufficient consideration to the potential impact of moving to five-minute settlement on NEM reliability and security.[113] Broadly, the concerns were in two parts, namely that the rule, if made, would:

- encourage greater volumes of fast ramping capability (e.g. batteries) that is invisible to AEMO, making it harder for AEMO to manage system security
- cause gas-fired generators to exit the market, reducing both system security and reliability.

A summary of stakeholder views on these two issues is provided below.

5.1.1 Effect of batteries on system security

Stanwell noted that the rule would increase financial returns for behind the meter energy storage, with the potential to accelerate uptake.[114] Russ Skelton & Associates, in a report prepared for the AEC, were of a similar view, submitting that the rule would accelerate the increase in demand side responses, non-scheduled generation and battery storage.[115] The AEC observed that unless batteries are of a sufficient size, they will be "invisible" to AEMO.[116]

ERM Power considered that batteries may destabilise the secure operation of the market through sudden changes to frequency and voltage. It submitted that this would lead to over-frequency and under-frequency events, requiring increased enablement of FCAS services, and the potential shedding of load or generation to maintain system security.[117] The AEC and Origin Energy were also concerned with the rapid ramping of batteries and the effect this could have on power system frequency.[118] ENGIE also noted that there would be an increased reliance on corrective services if variation in the output of new technologies increases substantially. It submitted that:

> "…the AEMC should not simply assume that encouraging more very fast ramping capability will be beneficial to the power system."[119]

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113 Directions paper submissions: ERM Power, pp. 2-3; Stanwell, p. 9.

114 Stanwell, directions paper submission, p. 5.

115 AEC, supplementary consultant report by Russ Skelton & Associates, 25 May 2017, p. 3.

116 AEC, directions paper submission, p. 2.

117 ERM Power, directions paper submission, pp. 3; 5-6.

118 Directions paper submissions: AEC, p. 3; Origin Energy, p. 11.

119 ENGIE, directions paper submission, pp. 4-6.

Snowy Hydro provided an example involving a 1,000 MW battery gaming the dispatch process.[120] In the example, the battery *discharges* for the first four minutes of a dispatch interval, then *charges* for the last minute of the interval, resulting in a variation of 2,000 MW in one minute. By charging in the last minute, the battery inflates the demand used to calculate the spot price for the following interval, which the battery subsequently benefits from by discharging again for the first four minutes. Snowy Hydro submitted that this would have cost implications for FCAS services and severe consequences for the reliability and system security of the power system.[121] The AEC also noted the potential for this gaming behaviour to cause an increase in the enablement of contingency FCAS services.[122]

The AEC and ERM Power considered that these issues could be resolved by ensuring that batteries bid into central dispatch. However, they also submitted that battery aggregators should also be required to bid into the market, otherwise they are likely to respond to prices in the wholesale market rather than security of supply signals.[123]

AEMO acknowledged the potential operational implications of new, responsive technologies, such as a large coordinated response by batteries to price spikes impacting on frequency and local voltages. However, it considered that this issue is not directly related to the rule change proposal.[124]

5.1.2 Exit of gas-fired generators

Hydro Tasmania submitted that the rule would limit the incentive for generators that cannot respond within five minutes from responding to price spikes at all, resulting in them withdrawing supply.[125] Similarly, the Major Energy Users noted that existing open cycle gas turbines will be made basically redundant by the changes as they cannot operate effectively within a five minute window.[126]

Snowy Hydro considered that unhedged peaking generators and the bidding behaviour of non-scheduled generators and loads would cause greater price volatility, and because peaking generators cannot rely on AEMO's pre-dispatch price forecasts they would be unable to earn sufficient revenue and would exit the NEM.[127] Similarly, the AEC thought that price volatility would increase and peaking generators would be unwilling to respond as they would be unlikely to derive a reasonable return within their minimum run times. The AEC submitted that in the absence of capacity payments, existing peaking generators will be "squeezed out", with variations in

120 Snowy Hydro, directions paper submission, pp. 16-17.

121 Snowy Hydro, directions paper submission, p. 2. See also Snowy Hydro, report by Marsden Jacobs, p. 1.

122 AEC, directions paper submission, p. 2.

123 Directions paper submission: ERM Power, pp. 3-6; AEC, p. 6.

124 AEMO, directions paper submission, pp. 4-5.

125 Hydro Tasmania, directions paper submission, p. 1.

126 Major Energy Users, directions paper submission, p. 20.

127 Snowy Hydro, directions paper submission, pp. 3; 8.

demand instead addressed by new technologies and existing technologies such as coal.[128] Arrow Energy also thought that the rule would negatively impact on gas-fired generation assets, which are currently crucial to providing system security.[129]

Russ Skelton & Associates submitted that the owners of peaking generators may withdraw them from the market before alternative providers of peaking capacity are installed. They noted that this is particularly the case for gas turbines that are easily relocated.[130] EnergyAustralia and Stanwell also considered that there would be risks to system security if alternatives to existing peaking generators are not readily available.[131]

EnergyAustralia and Origin Energy observed that even if there is an equivalent level of storage capacity, the firmness of this capacity is not guaranteed due to the energy constraints of batteries.[132]

SACOSS submitted that if gas-fired generators do not commit to generate, inertia levels, voltages and the ramping potential of the system will be completely different.[133] Similarly, ENGIE commented that a reduction in gas turbine capacity would decrease flexible generation, inertia and system strength.[134] Infigen also envisaged potential system security impacts from decreased rewards for comparatively slower technologies that provide the system with "real inertia".[135]

Marsden Jacobs, in a report commissioned by Snowy Hydro, considered that the rule change would warrant a "major overhaul" of the Market Price Cap, Cumulative Price Threshold and Market Price Floor. It considered there to be a high probability that the Market Price Cap would need to be significantly increased as peaking generators would otherwise receive lower revenue due to lower energy contributions during times of high price and low reserves. It stated a concern that:

> "If the reliability standard and settings are not reviewed, they may not continue to facilitate appropriate signals for investment."[136]

Stanwell and ERM Power observed increasing concerns regarding energy shortages, with recent examples of load shedding in South Australia and New South Wales, and an LOR2[137] condition in Queensland.[138] ERM Power considered it to be crucial for

128 AEC, directions paper submission, p. 2.

129 Arrow Energy, directions paper submission, p. 4.

130 AEC, supplementary consultant report by Russ Skelton & Associates, 25 May 2017, p. 4.

131 Directions paper submissions: EnergyAustralia, p. 5; Stanwell, p. 10.

132 Directions paper submissions: EnergyAustralia, p. 5; Origin Energy, p. 12.

133 SACOSS, directions paper submission, p. 19.

134 ENGIE, directions paper submission, p. 3.

135 Infigen Energy, directions paper submission, p. 4.

136 Marsden Jacobs, directions paper submission, pp. 4; 49.

137 Lack of Reserve 2 (LOR2): a notice issued to registered participants when AEMO considers that the occurrence of a critical single credible contingency event is likely to require involuntary load shedding.

there to be an adequate supply of fast-start plant capable of responding for extended periods of time. It submitted that availability payments would help to ensure reliable energy supply.

The Clean Energy Council provided a contrary view to other stakeholders, submitting that:

> "The premise that a change to five minute settlement will potentially create shortfalls in supply due to the closure of gas generators appears to be flawed."[139]

It considered that alternative providers of peaking capacity would be readily available. It observed that the deployment times of new generation and storage solutions are already short and becoming increasingly shorter, while the costs of demand response are low and large scale battery storage costs are reducing rapidly.[140]

5.2 Analysis

In responding to the issues raised, it is important to first clarify what is meant by reliability and security within the NEM.

5.2.1 Definition of system security and reliability of supply

System security and reliability are related but separate concepts. Reliability of supply has a consumer focus and describes the likelihood of supplying all consumer needs with the available generation, demand side and network capacity. As shown in Figure 5.1, the components of reliability require a number of elements:

- efficient investment, retirement and operational decisions by market participants (both supply and demand side) resulting in an adequate supply of dispatchable capacity to deliver a reliable supply to consumers[141]
- reliable transmission and distribution networks
- a secure system.

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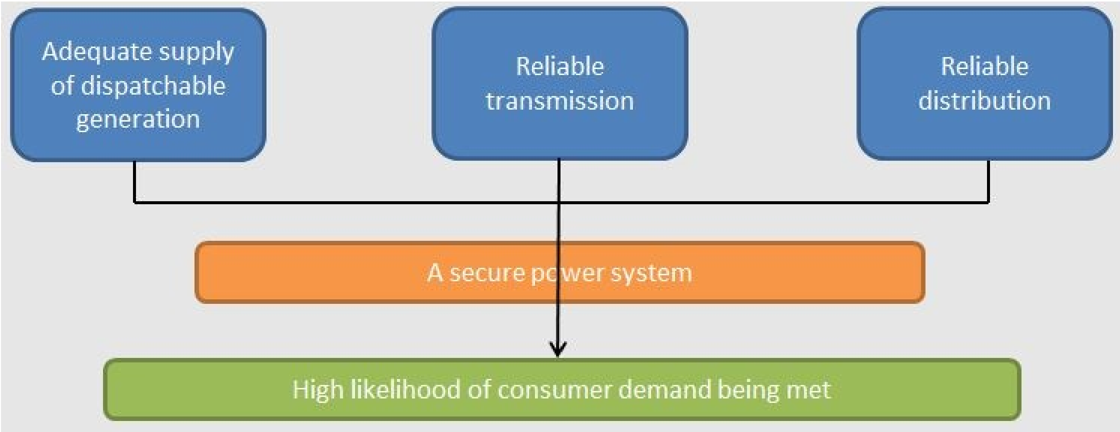
138 Directions paper submissions: ERM Power, p. 3; Stanwell, pp. 12-13.

139 Clean Energy Council, directions paper submission, pp. 4-5.

140 Clean Energy Council, directions paper submission, pp. 4-5.

141 To deliver a reliable supply to consumers it is necessary to always have the level of supply to be greater than current demand to allow for unexpected changes. This margin of supply over demand is termed 'reserves'.

Figure 5.1 Components of system security and reliability



This contrasts with security of supply (and a secure operating system), which is a necessary condition for meeting consumer electricity needs but is nevertheless distinct from reliability of supply. Security of supply is concerned with the power system's capacity to continue operating within defined technical limits, even in the event of the disconnection of a major power system element such as an interconnector, large generator or large load. In the Rules, power system security is defined as the safe scheduling, operation and control of the power system in accordance with the power system security principles.

These principles include maintaining the power system in a secure operating state and returning the power system to a secure operating state following a contingency event or a significant change in power system conditions, including a major supply disruption. Power system security is interrelated with technical parameters such as power flows, voltage, frequency, the rate at which these might change and the ability of the system to withstand faults.

In contrast, reliability is driven by the availability of generation, demand side and network capacity. Decisions about dispatchable capacity are made in response to price signals and incentives offered by the spot market. The contract market has been an integral part of the NEM market design since its inception and makes a major contribution to reliability. Participants make investment, retirement, operation and maintenance decisions on the basis of expectations of future spot prices provided by the contract market. These decisions underpin reliability in the NEM.

The Rules set limits on the extent to which wholesale prices can rise and fall. These are part of the reliability standard and settings, which are recommended by the Reliability Panel.

Currently, the NEM has a reliability standard expressed in terms of expected unserved energy. That is, the amount of energy required by customers but cannot be supplied. The current standard is set at 0.002 per cent expected unserved energy. This means at least 99.998 per cent of annual energy in any region is expected to be supplied. In considering the appropriate level of the standard, the Reliability Panel has regard to the costs associated with higher reliability and the costs of unserved energy. Having the standard set at this level reflects the fact that the most efficient level of reliability is not zero per cent unserved energy. Such an approach would be inefficient. The cost of the provision of a supply of energy at all times would exceed the value placed on it by consumers, given this value is not a constant and varies over time and with the duration and frequency of interruptions.

AEMO uses the reliability standard to forecast the potential for unserved energy. The outcomes of AEMO's forecasts then serve as a signal to the market that it should deliver enough capacity to meet a certain level of reliability, to avoid expected unserved energy.

Reliability is therefore distinct from system security. While the two concepts are separate, they are closely related operationally. A reliable power system is also a secure power system. However, the converse is not necessarily true; a power system can be secure even when it is not reliable. For example, the NER allows AEMO to undertake involuntary load shedding, potentially compromising reliability, in order to return the power system to a secure operating state.

5.2.2 Current review processes addressing reliability and system security issues

There have been recent concerns with the security of the power system and an increased focus on the reliability of supply. This has resulted in a range of review processes aimed at assessing the suitability of current arrangements to deliver on reliability and security aims. These processes are briefly described below.

AEMO Future power system security program

AEMO's future power system security program commenced in 2015. The program explores a number of areas – including frequency control, fault levels, system restart, cyber security, modelling and tools, and market information. It aims to constructively inform what actions may be required by AEMO and the industry to provide for the continued efficient management and secure operation of the power system of the future.

The initial focus of the program has been to understand the technical nature of the opportunities and challenges facing the power system together with their interlinkages, the conditions under which they may arise and the consequences should they arise. This understanding is essential to developing proposed solutions to these challenges that are holistic, and consider the overall technical needs of the power system, as well as their economic efficiency.

A recent output from this program was the report into the visibility of distributed energy resources published in January 2017. This report noted that the presence of large amounts of behind the meter distributed energy resources (DER) that is not visible and predictable will progressively decrease AEMO's ability to achieve the required reliability outcomes.[142] The report identified a range of information gaps that exist that need to be addressed, which were summarised as:[143]

- static data on location, capacity, and the technical characteristics of the systems, in particular the inverters interfaced to the network
- real time, or at least five-minute, DER output data, aggregated at the connection point level for operational forecasts.

AEMO Guide to generator exemptions

AEMO have recently completed a review of the generator exemption and classification guideline.[144] The guide has been revised to recognise the increasing impact of smaller scale generation (compared to historic large utility scale generation often with capacity in the hundreds or thousands of MW) and the potential impact of battery storage.

The guide now specifically excludes batteries of 5 MW or greater from being eligible for exemption from registration. It encourages such batteries to apply for registration as *scheduled generating* units. This reflects the rapid response which batteries are capable of and their ability to switch from generation to load within one cycle (Hz). Should registration as non-scheduled generation be sought, AEMO have indicated this is likely to require the imposition of registration conditions.

The guide also specifies that the consumption of a battery facility that is more than 5 MW will be required to be *scheduled load* so that it can be dispatched by AEMO. A participant who registers a scheduled load will incur the regulatory burden and costs of being scheduled.

AEMC Distribution market model

Changes on the demand side, driven by falling technology costs and the uptake of distributed energy resources are changing how consumers interact with the energy sector. This is having implications for reliability as well as security.

Increases in distributed energy resources, particularly solar PV which is intermittent, has occurred without a corresponding increase in the visibility of where these resources are located. Without proper visibility of distributed energy resources with current forecasting methodologies, AEMO cannot forecast the demand and supply balance as accurately as it could when energy was primarily supplied by thermal generators.

The issue was recognised by the Commission in the recent Distribution market model project.[145] It highlighted that there is a need to improve how distributed energy

142 AEMO, *Visibility of Distributed Energy Resources*, January 2017, p. 1.

143 *Ibid*, p. 3.

144 AEMO, *Guide to Generator Exemptions & Classification of Generation Units*, 7 July 2017.

145 The purpose of the Distribution Market Model project is to explore how the operation and regulation of electricity distribution networks may need to change in the future to accommodate an

resources interact with the wholesale market in order to allow better visibility, as well as distributed energy resources to assist with reliability. Stronger coordination relies on all relevant parties having sufficient information available to them. This information should be reflected in price signals that reflect the value of providing all possible services, so that buyers and sellers of those services can make efficient investment and operational decisions. The interaction of distributed energy resources with the wholesale market will be considered through the Commission's *Reliability frameworks review* discussed below.

In the final Distribution market model report, the AEMC noted that there were already existing processes underway to improve information about distributed energy. Specifically those by AEMO, as well as the recent announcement of a battery storage register by the Council of Australian Governments' (COAG) Energy Council.[146]

Further, the final report also noted that distributed energy resources have the potential to assist with providing frequency control ancillary services. Accordingly, it outlined that the Commission's frequency control frameworks review will consider the potential for distributed energy resources to provide frequency control services, along with any other specific challenges and opportunities associated with their participation in system security frameworks.

AEMC System security work program

The AEMC also recognises the interrelationship between AEMO's work and the AEMC's own system security work program.

In June 2017, the AEMC published a final report for the System security market frameworks review. This recommended a package of reforms to guard against technical failures that lead to cascading blackouts, and to deliver a more stable and secure power supply to Australian homes and businesses.[147] To develop the recommendations, we worked with stakeholders and AEMO to develop a comprehensive set of solutions that take into consideration issues raised by consultation across the system security work program.

Initial steps already implemented through rule changes include changes to emergency frequency control schemes and the introduction of a new type of classification for certain contingencies: the Protected Event. We are currently working on further rule changes that would introduce obligations to maintain system strength, together with making networks responsible for providing minimum levels of inertia where AEMO identifies a shortfall.

In addition, other recommendations relate to the potential to develop additional markets for system support services (or ancillary services) over the longer term. This includes considering markets for inertia and fast frequency control services.

increased uptake of distributed energy resources such as rooftop solar systems, battery storage and electric vehicles.

146 AEMC, *Distribution Market Model*, final report, 22 August 2017, pp. 47-48.

147 AEMC, *System Security Market Frameworks Review*, final report, 27 June 2017.

AEMC Frequency control frameworks review

In July 2017, the Commission announced commencement of the frequency control frameworks review. This is looking into the market and regulatory arrangements necessary to support effective control of system frequency in the NEM.

The review will progress a number of the recommendations made by the Commission in the System security market frameworks review to consider how best to integrate faster frequency control services offered by new technologies into the current regulatory and market arrangements. The review will also allow the Commission, in coordination with AEMO, to investigate and, if appropriate, address current concerns with frequency performance in the NEM. As noted previously, the review will further consider the interaction of distributed energy resources with the wholesale market.

While the changing generation mix is creating challenges for traditional forms of frequency control, it also offers opportunities to introduce new system services such as inertia services and fast frequency control services. Inertia services may potentially be provided by existing synchronous generation in which case such services may provide an additional revenue stream for participating generators. An example of a possible fast frequency control service would be a one second (or even 500 millisecond) raise or low service that capitalises on the ability of some technologies to provide a very rapid ramping service.

The existing reliability standard and settings are currently being considered in the Reliability Panel Reliability standard and settings review. This review will consider any potential impact on the reliability standard and settings as a result of the Commission's draft rule.

AEMC Reliability frameworks review

Over the past year, there has been a greater focus on reliability in the NEM. This has arisen from load shedding events on low reserve days, pre-emptive action and announcements from jurisdictional governments, as well as recommendations made by the Finkel Panel in the *Independent Review into the Future Security of the National Electricity Market*.

At the same time, the NEM is changing at a rapid pace on both the demand and the supply side. On the demand side, falling technology costs and the uptake of distributed energy resources are changing how consumers interact with the energy sector. On the supply side, ongoing trends such as the retirement of thermal generation and increasing penetration of variable, renewable generation are having implications for the NEM, and for reliability.

In July 2017, the Commission initiated a review into the market and regulatory frameworks necessary to support the reliability of the electricity system. The focus of the review is on the investment, retirement and operational decisions made by market participants, and what changes to the existing regulatory and market frameworks are necessary to provide an adequate amount of dispatchable capacity in the NEM to meet the reliability standard. This includes both generation and demand side sources of energy.

The review will identify any changes to the existing reliability frameworks that are needed to better allow for efficient investment, retirement, operation and maintenance decisions. This is to be made in the context of current and expected environmental policy mechanisms, ultimately resulting in an adequate supply of dispatchable capacity.

An issues paper for the review was published on 22 August 2017, which explains the features of, and potential issues associated with, the existing reliability framework.

ARENA/AEMO Demand response competitive round

In May 2017, the Australian Renewable Energy Agency (ARENA) and AEMO announced they were partnering to run a pilot program to incentivise demand response for reliability purposes. The three-year pilot program aims to provide 160 MW of reserve capacity which AEMO can call upon when reserves are low to prevent load shedding.

ARENA is providing $22.5 million in funding over three years.[148] The pilot will be trialled in Victoria, South Australia and NSW, with demand response capacity expected to be made available from December 2017.[149]

The deadline for offers closed 17 July 2017. Selection is understood to be based on targeting innovative approaches to delivering demand response. Actual activation of offers is based on AEMO utilising its short notice reliability and emergency reserve trader (RERT) function.

The program is aimed at "reliability demand response" - that is, demand response to provide for reserves for reliability purposes. It is intended to serve as a proof of concept that AEMO will then progress as a RERT rule change to the Commission in 2018. ARENA also intends for this project to be a stepping stone for innovation in demand side participation in the NEM beyond reliability.

The AEMC is following the trial closely. We are interested in any findings from the trial as to why demand response has not historically been interested in participating in the RERT. The findings from this trial will feed into the Commission's considerations through the Reliability frameworks review.

Reliability Standard and Settings Review

In accordance with the NER, the Reliability Panel is required to review the reliability standard and settings applicable in the NEM every four years. Through this periodic

148 See https://arena.gov.au/funding/programs/advancing-renewables-program/demandresponse/

149 The trial was initially limited to Victoria and South Australia. However, following an additional funding announcement from the NSW Government, ARENA and AEMO extended the trial to New South Wales.

review the Panel considers whether the standards and settings remain suitable to guide efficient investment in the power system to meet consumer demand for energy, while protecting market participants from substantial risks that threaten the overall stability and integrity of the market.

The Panel has started the 2018 review which is considering the standard and settings to apply from 1 July 2020. It will publish its final report by 30 April 2018. In accordance with the four year timetable, the Panel is to commence work on its 2022 review in 2021. However, the Panel in its June 2017 Reliability Standard and Settings Review (RSSR) discussion paper noted that certain market and policy conditions may arise that will trigger a reassessment of the findings of the 2018 review prior to the next four-yearly review in 2022.

Implications of work programs

Taken together, the above changes and ongoing work programs should substantially increase the transparency of distributed energy resources in the NEM and ensure that the impact of new technologies is considered with respect to reliability and security of electricity supply.

This has implications for claims that have been made in submissions about the potential impact five minute settlement will have on system security and reliability.

The following sections bring together the above discussion in the context of the two reliability and system security themes identified in submissions, namely, that under five minute settlement:

- greater volumes of batteries would negatively impact on system security
- gas fired peaking generators will exit the market and create security and reliability problems.

5.2.3 Effect of batteries on system security

It is clear that the rapid emergence of price competitive, fast response, energy storage options such as batteries will have significant impact on the structure and operation of the NEM. As highlighted in the above discussion of AEMO and AEMC work programs, this issue is already being addressed through initiatives including:

- moves to increase the visibility of behind the meter battery installations
- requirements for larger scale batteries to be registered as scheduled generators or be subject to registration conditions aimed at ensuring AEMO can control any technology related system security impact
- potential development of fast frequency response markets which will encourage battery participation (whether utility scale developments or through small scale aggregators) that enhances system security.

The changes to AEMO's generation exemption guideline together with processes to increase visibility of small scale batteries is likely to make the likelihood of batteries gaming dispatch as suggested by Snowy Hydro very low.[150] Similarly, battery projects such as the South Australian Government-Tesla project promise to reduce issues related to system security.[151] This is through acting as a rapid response energy source or load that smooths out frequency variations rather than increasing them as suggested by ERM Power.[152]

There are many challenges remaining to be resolved to fully and effectively integrate fast response energy storage. Nevertheless, the Commission is of the view that these are unlikely to be materially impacted by the adoption of five minute settlement. Existing processes are already working to effectively integrate fast response energy storage into the NEM.

5.2.4 Five minute settlement impact on gas peaking generation

The Commission recognises the uncertainty faced by gas peaking plant and all other generating technologies in the face of changes in their expected competitive position. This is based on market factors such as relative fuel costs, locational factors, fixed and variable operating costs and for new investments, relative capital costs. However, it needs to be recognised that a degree of uncertainty is an inevitable consequence of participating in a competitive market such as the NEM wholesale energy market.

Indeed, the financial case for peaking generation plant is generally predicated on there being occasions when demand exceeds the supply available from lower marginal cost generation such as renewables, coal fired thermal generation or combined cycle gas turbines. This leads to high price events that support investment in, and operation of, peaking plant.[153] It is typically the case that where generating plant is withdrawn, any resulting shortfall in available supply will result in increased prices. This will support the entry of new generation or offsetting demand response.

There have been a number of recent commitments to the rapid development of new generation and storage options in South Australia. This includes AGL Energy's new Barker Inlet power station, the South Australian Government's Tesla battery announcement and new Government owned power station for use in supply emergencies. The projects highlight the rapidity with which new technologies can be

150 Snowy Hydro, directions paper submission, pp. 16-17.

151 Premier of South Australia, viewed 30 August 2017, https://www.premier.sa.gov.au/index.php/jay-weatherill-news-releases/7736-tesla-to-pair-world-s-largest-lithium-ion-battery-with-neoen-wind-farm-in-sa.

152 ERM Power, directions paper submission, pp. 3; 5-6.

153 Conventional peaking plant such as OCGT is normally characterised as relatively low capital cost but high operating cost meaning that the short run operating costs are higher than more fuel efficient alternative plant.

implemented in the face of emerging supply shortfalls, as also noted by the Clean Energy Council.[154]

Chapter 4 in part explores the effect of five minute settlement on existing peaking generation and concludes that there is a likelihood peaking generators will continue to supply cap contracts. Further, with respect to the viability of existing gas peaking plant, the Commission notes that the development of new services in the NEM such as inertia services may offer additional revenue streams to support existing synchronous generation. For example, as part of the inertia ancillary service market rule change currently underway, the Commission has flagged looking at options for market mechanisms to deliver inertia above a minimum level. This would be provided where such inertia delivers market benefits, such as allowing for greater flows on interconnectors.

Further, concerns raised by Marsden Jacobs surrounding the reliability settings (such as the level of the market price cap) will be routinely dealt with during either the four yearly reliability standard and setting review (which is currently underway) or through a mid-period special review where it is considered necessary. An explanation of the reliability standard and reliability settings together with the review process can be found in the Reliability Panel's issues paper released as part of the 2018 review.[155]

Given these factors, the Commission is of the view that adoption of five minute settlement will not of itself cause widespread retirement of existing gas peaking plant.

5.3 Commission's position

Some stakeholders raised concerns that the rule, if made, would:

- encourage greater volumes of fast ramping capability that is invisible to AEMO, making it harder for AEMO to manage system security
- impact the ability of gas peaking generator to offer caps and remain financially viable, causing them to exit the market, reducing both system security and reliability.

The Commission acknowledges stakeholders concerns around the potential risks to system security and reliability with the introduction of five minute settlement. However, given the large amount of work currently being undertaken to address system security and reliability issues, and the developments in the market, the

154 Clean Energy Council, directions paper submission, pp. 4-5. Also see: https://www.agl.com.au/about-agl/media-centre/asx-and-media-releases/2017/june/agl-announces-development-of-$295m-power-station-in-sa. https://www.premier.sa.gov.au/index.php/jay-weatherill-news-releases/7198-south-australia-is-taking-charge-of-its-energy-future. https://www.premier.sa.gov.au/index.php/jay-weatherill-news-releases/7736-tesla-to-pair-world-s-largest-lithium-ion-battery-with-neoen-wind-farm-in-sa.

155 Reliability Panel, *Reliability Standards and Setting Review 2018*, issues paper, 6 June 2017.

Commission is satisfied that there is no direct threat to system security or reliability from making the rule change. In particular, this is because:

- work is underway examining changes that will promote the effective and efficient integration of technologies offering fast frequency response into the NEM
- analysis shows that peaking generators are likely to continue selling cap contracts under five minute settlement (chapter 4)
- work is also underway exploring the creation of a market for the supply of inertia services – this may in future offer additional revenue streams to support existing synchronous generation
- recent gas generation and storage commitments and investment decisions highlight the speed with which new technologies can be implemented in the face of emerging supply shortfalls
- AEMO recently published changes to its exemption and classification guideline to require storage facilities larger than 5 MW to be classified as scheduled loads, and therefore provide bids to AEMO and comply with dispatch instructions.

Additionally, if the Commission makes a final rule that reflects the draft rule, the transition period of three years and seven months prior to five minute settlement commencing will provided time for system security issues to be further addressed or resolved.

6 Five minute settlement design options

This chapter sets out the Commission's detailed policy settings choices for the implementation of five minute settlement. These policy settings relate to demand side optionality, metering, bidding resolution, pre-dispatch and the option of a conditional rule change.

6.1 Sun Metals' view

In its rule change proposal, Sun Metals proposed compulsory five minute settlement for all market generators, scheduled loads and market network service providers (i.e. merchant interconnectors). Registered market customers (i.e. retailers and large energy users) would have the option of being settled on a five minute or 30 minute basis. Retailers would not be required to offer five minute settlement to their customers.

Sun Metals' justification for providing this option for Market Customers was that not all loads:

- are capable or willing to undertake rapid demand response
- have suitable metering or SCADA systems to enable participation in five minute settlement.

Sun Metals suggested that optional demand side participation would help to reduce the implementation costs.

Optional five minute settlement for market customers would require AEMO to simultaneously operate both five and 30 minute settlement for different participants. This arrangement would create regional imbalances (i.e. settlement residues) between the money earned by supply-side participants settled on a five minute basis and the money paid by demand side participants, who could be settled on either a five or 30 minute basis. Sun Metals proposed a new mechanism to manage the imbalance. The imbalance amount, which could be positive or negative, would be recovered entirely from those demand side participants who continue to be settled on a 30 minute basis. An alternative option suggested by Sun Metals to manage the imbalance would be to combine the new imbalances with existing intra-regional settlement residues. This alternative treatment would minimise the changes that retailers would need to make to their IT systems in order to manage the imbalance.

Sun Metals proposed that five minute settlement be implemented by AEMO using operational data from SCADA systems to profile 30 minute energy readings into five minute periods within the respective half hour. Market participants would have the option of installing five minute interval meters at their own cost. Sun Metals considered it likely that some market participants will prefer the improved reliability of meter data over SCADA profiling. Sun Metals noted that the SCADA implementation coupled with optional five minute interval metering would involve costs to AEMO, metering data providers (MDPs), generators and retailers.

6.2 Stakeholder views

6.2.1 Demand side optionality

As with submissions to the consultation paper, support for optional demand side participation in five minute settlement in submissions to the directions paper was limited.

Energy Consumers Australia (ECA) suggested that the issues raised about optionality in the consultation paper, including complexity, settlement residue and contract markets, were all manageable if there are benefits from maintaining 30 minute metering and settlement in parts of the market. The ECA suggest that some opponents of optionality may have raised these concerns with an ulterior motive of increasing costs and complexity.[156]

Similarly, AusNet Services noted the issues identified around demand side optionality were not material in comparison to the substantial costs of replacing network billing systems and the larger costs associated with changing all existing advanced metering infrastructure (AMI) meters to provide five minute interval data.[157]

Most other stakeholders recognised the limitations of optionality, which centred around:

- a reduction in efficiency
- costs and administrative burden
- impact on the contract market.

AEMO noted that both the demand and supply side should have exposure to settlement to obtain the benefits from an improved price signal.[158] Similarly, ERM Power submitted that asymmetric settlement would lead to inefficiencies in the market by providing different incentives to the supply and demand.[159] The Major Energy Users suggested that whilst optional demand side participation would allow each consumer to reflect the reality of the way they consume electricity, optionality would be very difficult to implement equitably and would introduce distortions to the market.[160] Ipen Consulting also raised concerns that symmetry in supply and demand participation will become more important as more end-users become "prosumers", each with some mix of flexible demand, embedded generation and reversible storage

156 Energy Consumers Australia, directions paper submission, p. 7.

157 AusNet Services, directions paper submission, p. 6.

158 AEMO, directions paper submission, p. 2.

159 ERM Power, directions paper submission, p. 9.

160 Major Energy Users, directions paper submission, p. 32.

options. This symmetry will provide the incentive for retailers to become facilitators of this transformation.[161]

Added costs and administrative complexity was cited by several submissions as a reason why optionality should not be adopted. Mojo Power noted that the increased complexity would lead to higher costs.[162] Tesla raised a similar concern adding that optionality would distort price incentives for flexible generation.[163] Arrow Energy and Energy Queensland noted optionality would increase errors and costs by doubling the reporting and administrative requirements.[164] Energy Queensland also suggested that exemptions from providing five minute data could create issues for the settlement process by reducing the accuracy of the Net System Load Profile (NSLP). However they did recognise that the cost of data collection and storage for households and small businesses may be onerous.[165]

The contract market impact of allowing optionality was raised as a concern in some submissions. Aurora Energy and Energy Queensland stated that allowing optionality could substantially disrupt the contract market by creating two distinct contract markets for five and 30 minute contract periods. [166] Arrow Energy raised a similar concern, noting that two forward markets could lead to liquidity issues as was the case when the AFMA pass-through carbon clause was in place between 2011 and 2014.[167]

ECA, Energy Queensland, and Infigen all considered demand side optionality as undesirable when considered as an interim measure.[168] Energy Networks Australia suggested that if optionality were to be implemented, it would only be practical if it was in place for a capped period of three years.[169]

6.2.2 SCADA systems and metering

The use of supervisory control and data acquisition (SCADA) systems was originally proposed by Sun Metals as an option for metering in order to minimise the cost of transitioning to five minute settlement. There was no support for this approach in stakeholder submissions.

Arrow Energy noted that whilst SCADA systems have been discussed as a cost-effective alternative to revenue metering, the issues around accuracy and reliability rules it out as a viable option.[170] EDMI added that SCADA systems were

161 Ipen Pty Ltd, directions paper submission, pp. 1-2.

162 Mojo Power, directions paper submission, p. 2.

163 Tesla, directions paper submission, p. 1.

164 Directions paper submissions: Arrow Energy, p. 8; Energy Queensland , p. 6.

165 Energy Queensland, directions paper submission, p. 9.

166 Directions paper submissions: Aurora Energy, p. 3; Energy Queensland, p. 7.

167 Arrow Energy, directions paper submission, p. 9.

168 Directions paper submissions: Energy Consumers Australia, p. 7; Infigen, p. 5.

169 Energy Networks Australia, directions paper submission, p. 6.

170 Arrow Energy, directions paper submission, p. 8.

not subject to the same levels of metrological standards as revenue meters.[171] AusNet Services went further to note that improving SCADA systems to meter the appropriate requirements would be more costly than changing wholesale and interconnector meters.[172]

Several stakeholders stated their support for the use of metering over SCADA systems for 5 minute settlements.[173] ECA went further to suggest that a move to five minute resolution metering would have benefits irrespective of changes to the settlement period.[174] AusNet Services also noted that access to five minute data for large customers would enable distribution network service providers to better monitor and analyse parts of the network that are dedicated to supplying industrial and commercial customers.[175]

6.2.3 Implementing metering for five minute settlements

Whilst there was strong support for revenue metering over SCADA systems, stakeholder raised concerns over how this would be implemented. Some stakeholders suggested alternate implementation designs which could minimise costs.[176] For example, AEMO recommended a staged approach that introduces mandatory five minute settlement for the most price sensitive participants, but allows the market to test new business models and pilot implementations for smaller scale consumers. The design of the staged approach involves a mandatory implementation across all type 1-3 meters, optional implementation for type 4-6 meters and the development by AEMO of a five minute NSLP for each settlement region. This staged approach would not require the immediate investment disruption to customers caused by an imposed meter technology rollout and consequential changes to participants systems.[177]

Concerns raised by stakeholders were centred around the physical capabilities of meters and systems to collect, store and transfer five minute data, and the treatment of small customers. Energy Networks Australia suggested that most type 1 and 2 meters are able to record 5 minute data, but do not have the capacity to store the volume of data for the required length of time under the Rules. They also noted that remotely read interval meters (e.g. type 5 AMI meters) that are able to be reconfigured may not be able to meet the 200 day storage requirement, but could store 30-35 days.[178]

AusNet Services raised a similar point, noting that late model meters could be remotely reconfigured, but not all type 4 meters would have the memory capacity to store 35

171 EDMI, directions paper submission, pp. 3-4.

172 AusNet Services, directions paper submission, p. 4.

173 Directions paper submissions: AusNet Services, p. 7; EnergyAustralia, p. 10; Origin Energy, p. 13; Stanwell, p. 8; Mojo Power, p. 3.

174 Energy Consumers Australia, directions paper submission, p. 7.

175 AusNet Services, directions paper submission, p. 3.

176 SA Department of Premier and Cabinet, directions paper submission, p.2.

177 AEMO, directions paper submission, p. 2.

178 Energy Networks Australia, directions paper submission, pp. 2-3.

days of two channel interval data.[179] Jemena provided more detail suggesting that single phase AMI meters could be reconfigured to capture 5 minute data recording and will in the majority of instances have sufficient memory to meet the NER 35 day storage requirements. However, three phase meters would not be able to meet any new obligations.[180] Similarly, United Energy agreed that Victorian AMI meters could be reconfigured to capture five minute data and, with the exception of around 200 current transformer meters, will have sufficient data to meet the 35 day storage obligation.[181] ECA noted that the change of existing small consumer meters may be impossible given data storage requirements.[182]

Some distribution networks outlined the changes required to metering data systems to enable five minute settlement. Jemena noted that the sixfold increase in metering data being collected, communicated and stored would necessitate a significant upgrade to back end systems and processes of market participants and AEMO.[183] Similarly, Energy Networks Australia suggested that the increase in the volume of data being transmitted means more expensive data plans and data storage adequacy. They also noted that there would be a range of additional implications such as new training and process development, increased field testing with the possibility of a need to install temporary meters, and slower reading times due to an increased load on the telecommunications network.[184] United Energy highlighted that a firmware change would require rigorous testing for each metering configuration. Further, United Energy suggested the move to receiving five minute data from type 1-3 meters and eventually type 4-5 meters will require substantial application and database changes.[185] CitiPower and Powercor noted that as a meter provider, their advanced metering infrastructure (AMI) meters and communication network are well placed to accommodate five minute settlement. However, reinforcement works to support six times more data from these 1.2 million meters would be required to enable this functionality.[186]

Energy Queensland noted the competition in metering changes was designed to improve granularity of metering data by investing in metering where it is cost effective to do so. They raised concern that five minute settlement would potentially add costs to metering. This could undermine the business case and the market led roll out of meters from competition in metering.[187]

Stakeholders have proposed a range of design options to minimise the metering costs associated with five minute settlement. Several stakeholders proposed excluding

179 AusNet Services, directions paper submission, p. 7.

180 Jemena, directions paper submission, p. 2.

181 United Energy, directions paper submission, p. 2.

182 Energy Consumers Australia, directions paper submission, p. 7.

183 Jemena, directions paper submission, p. 2.

184 Energy Networks Australia, directions paper submission, p. 8.

185 United Energy, directions paper submission, p. 2.

186 CitiPower and Powercor, directions paper submission, p. 2.

187 Energy Queensland, directions paper submission, p. 3.

existing type 5 and type 4 meters that cannot be reconfigured and meet the storage requirements from providing five minute data. They suggested these meters are grandfathered after the rule is made.[188]

AEMO noted the storage requirements for meters should not be changed. A change would increase the risk of data loss adversely affecting settlements and customer and network billing.[189] Jemena suggested that if five minute data is not available, profiling may be necessary to achieve the objective at least in the short to medium term.[190] Stanwell suggested that around 600,000 meters will be rolled out as part of the competition in metering rule change over the next five years. It would therefore be counterproductive to exempt these meters from providing 5 minute data, as long as an appropriate transition timeframe is provided.[191]

Both CitiPower/Powercor and Energy Networks Australia raised concern about distribution network service providers needing to record both five and 30 minute data. It may lead to confusion about which numbers are used and would entail seven rather than six times the data needing to be communicated and stored.[192] Similarly, United Energy observed that the MDP could collect both 30 minute and five minute data and provide five minute data to AEMO and 30 minute data to retailers. The MDP could presumably elect to offer a data aggregation service to provide 30 minute data to retailers and Local Network Service Providers (LNSP) to avoid or defer system changes if this did not create other adverse impacts. However, this could mean that LNSPs will have additional costs to either procure data for network billing which would then be passed onto consumers, regardless of whether this service is offered or not.[193]

6.2.4 Conditional rule change

Some stakeholders have suggested that a rule implementing five minute settlement should only be made if certain pre-conditions have been met.

The AEC submitted that a monitoring regime in anticipation of suitable conditions for the rule would be more appropriate than making the rule at this time. Along with other design considerations, the AEC submitted that a biannual monitoring regime would report on the market, technological and investment environments to determine if conditions are right for aligning the dispatch and settlement cycles. A review would then be initiated to determine the best means of implementing the alignment of dispatch and settlement cycles, with disruption minimised.[194]

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188 Directions paper submissions: AEMO, p. 2; AusNet Services, p. 7; Origin Energy, p. 14; United Energy, p. 2.

189 AEMO, directions paper submission, p. 3.

190 Jemena, directions paper submission, pp. 1-2.

191 Stanwell, directions paper submission, p. 8.

192 Directions paper submissions: CitiPower and Powercor, p. 3; Energy Networks Australia, p. 8.

193 United Energy, directions paper submission, p. 4.

194 AEC, directions paper submission, p. 4.

The AEC and ERM Power made similar observations as to the types of conditions/indicators they deemed necessary to be monitored before five minute settlement should be implemented. These factors include liquidity in both the cap and swap market; development of new sources of cap contracts; system security and reliability; changes to the thresholds for non-scheduled generation; and, sufficient quantity of generation capable of dispatching from rest within five minutes in each NEM region.[195]

Snowy Hydro argued that now is not the time to align the dispatch and settlement cycles, with the need for synchronous generation for system security, and the high levels of regulatory and policy uncertainty that is stifling investment in synchronous generation plant. Snowy Hydro believes there may be a case for a monitoring regime (similar to the Optional Firm Access review) to determine the right market conditions to initiate a review of aligning the dispatch and settlement cycles.[196]

Origin Energy added that it believes a prudent approach would be to align the implementation of five minute settlement with the period when market conditions indicate greater potential for the benefits of the reform to be realised. Origin Energy also noted this could be achieved by making the rule contingent on a periodic assessment of market conditions, the first of which could occur in four years from the AEMC's final determination. Any decision to proceed with making the rule could then be followed by a three year transitional period so businesses have sufficient time to undertake the required system changes.[197]

6.3 Analysis

6.3.1 Demand side optionality

Demand side optionality was originally raised as an option in Sun Metals' proposal. This was to minimise the implementation costs associated with market customers that were unable or unwilling to undertake rapid demand response; or did not have suitable metering to participate in five minute settlement. In the directions paper, the Commission identified four potential issues created by demand side optionality, namely:

- weaker long-term incentives to respond to the physical requirements of the power system, and a subsequent reduction in efficiency
- a potential reduction in contract market liquidity and increased basis risk from the bifurcation of the contract market
- the creation of a new settlement residue from a misalignment of generators being settled on a five minute basis and load being settled on a 30 minute basis

195 Directions paper submissions: AEC, p. 7; ERM Power, p. 2.

196 Snowy Hydro, directions paper submission, pp. 4, 19.

197 Origin Energy, directions paper submission, p. 3.

- increased administrative burden and complexity.[198]

In light of these issues, the Commission set out an initial position in the directions paper of five minute settlement applying to both supply-side and demand side of the market. The majority of submissions to the directions paper supported this position on the basis of the issues raised. AusNet Services did raise concern about the costs of changing billing systems and changing the existing AMI meters to enable demand side participation.[199] These issues are discussed in more detail in section 6.3.3.

6.3.2 SCADA data under five minute settlement

Sun Metals' rule change proposal suggested the use of SCADA data to allocate or profile 30 minute energy reading to five minute periods. This proposal was suggested as it could be implemented by AEMO using existing systems and data, thereby minimising costs to both AEMO and market participants.

In the directions paper,[200] some drawbacks of using SCADA systems and data were identified. These drawbacks concerned the:

- accuracy, reliability and basis of measurement of SCADA data
- consistency of SCADA data with the National Measurements Act
- availability of SCADA data for demand side participants and small generators.

The primary concern is the lower level of accuracy of SCADA data. The accuracy standard for revenue metering at scheduled generating units is between +/-0.5 and +/-1 per cent. In contrast, the Commission understands the accuracy of SCADA is typically between +/-2 and +/-4 per cent. In light of these issues, the Commission set out an initial position in the directions paper of using metering instead of SCADA systems to collect settlement data. All submissions that commented on the issue supported the Commission's initial position.

6.3.3 Revenue metering under five minute settlement

In lieu of SCADA profiling, to implement five minute settlement, there would need to be upgrades to existing revenue meters so that they prepare and record five minute data. Revenue meters do not have the same issues around accuracy and reliability that SCADA systems have. However, they have larger costs associated with reconfiguration and replacement.

198 AEMC, *Five Minute Settlement*, directions paper, 11 April 2017, Sydney, pp. 77-82.

199 AusNet Services, directions paper submission, p. 6.

200 AEMC, *Five Minute Settlement*, directions paper, 11 April 2017, Sydney, pp. 86-89.

Existing meters: background

In 2016/17 there were over 13.6 million physical meters installed across the NEM. Each meter type has a different measurement and data storage capacity, which is illustrated in Table 6.1.

Table 6.1 Meters installed in the NEM

Meter type	Number of meters installed	Proportion of total meters	Typical* data measurement setting	Typical* data measurement capability	Typical* data storage capacity	Communication
Type 1 *>1,000 GWh*	184	0.001%	15 or 30 minutes	5 minutes if less than 15 years old	35 days of 15 minute data	Remote
Type 2 *100-1,000 GWh*	1708	0.01%	15 or 30 minutes	5 minutes if less than 15 years old	35 days of 15 minute data	Remote
Type 3 *0.75-100 GWh*	15,905	0.1%	15 or 30 minutes	5 minutes if less than 15 years old	35 days of 15 minute data	Remote
Type 4 *<750MWh*	402,767	3%	30 minutes	5 minutes if less than 15 years old	35 days of 30 min data	Remote
Type 5 + type 4A** *<750MWh*	3,533,127	26%	30 minutes	30 minutes	200 days of 30 min data	Most Victorian AMI meters are remote, rest are manual
Type 6	9,679,169	71%	Accumulated data read and profiled to half hour blocks	Data accumulated with no time period associated	None, but must keep at least 12 months of data.	Manual
Type 7	4612	0.03%	Calculated on a half hourly basis	No limit as load is calculated	No storage as load is calculated	Calculated

Source: AEMO and AEMC *This is an estimate of typical meter capabilities and settings, noting that there could be a large variance between specific meters.**Type 4A meters are not defined in the current rules, but are scheduled to be introduced on 1 December 2017.

Most type 1-4 meters are currently calibrated to record data on a 15 or 30 minute basis. If these meters were installed over the past 15 years, they will generally be able to be recalibrated to record five minute data. Manually read meter type 5 and 4A meters are only capable of recording data every 30 minutes. However, some Victorian Advanced Metering Infrastructure (AMI) meters, which are also classed as type 5 meters, are able to capture five minute data. Of the 3.5 million type 5 interval meters, approximately 2.9 million were installed under the Victorian AMI program. Type 6 meters are only able to capture data for a specific time period if they are manually checked for that period. Type 7 metering installations are not physically read. Rather the energy consumption of these installations is estimated based on a calculation, which can be adjusted to a five minute basis.

As discussed in the directions paper, remotely read interval meters are usually capable of being remotely reconfigured. This could reduce costs of reconfiguring each meter.[201] However, as United Energy identified, many of the meters would require a firmware change, which would require rigorous testing of each meter category and configuration by the Distribution Network Service Provider.[202] AEMO also identified that new and reconfigured meters may need to undergo additional testing for pattern approval by the National Measurement Institute.[203] Pattern approval tests the design of the measurement equipment to ensure that it does what it says on the faceplate. The testing will determine whether the instrument is capable of retaining its calibration over a range of environmental and operating conditions. This ensures the instrument is not capable of facilitating fraud. Manually read type 5 and 6 meters are unlikely to be able to be reconfigured, and if five minute data is required from these meters they will need to be replaced.

Existing meters: storage

One of the key concerns raised around revenue metering in the directions paper and in submissions was the availability of storage for existing meters that are reconfigured to collect five minute data. Each meter type has a specified minimum data storage requirement specified in the NER. These storage requirements are illustrated in Table 6.2. The storage requirements established in the NER are to account for meter malfunctions and meter reading cycles, allowing for enough capacity in case a reading cycle is missed.

201 AEMC, *Five minute settlement*, directions paper, p. 89.

202 United Energy, directions paper submission, p. 2.

203 More detail available in AEMO, *Five minute settlement: high level design*, September 2017, p. 8.

Table 6.2 Meter data reading and storage

Meter type	Storage requirement	Malfunction rectification timeframe	Reading cycles
Type 1-3	35 days	2 business days	Weekly
Type 4	35 days	10 business days	Weekly
Type 4A Type 5	200 days	10 business days	Quarterly

Source: AEMO, directions paper submission, p. 3.

Moving from 30 minute data to five minute data requires meters to have six times the storage. Stakeholders have suggested that some of the later model type 4 meters would have sufficient storage to meet the 35 day requirement, but some of the older models will not.[204] AEMO has stated a preference that the storage requirements listed in the NER on each meter type are not reduced, as the malfunction and reading risks have not changed.[205] One way to reduce replacement costs for meters that when recalibrated to collect five minute data fall short of the meter storage requirements, is for AEMO to potentially grant an exemption on a case by case basis. This means meters that fall a day or two short of the storage requirements (but which would otherwise satisfy the requirements for that meter type in the NER) would not need to incur the costs of meter replacement.

Existing meters: exemptions

Several stakeholders suggested that to minimise costs of implementation existing type 4 and type 5 meters be exempt from providing 5 minute data.[206] Excluding these meters could:

- avoid costs of replacement and reconfiguration of large quantities of meters, particularly in Victoria
- minimise data storage costs for the MDP and the retailer
- allow AEMO, MDP and retailers to test their systems with lower quantities of five minute data
- minimise data communication costs.

204 Directions paper submissions: AusNet Services, p. 7; Energy Networks Australia, p. 3; Jemena, p. 2; United Energy, p. 2.

205 AEMO, directions paper submission, p. 3.

206 Directions paper submissions: AEMO, p. 2; AusNet Services, p. 7; Origin Energy, p. 14; United Energy, p. 2.

Type 1-3 meters make up only 0.13% of all meters, yet in 2016/17 metered 408 TWh of electricity. An approach which move these meters to five minute metering first may be able to realise the bulk of the benefits, whilst minimising the initial costs. However, consumers with type 4 or 5 meters who are able to reconfigure their meters to record and store five minute data may receive the benefits of matching their demand to market movements. Small consumer demand response markets are yet to be developed in the NEM at a large scale, so obligations on these consumers to meter and provide this granularity of data may not be as time sensitive.

Using Net System Load Profile in five minute settlement

If data is not able to be provided at a five minute granularity, AEMO could profile the data to five minute periods using a NSLP. AEMO currently uses NSLP to profile data from accumulation meters so they can be settled on a 30 minute basis. Section 3.2.1 of AEMO's *Five minute settlement: High level design* report explains how NSLP work in greater detail.[207] However in short, AEMO:

1. aggregates all 30 minute energy flows from meters at the boundary of a distribution network region

2. subtracts from this aggregate all 30 minute interval metered loads and other loads such as controlled loads and deemed unmetered loads to create the NSLP

3. shapes the remaining load of type 6 accumulation meters and any errors using the NSLP.

Under five minute settlement, AEMO could adapt this process to shape the load based on the best available data. As described in section 3.3.2 of AEMO's *High level design* report,[208] this could involve AEMO:

1. aggregating all five minute energy flow from meters at the boundary of a distribution network region

2. using this aggregated data to profile 30 minute interval data into five minute increments

3. subtracting this combined load from the load at the boundary of a distribution network region

4. shaping the remaining load into five minute increments using the NSLP.

Profiling data using a NSLP does create a small imbalance between the price paid for electricity for each trading interval and the price received for electricity if the NSLP does not perfectly match consumption. This residue currently exists when profiling type 6 meters to 30 minute periods, and the local retailer bears this residue through the settlement by difference process. If the NSLP is used to profile 30 minute data to five

207 AEMO, *Five minute settlement: high level design*, September 2017, pp. 13-14.

208 AEMO, *Five minute settlement: high level design*, September 2017, pp. 14-16.

minute intervals, this residue is likely to increase. AEMO has advised that their initial investigation of this residue under five minute settlement suggests the scale of this residue would be negligible compared to the existing settlement residue.[209]

One way to potentially minimise this residue would be to have clearly defined wholesale and distribution network boundaries, which are used to calculate the NSLP. This would involve ensuring five minute metering is required for all transmission network connection points and any distribution network connections point where the market participant is a market generator or small generation aggregator. There are currently around 156 type 4 meters that fall into this category. Having these meters at a five minute granularity will also ensure the integrity of intra-regional residue calculations.

New and replacement meters

Under the National Electricity Amendment (Expanding competition in metering and related services) rule 2015 that will commence on 1 December 2017, all meters that are newly installed or replaced after this date for small customers will need to be type 4 meters that meet the minimum services specification (with limited exceptions). This policy had several objectives including the modernisation of the national metering fleet to give consumers more opportunities to access a wider range of energy products and services. In their submission to the five minute settlement directions paper, Stanwell estimated that 600,000 meters would be replaced over the next five years.[210] From discussions with stakeholders, the Commission understands that the majority of these meters will already be capable of recording five minute granularity data and meeting the storage requirements set out in the NER. In order for these new meters to be future-proofed to participate in demand response markets, the Commission's view is that it would be efficient for these meters to all have the minimum measurement and storage specifications to comply with five minute settlement. This change in minimum specification is likely to create minimal additional costs to meter providers or retailers, as these meters are in most cases already the default meter.

As mentioned above, new meters that are installed may need to undergo additional pattern testing to comply with National Measurement Institute specifications.[211] It may be appropriate to allow for a period of time for meters to undergo additional pattern testing, if required, before the commencement of any amendment to the minimum services specifications as set out in the NER. Further detail on the pattern approval is available in chapter 2 of AEMO's *High level design* report.

209 More detail on this is available in Chapter 3 of AEMO's High Level Design report.

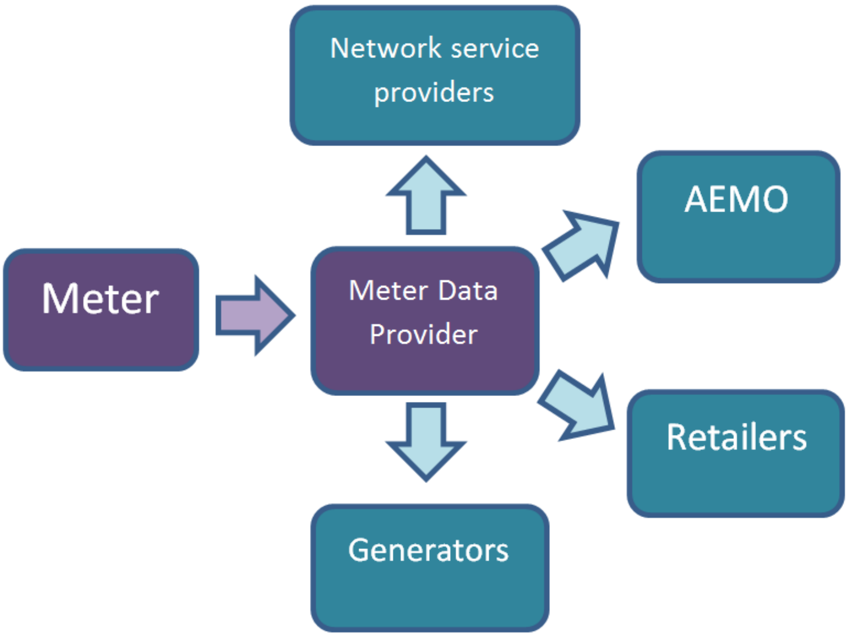
210 Stanwell, directions paper submission, p. 8.

211 For more information on the pattern approval process please see: http://www.measurement.gov.au/Industry/services/Pages/Pattern-Approval.aspx

6.3.4 Meter data systems and processing

A move to five minute metering would require IT systems to be updated to accept this granularity of data. Additionally, some stakeholders have noted they would need to update meter communication infrastructure or increase their bandwidth contracts to handle the sixfold increase in data. Figure 6.1 illustrates the data flows from the consumer meter to each participant class.

Figure 6.1 Consumer meter data flows



benefits of five minute settlement include, improved accuracy of pre-dispatch and improved visibility that network service providers will have over usage of their network from five minute data. A large proportion of these benefits will be realised through five minute granularity from large consumers with type 1-3 meters and at transmission connection points. For these customers five minute data would be required for each of the participants in Figure 6.1. For small customers with types 4 and 5 meters,[212] AEMO and retailers may not receive as great a benefit from that five minute granularity, given the MDP system change costs. If optional five minute data collection and provision from five minute capable meters were to be adopted, it would:

- potentially delay the full cost of MDP and retailer system upgrades to handle five minute data
- reduce data storage for both the retailer and the MDP
- reduce data communication costs for the MDP.

212 This is with the exception of type 4 meters that are at transmission network connection points or distribution network connection points where the market participant is a market generator or small generation aggregator.

The Commission understands that some MDPs already have systems that can handle five minute data. Additionally, whilst data storage and communication costs will increase from handling five minute data, a gradual transition of type 4 and 5 meters to five minutes should allow the costs of these services to continue to decrease by the time there is large-scale implementation. Further, having five minute granularity of data for all small consumers with five minute capable meters could incentivise retailers to develop products to make use of this data.

6.3.5 Bidding resolution

In the NEM, the current settlement price is based on the time-weighted average of the six five-minute dispatch interval prices over the 30 minute trading interval. Generators are required to submit initial price/quantity offers for each 30 minute trading interval in up to ten price bands to AEMO by 12:30pm the day before trading day.

In addition, generators and market customers can submit rebids up until the start of processing for the relevant five-minute dispatch interval.[213] Rebids involve moving capacity between the nominated price bands, in response to changing market conditions. Since the rebid varies the original dispatch offer, the rebid applies for the whole 30 minute trading interval. The exception to this is when a rebid is submitted for a trading interval that has already started. In this case, the rebid only affects the remaining dispatch intervals of that half hour.[214]

Each generator's initial offers submitted to AEMO are combined into a merit order and used to forecast the dispatch outcomes for the following day's trade. As time progresses from the initial offers, rebidding facilitates an iterative process of price discovery. This provides generators with the necessary flexibility to adjust their position to accommodate changes in the market.

The NER contain a market design principle that states that Chapter 3 of the NER (including the bidding and rebidding rules) ought to give effect to the:

> "maximum level of market transparency in the interests of achieving a very high degree of market efficiency, including by providing accurate, reliable and timely forecast information to Market Participants, in order to allow for responses that reflect underlying conditions of supply and demand.[215]"

In this context, the Commission considered the appropriate bidding resolution if 5 minute settlement were to be implemented.

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213 NER, rule 3.8.22. Among other things, generators can vary their available capacity. This is defined as: "in relation to a specific price band, the MW capacity within that price band available for dispatch (i.e. availability at each price band)".

214 Technically, the rebid changes the offer for the whole trading day, but settlement is based on the offer or rebid that was accepted by the dispatch engine.

215 National Electricity Rules, clause 3.2.4(2).

Analysis

This section examines the benefits and drawbacks of two options for bidding and offering into the NEM:

(a) maintaining the bidding resolution at 30 minutes

(b) changing the bidding resolution to five minutes.

In order to evaluate the most appropriate bidding resolution, the Commission has analysed each option under four different criteria: price discovery, compliance, system changes and data/process implication. Table 6.3 below summarises the findings.

Table 6.3 Bidding resolution design options

Issue	5 minute settlement / 30 minute bidding resolution (no change to bidding resolution)	5 minute settlement / 5 minute bidding resolution
Price discovery	• Relatively less effective for price discovery • 30 minute bidding resolution is less accurate, which is likely to be a material issue under five minute settlement, considering there will be a greater incentive to shift generation and load at a five minute resolution • Even though a more granular physical capability can be expressed via rebidding, this may only occur once the 30 minute interval has commenced. The less effective price discovery via the pre-dispatch schedule will result in more rebidding as dispatch approaches	• More effective price discovery • Some of the benefits claimed as a result of five minute settlement would rely on accurate pricing to be realised. Prices may be less reliable if market participants are hindered in submitting bids that accurately reflect their prices and available capacity • Generators and loads (including batteries) can represent physical capabilities more accurately and more immediately through both initial offers and rebids. This would lead to more accurate forecasting via pre-dispatch schedule, which in turn is likely to result in decreased rebidding
Compliance	• May cause some participants to be in breach of prohibition on making "false and misleading offers". For example, a battery with 45 minutes of discharge capability, intending to discharge for 45 minutes, has to choose between bidding to supply for either 30 minutes or 60 minutes • Current compliance framework requires that market participants submit bids that accurately reflect their capabilities and available capacity at the time of dispatch. Market participants would not be able to submit such	• Avoids potential compliance issues

Issue	5 minute settlement / 30 minute bidding resolution (no change to bidding resolution)	5 minute settlement / 5 minute bidding resolution
	bids, they would continuously need to update their 30 minutes bids	
System costs	• AEMO's and market participants' bidding systems would not need to change • Market participants would continue to submit 30 minute resolution bids, with no additional cost expected	• Will have an impact on AEMO's and market participants' bidding systems, which would require further changes • The marginal cost to market participants may be small given the extent of the changes already required to energy trading software due to the move to five minute settlement
Data/process implications	• No changes in the volume of data when submitting and processing bids and offers • Likely that more rebids will occur within the late rebidding period, requiring an increased volume of record keeping for market participants	• Greater volume of data (6x) to be processed by market participants and AEMO and to be transferred between market participants and AEMO • However, if 30 minute bidding resolution was retained, a market participant could still update their price at least 5 times (i.e. at least once in every dispatch interval) then the processing effort required for the two options would be equivalent

6.3.6 Pre-dispatch

The NER prescribes that AEMO must prepare and publish a pre-dispatch schedule[216] in accordance with the Spot Market Operations Timetable.[217]

Currently AEMO runs pre-dispatch every half hour, on the half hour for each trading interval up to and including the last trading interval of the last trading day for which bid band prices has closed. As changes to bid band prices for the next trading day close at 1230 hours, AEMO will at 1230 hours, publish pre-dispatch for all trading intervals up to the end of the next trading day. AEMO also voluntarily provides a five minute pre-dispatch schedule for the hour before a dispatch interval, although this is not currently required in the rules.

216 Pre-dispatch is an indicative forecast of dispatch and pricing for the current trading day (and next trading day, after 12:30pm EST) to a half-hourly resolution, and is updated every 30 minutes.

217 NER, rule 3.8.20.

As a consequence of implementing five minute settlement and five minute bidding, the Commission has also considered whether the rules should be amended to include a requirement for AEMO to publish a five minute pre-dispatch schedule.

Analysis

According to AEMO's Pre-dispatch Process Description[218], the pre-dispatch has two major purposes:

- to provide market participants with sufficient unit loading, unit ancillary service response and pricing information to allow them to make informed and timely business decisions relating to the operation of their dispatchable units
- to provide AEMO with sufficient information to allow it to fulfil its duties in accordance with the rules, in relation to system reliability and security.

Increasing the granularity of pre-dispatch from 30 minutes to five minutes would provide AEMO and market participants with sufficient information to achieve the above. It would also likely lead to a more accurate forecast. However, increasing the pre-dispatch granularity would increase the costs for AEMO and market participants. This is because it would increase AEMO's data handling and processing requirements.

The Commission understands that five minute pre-dispatch forecast information granularity is most useful to market participants for the 15 to 30 minutes prior to the real time dispatch of generation units. Otherwise the 30 minute pre-dispatch schedule (with its accompanying scenarios) provides sufficient information with which to make decisions about market positions.

6.3.7 Conditional rule change

Some stakeholders have suggested that a rule implementing five minute settlement should only be made if certain pre-conditions have been met. A number suggested this could be done along the lines of the approach the Commission has taken in assessing Optional Firm Access.

It is important to note though that the cases where a monitoring regime has been used, for example the Optional Firm Access review and the Victorian Designated Wholesale Gas Market review, were both market reviews[219] and not rule changes.

The AEMC cannot make a conditional rule. The rule making provisions in the NEL prescribe that a rule must commence on the day it is made or on some future date which is specified in the rule itself. There is no power in the NEL for the AEMC to

218 AEMO, Pre-dispatch process description, July 2010, p. 6.

219 The AEMC can conduct market reviews and provide advice in accordance with terms of reference provided by the nation’s energy ministers and can also formally initiate their own reviews on matters related to the rules. In the reviews and advice the AEMC take a long term view of what needs to be done to deliver reliable, secure energy at the best price for consumers.

make a rule where the commencement of that rule is dependent on the occurrence of a specified trigger or event.

This is also consistent with the principles of good regulatory practice for the making of delegated legislation. It would be inconsistent with these principles to have a power to make a rule contingent on the occurrence of a trigger or future event.

6.4 Commission's position

Demand side optionality

Sun Metals proposed that under five minute settlement market customers would have the option of being settled on either a five minute or 30 minute basis. As identified in the directions paper, this approach would:

- create ongoing complexity and have negative impacts on certain types of hedging contracts
- reduce the efficiency of price signals for demand side participants.

The Commission's view is that five minute settlement should apply to both the supply-side and demand side of the market. The Commission acknowledges that in the short-term compulsory five minute settlement means that one-off metering and IT system costs would be higher for those demand side participants who would have otherwise chosen to settle on a 30 minute basis. However, it considers that these costs are likely to be outweighed by the benefits of the improved price signal and avoiding administrative burden, and potential basis risk and liquidity issues with certain types of contracts.

Metering under five minute settlement

The Commission is of the view that a solution involving five minute data from revenue meters would be most appropriate to support five minute settlement. Use of SCADA systems to profile energy flow data may provide some initial cost savings, however these benefits are outweighed by issues around accuracy, reliability and consistency in measurement. Revenue metering, while a higher cost option, will be able to provide the accuracy and reliability required for NEM settlement.

Type 1-3 meters make up only 0.13% of meters but process over 400TWh of energy annually. If these meters have been installed in the past 15 years they should have the capability to measure energy flow at a five minute granularity and most can be remotely reconfigured. The draft rule therefore prescribes that type 1-3 meters will need to record and store five minute data from the commencement date of the rule.

The draft rule requires type 4 meters that are located at transmission network connection points; or at distribution network connection points where the relevant financially responsible market participant is a market generator or small generation aggregator; to record and store five minute data from the commencement date. These type 4 meters will require five minute granularity to ensure the wholesale and distribution network boundaries can be calculated accurately. This will also avoid the need to explicitly deal with profiling imbalances in the intra-regional settlement residue calculations.

The draft rule does not require all other type 4-6 meters that are already installed to provide five minute data at the commencement date. The data from these meters will be profiled to five minutes by AEMO using the NSLP. This is described in more detail in AEMO's High Level Design report.

Table 6.4 illustrates the current and proposed treatment of existing meters in the NEM.

Table 6.4 Proposed treatment of existing meters under 5 minute settlement

Meter type	Treatment under 30 minute settlement	Treatment under 5 minute settlement
Type 1-3	30 minute data collected and used for settlement	5 minute data collected and used for settlement
Type 4, 4A and 5	30 minute data collected and used for settlement	5 minute data collected from new, replaced or reconfigured type 4 or 4A meters and meters that make up the wholesale and distribution boundary. Other meters collect 30 minute data which is profiled to 5 minutes using NSLP
Type 6	Data collected quarterly and profiled to a 30 minute basis for settlement	Data collected quarterly and profiled to 5 minute intervals using NSLP for settlement
Type 7	Unmetered loads calculated on 30 minute basis	Unmetered loads calculated on a 5 minute basis
Controlled load	Sample meters used to profile load to 30 minutes	Sample meters used to profile load to 5 minutes

To minimise costs for existing type 1 to 3 and type 4 meters that can be reconfigured to five minute granularity but fall just short of the storage requirement, the draft rule empowers AEMO to grant exceptions to a metering provider. This can be done in relation to the storage requirements in the NER on a case by case basis, as long as AEMO is reasonably satisfied that the metering provider will otherwise be able to comply with the requirements in the rule.

As most new type 4 and 4A meters are able to record and store five minute data already, the draft rule requires that all new and replacement meters that are installed will need to record and store five minute data from 1 December 2018. This will future-proof the metering fleet and will make it easier for consumers to utilise any new services and products that take advantage of five minute settlement.

Meter data systems and processing

The draft rule requires that five minute data be collected and used from all new and replacement meters. Allowing the MDP the choice of whether to record and use five minute data from new and replacement type 4 meters could delay the IT system change costs for MDPs and retailers. However, the Commission believes the benefits of having five minute granularity of data from small customers will outweigh the costs. This is based on:

- some MDPs already have systems that can handle five minute data
- the gradual transition of meters to five minutes allowing storage and data communication costs to decrease
- the additional incentives that retailers and other new service providers will have to utilise five minute granularity of data for all small consumers.

Bidding resolution

The Commission is of the view that five minute bidding resolution is the most appropriate solution because it will lead to more effective price discovery than retaining 30 minute bidding resolution under five minute settlement.

In deciding to change the bidding interval to five minute resolution, the Commission has considered:

- whether five minute offers and rebids would be an improvement in comparison to five minute settlement with 30 minute offers
- the likely costs to participants and AEMO to provide and process more granular offers (i.e. 288 price-volume combinations for a day, as opposed to 48 at present).

The draft rule requires market participants to submit dispatch bids and offers for five minute trading intervals for both their initial offers and for any rebids. Initial offers must be submitted before 12.30pm (i.e. between 15.5 and 39.5 hours before the trading interval to which the offer relates). Considering how far in advance initial offers are submitted, the five minute granularity may not be all that useful for initial offers. However, in rebidding, the five minute granularity would allow for a rebid to be targeted at a specific five minute period rather than applying for several five minute periods in a half hour.

Five minute bidding would better accommodate energy-limited supply sources and generators with complex ramping characteristics. For example, peaking generators have historically been able to generate for more than half an hour, but might, in some cases, face challenges in expressing physical limits in 30 minute bids.

In the future there may be more supply sources that will provide energy for less than 30 minutes at a time (e.g. batteries). As explained in the Table 6.3 above, this may present a compliance issue if energy-limited supply sources make 30 minute bids that they are physically incapable of honouring.

Pre-dispatch

The Commission is of the view that:

- the requirement for AEMO to provide a 30 minute pre-dispatch schedule covering each 30 minute period to the end of the last day for which bids and offers have been received should be maintained

- the rules should be amended to introduce a requirement for AEMO to provide a five minute pre-dispatch schedule covering each five minute trading interval for a minimum of 60 minutes prior to dispatch.

This approach does not result in further costs to be incurred by AEMO in relation to the preparation and publication of the pre-dispatch schedule. It also gives AEMO the flexibility to increase the outlook period for which five minute pre-dispatch schedule is provided if, in future, AEMO or market participants think this is desirable.

7 Implementation of the rule change

The current 30 minute settlement framework has been in place for nearly two decades. There will therefore be large costs, practical challenges and risks associated with implementing five minute settlement. Financial contracts, metering and IT systems have all been designed with reference to 30 minute settlement and a 30 minute spot price. This chapter assesses the:

- cost and practical issues associated with introducing five minute settlement as it relates to contracting, metering and IT systems
- the use of an appropriate transition period to reduce or mitigate the costs and risks of implementation.

The issues related to the impact of five minute settlement on the financial contracts market have been addressed in Chapter 4.

7.1 Sun Metals' view

Sun Metals estimated that the costs of implementing five minute settlement may be in the order of $10.27 million in present value terms. This included $7.09 million in upfront costs and ongoing annual costs of $560,000.

Sun Metals did not address transitional issues or a transitional period for the introduction of five minute settlement. Sun Metals did though submit that optional demand side participation in five minute settlement (section 6.3.1) and the use of SCADA data (6.3.2) would mitigate implementation costs.

7.2 Stakeholder views

7.2.1 Stakeholder views: Overall implementation costs

The AEC commissioned Russ Skelton & Associates (RSA) to prepare a paper to "contribute to the discussion regarding the proposed rule change to introduce 5 minute settlement". The report provided information on the potential costs of making the rule change, except for the cost of metering changes. They concluded that "the present value of the total costs over 15 years of the implementation of five minute settlement would exceed $250 million."[220] These included:

- Costs to re-negotiate contracts longer than 3 years: $8.3 million
- System change costs: $150 million
- On-going costs (licencing fees, maintenance costs and storage costs): $7 million/year (present value = $50 million)

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220 AEC, consultant report by Russ Skelton & Associates, directions paper submission, pp. 22-23.

- AEMO system change cost: $10 million.

Snowy Hydro noted that the benefits advocated by supporters of the five minute settlement rule change has been predominantly premised on theoretical benefits from aligning dispatch and settlement. Snowy Hydro was of the view that, in comparison, the costs associated with five minute settlement are expected to be both significant and tangible. These costs include both one-off implementation costs (using the RSA report estimate) and ongoing costs from a change in the contract market structure (discussed in chapter 4). Snowy Hydro estimated these costs would exceed $500 million.[221]

Further, some stakeholders were of the view that a detailed cost benefit analysis of the proposed rule change should be conducted before proceeding to the draft determination stage.[222]

7.2.2 Stakeholder views: Contract market requirements

Hydro Tasmania noted that the proposed rule would have impacts on many long term contracts and agreements, affecting both derivative contracts and off-market contracts and agreements. In their view, a move to five minute settlement would be disruptive for these contracts. This would have a material financial impact for participants to such agreements.[223]

Stakeholder views: One-off contract negotiation costs

The RSA report prepared for the AEC, estimated the number of contracts that would need to be re-negotiated as a result of implementing five minute settlement, based on discussions with market participants. The methodology assumed that there are 97 "standard" contracts, 54 "bespoke" contracts and 15 "large" complicated contracts that are longer than 3 years, which would all need to be renegotiated. The respective costs of renegotiating these categories of contracts were $5,000, $50,000 and $300,000 each, resulting in a cost of $7.7 million. Adding to this, $600,000 in "collective AFMA negotiation costs", resulted in a total cost estimate of $8.3 million.[224]

Origin Energy indicated that the AEMC's proposed transitional period as set out in the directions paper would still result in significant contractual disruption. It highlighted that analysis undertaken on behalf of the Australian Energy Council by RSA[225] suggested that contract renegotiations costs could be in the order of $8.3 million.[226]

221 Snowy Hydro, directions paper second supplementary submission, 4 July 2017, p. 2.

222 Directions paper submissions: AEC, p. 2; Energy Queensland, p. 2; Aurora Energy, p. 1; Origin Energy, p. 1; Major Energy Users, p. 22.

223 Hydro Tasmania, directions paper submission, p. 2.

224 AEC, consultant report by Russ Skelton & Associates, directions paper submission, p. 22.

225 Russ Skelton & Associates, directions paper submission, p. 22.

226 Origin Energy, directions paper submission, p. 13.

ERM Power noted that not all contracts will need to be renegotiated, with most if not all ASX-traded contracts rolling off within the proposed three year transition period. However, there will be some long term contracts that will have to be reopened, as a change in settlement timing would potentially be classified as a disruption event. ERM Power suggested the figures ($8.3 million) provided by Russ Skelton in his presentation at the AEMC's five minute settlement forum, appear to be a reasonable estimate of the costs involved in renegotiating these contracts.[227]

Arrow Energy stated that legal costs are likely to be significant due to the requirement to potentially unwind contracts with counterparties. Portfolios would be exposed to a high level of uncertainty as renegotiation or termination of contracts is resolved. This risk would expose market participants to hundreds of millions of dollars of uncertainty.[228]

Aurora Energy noted that a transition period would reduce one-off contract negotiation costs with wholesale arrangements. However these costs are not material when compared to the broader IT and meter data management costs that would be incurred.[229]

AFMA reasoned that although a significant transition period would mitigate the one-off negotiation costs, as this would allow the majority of current contracts to mature without the need for renegotiation, it is important to ensure that "market disruption events" provisions are not triggered for as many current contracts as possible. AFMA added that even though firm data on outstanding maturities is difficult to estimate, historical Australian Financial Markets Report data indicates that there are a significant number of contracts (such as power purchase agreements (PPAs)) that have much longer maturities (out to 2030 in some instances). Depending on the transition period chosen, one-off negotiation costs and market disruption events are inevitable for participants with long term contracts. AFMA concluded that the longer the transition period, the greater the mitigation of one-off contract negotiation costs.[230]

United Energy suggested that contract negotiation costs extend beyond the wholesale market type contracts. This could include such things as changes to meter procurement and possibly core changes to IT systems with vendors. It noted there may also be impacts on newly formed Metering Coordinators' agreements and value add services and pricing.[231]

227 ERM Power, directions paper submission, p. 9.

228 Arrow Energy, directions paper submissions, p. 11.

229 Aurora Energy, directions paper submission, p. 4.

230 AFMA, directions paper submission, pp. 6-7.

231 United Energy, directions paper submission, p. 3.

Stakeholder views: Effect of a transition period on contracts

Many stakeholders provided feedback on their views about how a transition period would affect contract renegotiation time and costs. A summary of the submissions can be found below.

AFMA noted their members hold different opinions as to whether the three year transition period is achievable, as there are many issues to consider outside of financial market implications. Most members consulted have expressed a preference for a longer transition period. This is to minimise the expected negative consequences and costs of a change, as well as ensuring market readiness for the proposed change, both in the physical and financial markets.[232]

Major Energy Users indicated that in order to avoid the inherent costs caused by the disruption, the time for any transition should be longer than contracts that are already in place. Alternatively, if a shorter transition is deemed necessary, the costs of unwinding these long term contracts need to be included in the costs involved with the transition.[233]

Arrow Energy suggested that while each market participant would have a different position, the proposed three year transition period would not be sufficient to enable all contracts to expire for participants. For instance, many PPAs are long dated.[234]

Snowy Hydro expressed some concerns about the proposed three year transition period. According to Snowy Hydro, there would inevitably be major disputes between counter-parties when the ISDA[235] market disruption clause is activated. In its submission, Snowy Hydro estimated that a transition to 2030 is probably too long but an 8 year transition may be a reasonable compromise. The proposed 8 years was derived from the average of 3 years for the liquid period of over-the-counter (OTC) forward trading and 13 years for PPAs ending in 2030 i.e. (3+13)/2.[236]

Energy Queensland considered the effect of a transition period on contracts will be specific to market participants and the individual contracts it has negotiated. Even with a transition period, there is the potential to disrupt these bespoke contractual arrangements. It noted that, at present, their longest market based contracts are 10 year PPAs.[237]

ERM Power noted that there are a substantial number of contracts between renewable energy generators that produce large scale generation certificates and retailers. Many of these contracts will extend until 2030 when the renewable energy target is scheduled to end. A shift to five minute settlement before then would potentially mean reopening

232 AFMA, directions paper submission, p. 2.

233 Major Energy Users, directions paper submission, p. 34.

234 Arrow Energy, directions paper submission, p. 9.

235 International Swaps and Derivatives Association.

236 Snowy Hydro, directions paper submission, p. 19.

237 Energy Queensland, directions paper submission, p. 10.

these contracts. Therefore, the longer the transition period, the lower the overall costs will be as some longer terms contracts start to end.[238] ENGIE made a similar observation, noting that since the renewable energy target extends out to the year 2030, the PPAs that have been employed are long term agreements. These would extend beyond the proposed three to five year transition period.[239]

AFMA added that financial market participants will need to develop and agree upon new standardised documentation in swaps and option contracts that reference five minute settlement prices. This can be done in advance of the change once a decision is made. AFMA also indicated that some participants may have already started to bilaterally agree individual long term contracts which have clauses that have been developed to allow for a change to five minute settlement. It highlighted though that AFMA has not been engaged in the work of creating any new form of standardised documentation.[240]

7.2.3 Stakeholder views: Metering requirements

Stakeholder views on metering upgrades to accommodate a move to five minute settlement were canvassed in section 6.2. These views specifically relate to the physical capability of meters to record and store data at a five minute granularity, the requirements for reconfiguring these meters, and the types of meters that should be required to provide five minute data. This section explores stakeholder views on metering implementation costs and timeframes for five minute settlements.

Stakeholder views: Metering implementation costs

AusNet Services indicated that the cost implications of applying five minute settlements as proposed to existing Victorian Advanced Metering Infrastructure (AMI) meters and system would be particularly significant with costs in excess of $100 million. However, it noted the costs would be lower if the scope of the five minute settlement rule change were limited to new and replacement metering for small customers.[241]

CitiPower and Powercor noted they have not conducted a fulsome review of the requirement for additional access points, but they believe the cost could be in the order of $8 million. Due to the significant volume of AMI interval meters capable of providing five minute settlement in Victoria compared to other States (type 6 accumulation meters would not need to provide five minute data), the extent of system changes in Victoria is likely to be greater than elsewhere.[242]

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238 ERM Power, directions paper submissions, p. 9.

239 ENGIE, directions paper submission, pp. 3-4.

240 AFMA, directions paper submission, p. 6.

241 AusNet Services, directions paper submission, p. 6.

242 CitiPower and Powercor, directions paper submission, p. 2.

Energy Queensland noted that their Ergon Energy arm had a fleet of around 313,000 electronic meters of which only around 2500 were remotely read for settlement. The remaining 310,000 interval meters would require a site visit to be reprogrammed or replaced if they were required to provide five minute data. Ergon Energy estimated that meter replacement/reprogramming costs may vary from $500 to $1500 per meter with types 1-4 being at the higher end of this bracket depending on hardware, site location and the appointed meter provider's testing and validation procedure.[243] Energy Queensland's Energex arm has around 765,247 electronic meters, of which around 4,000 have remote communication capabilities. However, none of the 4,000 meters that have remote communication capabilities are being used for market purposes, so all will need to be replaced or reprogrammed if they are required to provide five minute data.[244]

AusNet Services considered the rule change would result in the following direct costs: about $4 to $7 million in costs to replace transmission and sub-transmission metering and roughly $10 million in replacing their first 50,000 AMI meters that cannot be reconfigured to provide five minute metering data. It noted not all AMI meters would be able to store the required 200 days of metering data and suggested the metrology requirement would need to be relaxed. The increase in its AMI metering data communication network volume requirements would result in higher third party telecommunication (mobile data) costs in the order of $1 million per year.[245]

Aurora Energy was of the view that there would be a range of metering implementation costs. This includes reconfiguring existing interval meters, reprogramming new and replacement meters, contract variations to newly established metering coordinators, meter providers and meter data providers, additional bandwidth for metering communications, increased data storage costs, increased meter read frequency for type 4A meters, and late delivery of NEM12 data which can impact the prepayment customer segment.[246]

SA Water indicated it would need to audit around 1640 metering sites to ensure the delivery of five minute data, of which 150 to 200 sites would require an upgrade or replacement. They suggested that implementation costs could be minimised by exempting those who do not directly participate in the NEM and realising the benefits to participants with solar and batteries. SA Water also suggested that companies may delay upgrading older meters pending the outcome of the five minute settlement rule change.[247]

243 Energy Queensland, directions paper submission, p. 7.

244 Energy Queensland, directions paper submission, p. 8

245 AusNet Services, directions paper submission, p. 9.

246 Aurora Energy, directions paper submission, p. 5.

247 SA Water, directions paper submission, p. 4.

EnegyAustralia was of the view that the Commission should be mindful of the costs of replacing meters prior to the end of their life when assessing whether the proposed rule change generates a net benefit.[248]

Stakeholder views: Metering implementation timeframe

United Energy was of the view that there could be benefits from aligning a site visit for meter testing or inspection with a meter exchange, where needed.[249] United Energy noted that with the commencement of metering competition on 1 December 2017, a number of competitive providers in the market would be gearing up for meters capable of 30 minute data and systems capable of their value add offering. These new competitive providers may be able to more readily provide five minute capable meters in the competitive meter rollout. However, many of their IT investment decisions may have been made in light of the 1 December 2017 version of the NER and NEM procedures. These new systems may not be at the end of their life cycle within the three to five year period envisioned by the proposed transition.[250]

United Energy cautioned against the three to five year transition timeframe, especially in Victoria, implying AMI meters needed to be replaced or reconfigured. It suggested the AEMC could consider a longer transition period, where five minute data would only be required for meters installed after a certain date (for small customers) or if there is generation/demand response at the site. United Energy noted this more flexible transition is no different to the commencement of mass market retail competition where earlier tranches required remotely read interval meters but the last tranche was profiled as a cheaper alternative to cater for a lengthier transition. It argued that any transition approach should be pragmatic and allow the flexibility of the market to respond at appropriate times when systems need upgrading.[251]

CitiPower and Powercor stated that the 15,000 type 1-4 interval meters in their network represent around only 1.2 per cent of total meter volumes, however, the network revenue associated with these meters is around 50 per cent of total network revenue. It suggested these meters transition to five minute settlement first, which would unlock the rule change's benefits for half of transactions (by value), while allowing IT changes to be tested with lower data quantities. With this transition, unforseen issues will be identified without affecting millions of data points generated from the 1.2 million type 5 AMI meters. CitiPower and Powercor proposed type 1-4 interval meters transition to five minute settlement over three years from when the rule comes into effect and type 5 AMI meters to transition within five years.[252]

AusNet Services recommended a longer transition period for Victoria customers than the AEMC's proposed approach. If though a rapid change is preferred, the AEMC

248 EnergyAustralia, directions paper submission, p. 10.

249 United Energy, directions paper submission, p. 2.

250 United Energy, directions paper submission, p. 4.

251 United Energy, directions paper submission, p. 5.

252 CitiPower and Powercor, directions paper submission, p. 3.

should give consideration to efficient cost recovery and cost minimisation approaches for Victorian customers. AusNet Services is of the view that the Victorian government should be involved in the consideration of new metering requirements that have the potential to add very significant costs to existing customers. AusNet Services may be able to work together with the Victorian government to make such a change in a manner that is economically efficient.[253]

Energy Queensland considered that any implementation timeframe should align with a testing and inspection regime or with a new and replacement programme. However, it also noted that not all participants will have the same testing and inspection regime as defined in the NER and this may create inconsistencies.[254]

7.2.4 Stakeholder views: IT system requirements

Most stakeholders indicated that major changes to the information systems and processes of market participants and the market operator will be required to implement five minute settlement. Their concerns mostly revolved around the proposed implementation timeframe and also the implementation costs that participants would have to incur.[255]

Stanwell suggested that the Commission develop an implementation roadmap, setting out no-regrets issues such as the proposed metering changes as well as preconditions and decision gateways for potentially expensive issues. It also recommended that AEMO should reach a certain level of system development before the broader industry progresses. One example of this would be in relation to the structure of tables in the *EMMS Data Model* database. This currently includes similar, but not identical information in separate tables, in relation to dispatch intervals and trading intervals.[256]

AGL Energy made similar observations, noting that analysis on the impact on settlement systems should be undertaken before decisions on implementation timeframes and processes is taken. It noted that AEMO, as the market operator, would be ideally placed to perform this task. In addition, further opportunities to increase the efficiency and effectiveness of existing market operating systems or regulatory processes in a five minute settlement environment may be identified as part of this work.[257]

The AEC expressed concerns that there is a high risk of failure during implementation. This is because of the complexity of the system changes and the need for new systems implemented by a wide range of organisations to work effectively together immediately following the introduction of five minute settlement. The consequences of

253 AusNet Services, directions paper submission, p. 6.

254 Energy Queensland, directions paper submission, p. 8.

255 Directions paper submissions: Aurora Energy, pp. 4-5; AEC, p. 2; Arrow Energy, p. 11; ENGIE, p. 3; Hydro Tasmania, p. 2; Flow Power, p. 2; ERM Power, p. 2.

256 Stanwell, directions paper submission, p. 6.

257 AGL Energy, directions paper submission, p. 2.

such a failure could be significant and affect the secure and reliable operation of the power system.[258]

ERM Power added that the recent history of changes to retailers' billing systems shows that the transition to new billing systems can lead to problems. To the extent that this leads to erroneous bills or delays, this can undermine confidence in the retail market. ERM Power noted retailers are also in the process of implementing major changes to systems as part of Power of Choice reforms. It warned that care must be taken that a major change like five minute settlement is not rushed through and that retailers are given adequate time to develop, test and implement new systems.[259]

Stakeholder views: IT systems affected by the rule change

Stakeholders identified many of the various IT systems that would require upgrades due to the proposed rule change, which include, but are not limited to risk management, trading, meter data management, settlements, billing, reporting and data collection and storage.[260] ENGIE noted that all these changes are on top of the system and process changes that AEMO would also need to implement.[261]

EnerNOC noted that many participants already have IT systems capable of processing five minute settlement because the FCAS markets already settle at five minute intervals, and have done so for years. An analysis of AEMO's Registration and Exemption list indicates that 19 participants are registered to offer FCAS and that these 19 participants account for approximately 77 per cent of the registered capacity in the NEM. However, EnerNOC indicated that the majority of participant transition costs would relate to changes to risk management IT and software.[262]

Energy Networks Australia noted that the anticipated six-fold increase in metering data volume is likely to result in a significant increase upon, if not the exceeding of, the processing and storage capability of most network service providers' (NSPs') existing billing systems. In its view, this would result in, at minimum, the need to significantly modify, if not lead to the replacing of current network billing systems.[263]

Jemena and AusNet made similar observations, stating that a sixfold increase in metering data to be collected, communicated, and stored there would necessarily be a significant upgrade to back end systems and processes of market participants and AEMO. The impacts on system design would be significant across the industry and further industry wide consultation is encouraged.[264]

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258 AEC, directions paper submission supplementary report, p. 5.

259 ERM Power, directions paper submission, p. 12.

260 Directions paper submissions: Energy Queensland, p. 11; ENGIE, p. 3.

261 ENGIE, directions paper submission, p. 3.

262 EnerNOC, directions paper submission, pp. 4-5.

263 Energy Networks Australia, directions paper submission, p. 4.

264 Directions paper submissions: Jemena, p. 2; AusNet, pp. 2, 8.

United Energy and CitiPower/Powercor provided specific guidance on the types of changes required in their systems for the five minute settlement rule change.[265] According to United Energy, the following potential changes and ongoing operating efforts would be required to enable collection, handling and provision of five minute interval data into the market as an initial Metering Coordinator or Metering Data Provider:

- additional capacity in the radio mesh network and 3G data plans to accommodate the additional data
- upgrade to head end interval data collection systems to enable the additional data to be collected and comply with the Victorian AMI daily meter data collection and publishing requirements, which may require substantial changes to core vendor applications
- upgrade (or replacement) of meter data management applications to enable processing of five minute interval data. This will likely require substantial redesign and re-implementation of the vendor application to enable data processing, quality and delivery timeframes to be maintained. This assumes data delivery to AEMO for settlement will remain within the current service levels, as opposed to adoption of a more frequent delivery schedule, which would drive further change and complexity
- impacts on internal integration software and gateway sizing, which would drive the requirement to upgrade or replace current technology
- increased data for network billing calculation and invoice aggregation and possible change of network tariff structures if five minute data as opposed to 30 minute data was used for some/all customers
- increased volumes of data and the change of data format/meter configuration is likely to lead to increased queries and exceptions management across the market
- ongoing IT and business operational effort and complexity would likely increase with the move to five minute interval data, through increased IT system availability requirements and the requirement for more frequent maintenance, system upgrades and increased archiving activities.

In addition, United Energy noted that, for the MDP role, the requirement to provide 30 minute and five minute data would require a separate parallel meter data processing approach. The current IT solution validates all 30 minute incoming data before publishing the same dataset to retailers and AEMO. If there were to be different interval granularity, there would likely be IT system redesign required.[266]

265 Directions paper submissions: United Energy, p. 2; CitiPower and Powercor, p. 2.

266 United Energy, directions paper submission, p. 4.

Stakeholder views: IT systems implementation costs

Market participants

The implementation costs of IT systems changes are an area of concern for most stakeholders.

On this issue, Aurora Energy envisaged the magnitude of the transition to five minute settlement to be similar to the project currently being undertaken to prepare for the metering competition rule change. This has an estimated total project cost of around $20 million to Aurora Energy.[267]

Origin Energy noted that market participants would face significant upfront costs in undertaking the necessary system and IT changes. Origin Energy estimated it could cost approximately $33 to $38 million to effect the necessary system changes to Origin Energy's systems alone.[268]

Arrow Energy observed that while not all systems would need to be fully replaced and some might be easier to transition than others, an entire review of all systems would need to be implemented to identify the costs and timing impacts to each participant. Arrow Energy expects that all participants would be exposed to a substantial IT system upgrade and this could run into the millions of dollars.[269]

Energy Queensland reasoned that even though it has not undertaken a full costing assessment, it anticipated the costs to upgrade of their IT systems to be in the order of tens of millions of dollars.[270]

The RSA report prepared for the AEC, indicated that the introduction of five minute settlement would require major changes to market participant's business systems. Typically, this would include changes to: wholesale market trading systems; retail customer management systems and risk management and reporting systems. They estimated the total one-off system costs for participants to be approximately $150 million. In addition to these costs, they estimated a $7 million per annum increase in ongoing costs of operating business systems as result of increased license fees, maintenance costs and storage costs. RSA suggested that the present value of these costs over a 15 year life at a discount rate of 5% would be approximately $200 million.[271]

Stanwell agreed with the broad estimate of "tens of millions of dollars" in the Energy Edge report,[272] but added that at this stage it is unable to estimate how many tens of

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267 Aurora Energy, directions paper submission, p. 4.

268 Origin Energy, directions paper submission, p. 2.

269 Arrow Energy, directions paper submission, p. 11.

270 Energy Queensland, directions paper submission, p. 11.

271 AEC, consultant report by Russ Skelton & Associates, directions paper submission, p. 22.

272 Energy Edge, Effect of 5 minute settlement on the financial market, March 2017, p. 86.

millions. Further, Stanwell noted that the estimate provided at the forum of industry wide IT costs exceeding a quarter of a billion dollars[273] is likely to be realistic.[274]

EnergyAustralia went on to add that until the Commission publishes a draft rule that outlines the proposed changes to the NER, the system changes, compliance requirements and other related costs cannot be accurately quantified. EnergyAustralia added that some of the costs that are highly likely to be imposed on the wholesale operations of the business have been quantified in the work of RSA on behalf of the Australian Energy Council.[275]

Networks

A few of the NSPs provided their views on the implementation costs of the proposed rule change.

United Energy noted that a range of IT systems will require core system changes. This may involve vendors re-designing their products or it could involve a full tender for an alternative IT system with more suited capability. Based on a preliminary view, United Energy expects that costs would exceed $20 million, depending on the need to replace IT systems. It added that a better estimate could only be provided after a more thorough review and discussions with vendors on their product capability and willingness to redesign products has occurred. Also more detailed input on the 30 minute to five minute transition complexity and network pricing needs to be considered in its system redesign assessment and cost estimates.[276]

AusNet suggested the requirement to perform network billing on five minute metering data as proposed in the directions paper would require a replacement of their network billing system. Based on previous estimates, the system replacement costs are in excess of $20 million.[277]

CitiPower and Powercor indicated that the costs to upgrade their systems to accommodate five minute settlement could be in the order of $12 million. This includes costs of changes to AMI network management, meter data management and market transaction systems. CitiPower and Powercor also estimated data storage costs to amount to $11 million over a period of five years, based on a 6 times increase to its current cost.[278]

AEMO

AEMO provided an estimation of the upfront costs for an implementation of five minute settlement within its systems and operations to be in the range of $10 to $15

273 Russ Skelton and Associates presentation 2, AEMC 5 minute settlement public forum, May 2017, slide 5.

274 Stanwell, directions paper submission, p. 3.

275 EnergyAustralia, directions paper submission, p. 10.

276 United Energy, directions paper submission, p. 3.

277 AusNet, directions paper submission, p. 9.

278 CitiPower and Powercor, direction paper supplementary submission, p. 1.

million. AEMO noted that their estimate incorporated the following costs: IT and systems development, design, integration and testing; policy development and design; procedure consultation and amendment; program management; internal business readiness; transition planning, readiness and cutover; and stakeholder engagement.[279]

AEMO also added that ongoing costs are estimated to be in the range of $2 to $7 million (per annum) and incorporate costs relating to licensing, databases, application software, hardware and storage, and modules.[280]

The RSA report prepared for the AEC noted that the expected costs for AEMO would be significant. They suggested an indicator would be the costs of implementing the demand response rule change, in the order of $10 million.[281]

Stakeholder views: IT systems implementation timeframe

The AEC was of the view that the proposed three year transition period would be inadequate for the anticipated unbudgeted IT system changes. Many market participants may be reliant on the same IT expertise and external service providers to conduct the necessary changes – a resource which may not available due to the concurrent demands.[282] EnergyAustralia made similar observations. It noted that the resource requirements from IT vendors when making such detailed changes will be significant. Scarcity of suitable expertise will have an impact on the price able to be demanded by vendors facing significant time pressures to complete the required work.[283]

Arrow Energy indicated that a transition period of at least five years would be appropriate and allow for necessary budgeting.[284] EnergyAustralia stated that a period of not less than five years from any announcement to proceed with the alignment would allow for a much lower cost transition to a new market.[285]

Origin Energy was of the view that at least six to seven years is required for a transitional period, noting this would better align with the timeframe proposed for the completion of metering changes in support of five minute settlement.[286]

Energy Queensland indicated that the lead time required to implement a rule change such as the proposed one is most likely to be in the order of five years at a minimum. In addition, Energy Queensland stated that the AEMC should be cognisant of broader

279 AEMO, directions paper submission, p. 4; AEMO, *Five minute settlement: High level design*, September 2017, p. 29.

280 AEMO, directions paper submission, p. 4.

281 AEC, consultant report by Russ Skelton & Associates, directions paper submission, p. 23.

282 AEC, directions paper submission, p. 2.

283 EnergyAustralia, directions paper submission, p. 10.

284 Arrow Energy, directions paper submission, p. 11.

285 EnergyAustralia, directions paper submission, p. 12.

286 Origin Energy, directions paper submission, p. 3.

market reforms currently underway, such as the metering contestability framework brought about as part of the Power of Choice reforms. It highlighted that any transition to five minute settlement should not commence until Power of Choice has been stabilised.[287]

Infigen made similar observations, suggesting a long transition time would assist with system development and upgrades to existing market and operational systems. Infigen proposed a transition timeframe of at least four and a half years (to align with ASX futures expiry) to allow for IT upgrades.[288]

Stanwell cautioned against the three year transition period proposed in the directions paper, noting it would be insufficient for the redevelopment of IT systems.[289]

AusNet indicated that the timeframe for properly planning, designing, delivering and testing the types of IT systems and metering changes to implement the rule change is likely to be two years. Developing consequential changes to AEMO's market procedures and metrology requirements is also timely and may require six months to complete in addition to the system development timeframe. This reflects their experience in years of AMI metering and system changes and their more recent Power of Choice program implementation.[290]

EnerNOC supported the AEMC's preliminary view to implement five minute settlement following a three year transition period.[291]

A contrasting view was provided by Aurora Energy, which noted that it would take a large dedicated team around 18 months to undertake the required upgrades to its systems to accommodate the five minute settlement rule change.[292]

7.2.5 Stakeholder views: Transition

General views

Many stakeholders were of the view that a transitional period of adequate length may help reduce implementation costs.[293] PIAC reinforced the importance of the transitional arrangements and implementation timeframe to allow affected parties to efficiently manage risks and costs while not unnecessarily delaying the benefits to consumers.[294]

287 Energy Queensland, directions paper submission, p. 11.

288 Infigen, directions paper submission, p. 8.

289 Stanwell, directions paper submission, p. 6.

290 AusNet, directions paper submission, p. 8.

291 EnerNOC, directions paper submission, p. 1.

292 Aurora Energy, directions paper submission, p. 5.

293 Directions paper submissions: EnergyAustralia, p. 10; TasCOSS, p. 4; Mojo Power, p. 3.

294 PIAC, directions paper submission, p. 1.

The Clean Energy Council noted that the evolution to the new arrangements will require a transitional period to deliver immediately following implementation. In their view, the transition period will be crucial to allow participants to be prepared to respond to new market signals, implement changed/new systems and manage contractual changes. In addition to information technology and settlement system changes, retailers will need time to explore and understand the potential new market before implementation. Similarly, the transition period should allow competitive new entrants to prepare to enter the market with the capability to operate under a five minute regime.[295]

Three years is appropriate

EnerNOC and the Clean Energy Council indicated they support the AEMC's preliminary view to implement five minute settlement following a three year transition period.[296] The Clean Energy Council also recommended that the transition should incorporate two key elements: a) a test environment or model; and b) an industry readiness review.[297]

Wartsila added that the proposed three year transition period is a comfortable timeframe for generators to invest in and install fast response plants. Wartsila noted it can typically set up plants of sizes ranging from 100 to 300 MW plants in 15-18 months.[298]

EDMI noted that the proposed three year transition period is entirely consistent with the adoption process for metrological and safety standards and would minimise the impact on the market.[299]

Longer transition period

Infigen noted that a longer transition period is clearly more desirable than a shorter one as this will enable contracts to unwind and importantly, competitively priced technology to be tested in the market and potentially deployed.[300]

Energy Queensland indicated that if the rule change were to proceed, a period of transition would likely result in a more orderly transition and potentially smooth costs over the period. Energy Queensland proposed at least a five year transition period if the rule change is adopted.[301]

295 Clean Energy Council, directions paper submission, p. 5.

296 Directions paper submission: EnerNOC, p. 1; Clean Energy Council, p. 5.

297 Clean Energy Council, directions paper submission, p. 5.

298 Wartsila, directions paper submission, p. 3.

299 EDMI, directions paper submission, pp. 5-6.

300 Infigen Energy, directions paper submission, p. 6.

301 Energy Queensland, directions paper submission, p. 10.

Arrow Energy suggested a transition period of at least 10 years would be required, with no demand side optionality. In addition, Arrow Energy noted that sufficient and proven new generation technologies should be in place before the transition.[302]

EnergyAustralia considered that the proposed three year transition period may not align with the natural replacement of meters at the end of their life.[303]

Shorter transition period

A contrasting view was provided by some stakeholders, which is summarised below.

The South Australian government supported the rule change being introduced with as short a transition period as practicable using a staged transition process if necessary. The South Australia government urged the AEMC to consider ways to stage the transition so that five minutes settlement could commence earlier at least on the supply side.[304]

The Future Business Council suggested the transition period be reduced from three years to two years. This would send a strong market signal that will encourage higher rates of investment in grid connected energy storage technology and advanced demand management capabilities. This would also help ensure that lower wholesale prices are achieved in a shorter timeframe.[305]

Ipen Consulting noted that transition costs are inevitable and will only increase over time as new participants enter the market. For that reason, the transition should start as soon as possible with a transition period of no longer than three years.[306]

Tesla also supported an accelerated transition period, considering that battery energy storage is technically capable, and market ready, to participate in five minute dispatch intervals. Battery storage has the capability to be deployed at scale with a short project lead time. Tesla believes a 1-3 year transition period provides sufficient time for adoption of the rule change.[307]

Two stage transition approach

Some stakeholders also provided feedback on the two stage transition approach proposed in the directions paper. Their views are summarised below.

AEMO was of the view that a three year transition period should allow for impacts on interregional settlement residue and settlement residue auctions to be appropriately managed. Under the interim transition period between Stage A and Stage B,

302 Arrow Energy, directions paper submission, p. 9.

303 EnergyAustralia, directions paper submission, p. 10.

304 South Australia Department of Premier and Cabinet - Energy and Technical Regulation Division, directions paper submission, p. 2.

305 Future Business Council, directions paper submission, p. 1.

306 Ipen Consulting, directions paper submission, p. 2.

307 Tesla, directions paper submission, p. 1.

settlement-by-difference imbalances will be allocated to the local retailer under existing market settlement rules. Under the transition period, this may involve a mix of five and thirty minute data, leaving the local retailer exposed to a basis differential against those second tier retailers within its local region that are still on thirty minute settlement. This could potentially be addressed through a modified Net System Load Profile (NSLP) to mitigate the exposure of the local retailer. A consideration of alternative approaches to energy allocations may also be warranted in order to allocate imbalances and losses more equitably between local and second tier retailers.[308]

AusNet and Mojo Power considered the phased approach outlined by the AEMC offers a reasonably balanced, practical implementation timetable for the new five minute settlement regime.[309]

ECA suggested the benefits of a two stage transition to be unclear. If type 4 and remotely read type 5 meters are capable of being upgraded to five minute settlement there seems to be no reason to delay this until a point between three and five years in the future. Consumers are likely to benefit from the greater granularity of data from their meter, especially if the means to access that data more quickly are also provided.[310]

ERM Power indicated that the proposed two-stage transition would add to the costs and complexity of adjusting systems to new settlement timing. It would need to build, test and implement one new IT system for five minute settlement, while also adjusting its existing IT system to remove the load being settled on a five minute basis, while keeping load settled on a 30 minute basis. ERM Power noted that other retailers and AEMO would likely face similar challenges in case a two-stage transition is adopted.[311]

In addition, ERM Power considered that a single five year period would lower the costs of upgrading IT systems.[312]

Infigen was of the view that the three year period proposed for stage A is not sufficient, noting their preference for a transition period of more than four years.[313]

United Energy noted the proposed two stage transition appears reasonable, but added the following qualifications:

(a) if there are any changes to meter data management/data processing to streamline arrangements in conjunction with metering data providers, then any amendments are finalised in NEM procedures within 8 months of the rule change to allow the change of contracts and IT systems

308 AEMO, directions paper submission, p. 4.

309 Directions paper submissions: AusNet, p. 8; Mojo Power, p. 3.

310 ECA, directions paper submission, p. 8.

311 ERM Power, directions paper submission, p. 11.

312 ERM Power, directions paper submission, p. 11.

313 Infigen, directions paper submission, p. 8.

(b) current participants may already aggregate any 15 minute data provided to 30 minute data so that data storage is maintained for 30 minute data only. The move to five minute data should only occur after participants are ready to receive and perform their own aggregation or have the flexibility to manage both five minute and 30 minute data

(c) consideration of a possible gating process to evaluate the benefits of the rule change based on the emergence of new technologies and assess settlements residue growth/distortions at the time. This could include the realisable benefits where small customers not involved in new generation technologies or demand response remain on 30 minute data until the next meter replacement which could occur beyond the five year period.[314]

Test environment prior to five minute settlement commencement

Some stakeholders recommended that a shadow market/test environment is provided to market participants for a pre-determined period before five minute settlement commences.

GreenSync (one of the members of the Australian Energy Storage Alliance) noted that it fully supports the move to five minute settlement, but also understands that changes may affect market price certainty. To address this concern, it recommended the introduction of a shadow market for a full 12 months to offer stability to market through its introduction.[315]

The Clean Energy Council recommended the creation of a test environment or model that can allow market participants to explore the characteristics of the new settlement regime and how they may interact with the new market in the coming years. This should be an open source format developed by an appropriate independent party (such as a university) and made freely available.[316]

The RSA report prepared for the AEC, suggested that the AEMC should work with all affected parties to set in place a fall back option. This would, in the event of any problems arising, allow the market to revert to previous systems and processes for as long as necessary to ensure that any failure can be resolved.[317]

7.3 Analysis

The analysis in:

- Chapter 3 identified the benefits of five minute settlement

314 United Energy, directions paper submission, pp. 4-5.

315 Australian Energy Storage Alliance, directions paper submission, p. 5.

316 Clean Energy Council, directions paper submission, p. 5.

317 AEC, supplementary consultant report by Russ Skelton & Associates, directions paper submission, 25 May 2017, p. 7.

- Chapter 4 explored the potential effect of five minute settlement on hedging and risk management
- Chapter 5 assessed the concerns raised about the impact the rule change might have on system security and reliability
- Chapter 6 discussed the metering challenges that arise in implementing five minute settlement and proposed an approach to manage these challenges.

The existing NEM 30 minute settlement framework has been in place for almost two decades. Financial transactions, metering and IT systems are all designed on this basis. The Commission recognises this means that despite the potential benefits identified in Chapter 3 there are likely to be significant practical challenges, risks and costs associated with implementation. In particular, large one-off costs.

The Commission has identified the following one-off costs associated with five minute settlement:

- contract disruption and the potential need to renegotiate existing contracts and negotiate new contracts[318]
- metering costs to access five minute data (identified already in Chapter 6)
- IT systems changes.

Of these one-off costs, contract disruption and metering costs would potentially be reduced if there was an appropriate timing of the implementation of five minute settlement. As indicated by many stakeholders, contract disruption and metering costs are of a much lower order of magnitude than those associated with IT system changes. The Commission understands that the changes required to IT systems and processes will affect most market participants, and will be significant.

A key matter for the Commission is whether any of the identified risks and costs with implementing five minute settlement can be mitigated or reduced through the adoption of a transition process. The potential for transitional arrangements to be used to reduce costs was recognised in exploring the issues of optionality and of metering approaches in Chapter 6.

This section examines in further detail the costs and practical challenges of implementation, and the proposed transitional arrangement to reduce cost in relation to:

- contracts
- metering
- IT systems.

318 The issues related to the impact of five minute settlement on the financial contracts market have been addressed in Chapter 4.

7.3.1 Overall implementation costs

The Commission acknowledges that some market participants provided cost estimates of the impact of five minute settlement to their businesses. In addition, RSA on behalf of AEC (representing 21 electricity and downstream natural gas businesses operating in the competitive wholesale and retail energy markets), submitted a report that estimated costs of the proposed rule change. This report concluded the total implementation costs would reach $250 million[319], noting that this figure has been rounded up from a sub-total of $218.3 million.

The RSA report states that there will be an additional $7 million per year required in on-going costs with a present value of $50 million.[320] These costs include "licencing fees, maintenance costs and storage costs". Given the technological improvements and decreasing costs of data storage over time, the Commission expects the ongoing costs of storing larger volumes of data should be declining. Further, it is unclear why licensing or maintenance costs would be higher once the five minute settlement system changes are made.

The Commission notes that the RSA $250 million estimate of implementation costs, if taken at face value, does not equate to the increase on "business as usual" of making the rule. It is understood that some expenditure will happen irrespective of the rule change because systems are routinely updated and replaced. There will also be other benefits of upgrades aside from compliance with the draft rule if it is made. It would therefore be inaccurate to attribute this full cost to the implementation of five minute settlement.

A contrasting view was provided in the Energy Edge report, which estimated that the costs of systems changes would be in the order of tens of millions of dollars,[321] which is a significantly lower amount when compared to the $150 million identified by the RSA report.

As discussed in Chapter 3, the NEM is in the midst of a significant transition, with a changing generation mix. In Australia, and worldwide, there has been the retirement of synchronous thermal generators, and increases in penetration of intermittent generation, such wind and solar. Box 7.1 highlights that in the NEM over the next decade nearly 7,000 MW of thermal generation capacity will be nearing the end of its design life.[322] This creates the potential need for investment of $10-$28 billion. Further, if thermal generation plant older than 30 years is also included (more than 15,000 MW of capacity), the medium term investment need grows to between $34-$90 billion.

Box 7.1 Generation mix and investment requirement

The NEM is in the midst of a significant transition. In the next decade over 45 per cent of the existing electricity generation plants in the NEM will be at least 40

319 AEC, consultant report by Russ Skelton & Associates, directions paper submission, pp. 22-23.

320 AEC, consultant report by Russ Skelton & Associates, directions paper submission, p. 22.

321 Energy Edge, *Effect of 5 Minute Settlement on the Financial Market*, March 2017, p. 86.

322 For further detail, see AEMC, *Five minute settlement directions paper*, April 2017, pp. 32-34.

years old. It is likely that significant new investment will be required in the short-to-medium term to either upgrade or replace this infrastructure.

The potential magnitude of the investments is evidenced from the fact that, at a high level:

- the value of electricity settlements within the NEM were around $16 billion in 2016/17[323]
- estimated replacement cost of NEM generation assets are in the order of $130 billion[324]
- estimated replacement cost of NEM network assets are in the order of $120 billion.[325]

Taken together, the total replacement cost for NEM assets is estimated at a quarter of a trillion dollars or over $10,000 for every person in Australia.

The age distribution of existing thermal generation plant in the NEM suggests there will also be significant age-related generation plant retirements in the short-to-medium term. This is unless a very significant capital renewal plan is implemented for the existing fleet. Figure 7.1 presents the age distribution of existing thermal generation plant in the NEM.

Figure 7.1 Age distribution of NEM thermal generation plant

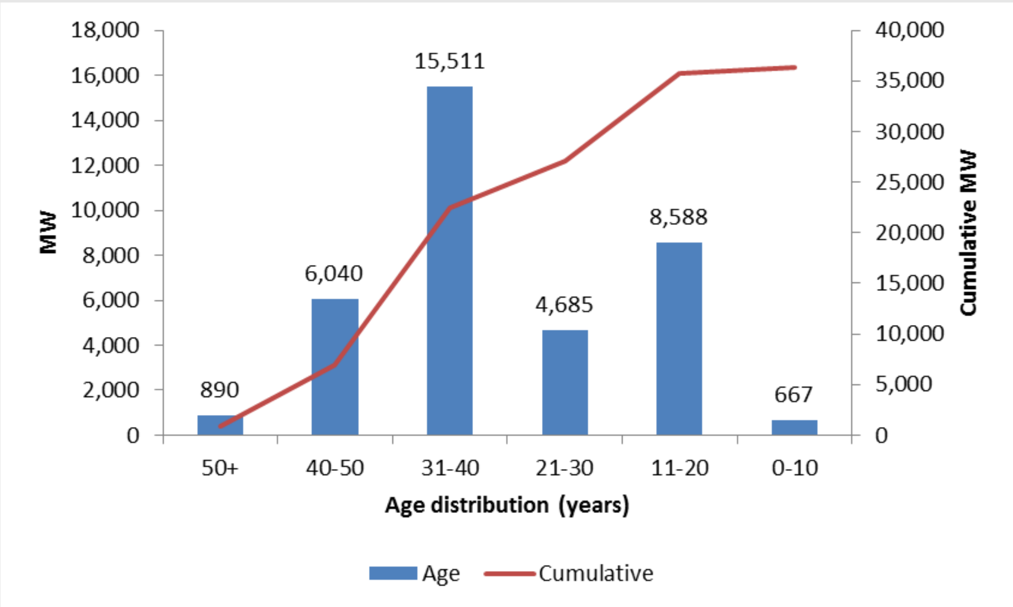

Figure 7.1 shows there is nearly 7,000 MW of thermal generation capacity that is

323 AEMO *Fact sheet: The National Electricity Market* 2017, p. 1.

324 This estimate is based on 45GW of capacity with an average replacement cost of $2.9 million/MW.

325 This estimate is based on the aggregate regulated depreciated asset values of around $80 billion and an assumption of two thirds life expired.

over 40 years of age and more than 15,000 MW between 31 and 40 years old. The design life of thermal generation plants tends to be 30 to 40 years depending on the technology. While in practice thermal generation plants can last significantly longer, the decision for the owners is often whether to maintain the existing plant through further renewal investment, or undertake investment in a new plant.

With these plants nearing the end of their design life, there is an almost immediate need for between $10 billion and $28 billion in investment to upgrade or replace potentially end of life thermal generation fleet. If thermal generation plant older than 30 years is also included, where replacement or upgrade planning should already be underway, then the medium term investment need grows to between $34 billion and $90 billion.[326]

The Commission considers that the significant level of investment that is likely to be required in new generation over the next decade would greatly benefit from the improved price signal that five minute settlement will bring (see chapter 3). These investments will be required by the sector irrespective of whether or not five minute settlement is implemented in the NEM.

Using the RSA estimate of $250 million in total implementation costs of five minute settlement:

- Based on the estimated range of $10-$90 billion for the new investment required to replace retiring thermal generators (Box 7.1), the five minute settlement implementation costs vary between 0.25 and 2.5 per cent of the NEM future investment.
- Alternatively, in 2016-17, taking the approximately $16.6 billion[327] and 196.5TWh of electricity traded in the NEM,[328] the five minute settlement implementation costs would equate to an additional cost of $1.27/MWh over one year.

Given the size of the electricity traded and the investment required in the NEM, it would only take very minor efficiency increases in operating and investment decisions from the improved price signal to outweigh the implementation costs. This particularly the case given the benefits from the improved price signal resulting from five minute settlement will be enduring, while the costs are largely one-off. For example, if improved wholesale price signals resulted in as little as a $0.50/MWh reduction in

326 The actual cost will vary depending on the technology adopted. The lower cost estimates are consistent with gas turbine costs of around $1.5 million/MW. The high costs reflect coal generation at around $4 million/ MW. It is likely that renewable generation with some level of energy storage will fall within this cost range. The use of gas and coal plant costs should be considered illustrative only and does not reflect a view on the preferred technology.

327 AEMO *Fact sheet: The National Electricity Market* 2017, p. 1.

328 AER, Wholesale statistics, accessed on 23/08/2017 https://www.aer.gov.au/wholesale-markets/wholesale-statistics/electricity-supply-to-regions-of-the-national-electricity-market .

average wholesale costs, this would represent just under a $100 million per year saving in energy costs that will be passed onto consumers.

Separate to the analysis discussed above which the Commission has undertaken, several stakeholders have submitted that a cost-benefit analysis (CBA) of the proposed rule change should be conducted supported by detailed modelling. The Commission notes however, that CBAs based on modelling work are traditionally limited by the assumptions that need to be made. In this instance, a major limitation of any analysis is the data, given that all historical bidding information is based on 30 minute settlement outcomes.

Any modelling would therefore need to make assumptions about the behavioural change of bidders in response to five minute settlement. This is currently unknown. A number of stakeholders, including those who requested a CBA, have acknowledged that this makes any assessment challenging.

Based on discussions with experts with market modelling capability, it is likely that even the most simple modelling of wholesale market outcomes will require extremely limiting assumptions about future bidding and contracting behaviour. The Commission's view is that given the limiting assumptions that would need to made, any market modelling is unlikely to provide additional information of value, and would even risk providing very misleading estimates of the magnitude of any enduring benefits from five minute settlement. On this basis the Commission considers that there is no value in undertaking the type of market modelling requested.

7.3.2 Contract market requirements

As highlighted in Chapters 3 and 4, the Commission acknowledges the important role financial contracts play in the electricity market. The contract market reduces price uncertainty for generators and consumers of electricity. It allows generators to manage risk, secure finance and provides signals for ongoing efficient operation of the generator and efficient investment in generation capacity. It also enables retailers to deliver price stability for consumers, and allows them to secure financing for their own operations.

The Commission acknowledges that a move to five minute settlement would disrupt contract market operations. It would involve one-off administration costs associated with the renegotiation or replacement of existing contracts that endure beyond the implementation date of five minute settlement. This cost is separate to that addressed in Chapter 4 relating to concerns about the potential structural impact on the cap contract market.

One approach to mitigating these one-off contract costs would be to adopt an adequate transition period. If the transition period is sufficiently long, then the bulk of open contracts will be able to run their course. For those that endure beyond the transition period, counterparties may be able to negotiate to:

- change provisions relating to the reference price

- change the strike price to reflect a changed risk profile
- terminate the contract if one or both parties are no longer able to cost-effectively manage their obligations under the contract.

The process for doing this would vary depending on whether contracts are:

- exchange-traded via the ASX
- OTC trades
- PPAs
- settlement residue auction (SRA) positions.

Some relevant features of these trading arrangements are summarised in Table 7.1. Each type of contract is considered in greater detail below.

Table 7.1 Comparison of different trading agreements

Market	Legal framework	Length of forward trading	Ability to renegotiate open position?
ASX	ASX rules and policies	Up to 4 years ahead	No
OTC	ISDA	Unlimited	Possible, if standard conventions adopted
PPAs	ISDA or contract law	Unlimited	Possible, if included in contract
SRAs	NEL, NER, AEMO procedures	Up to 3 years ahead	No, but can be terminated

This consideration of the different trading arrangements shows that there are avenues potentially available to parties to vary contracts if five minute settlement was introduced. Further, it appears increasingly that a significant proportion of contracts are of a shorter duration.

This indicates that, from a contract markets perspective, transitioning to five minute settlement would be a large but not insurmountable undertaking for the NEM and financial market stakeholders if an appropriate transition period were to be adopted. There would however be a one-off cost incurred in renegotiating or terminating existing contracts that endured beyond this transition period.

7.3.3 Metering requirements

The main reason five minute settlement was not implemented at the start of the NEM in 1998 was due to limitations in metering and data handling technologies. These limitations no longer exist, however existing metering infrastructure and systems are all configured for 30 minute data.

Chapter 6 sets out the Commission's preferred approach to implementing five minute settlement in relation to metering. At the commencement date:

- all type 1, 2 and 3 meters and some type 4 meters[329] would be required to be upgraded so that metering data providers can provide AEMO with five minute resolution data from these meters for settlement; and
- AEMO would for the settlement processes, profile the 30 minute data it receives from metering data providers from the remaining type 4 meters and most remotely read type 5 meters into five minute increments.

Existing meters

In many cases, the types 1, 2, 3 and 4 meters that need upgrading for the commencement date of five minute settlement can be converted by remote reconfiguration of existing interval meters at minimal cost. However, some older meters will need to be replaced and this would incur a moderate one-off cost.

The Commission notes that a transition period consistent with the inspection and testing requirements specified in Schedule 7.3 of the NER may be suitable to reduce the cost of upgrading relevant meters. The NER[330] sets out the maximum times between tests and inspections of the different categories and configurations of metering installations, as follows:

- type 1 metering installations: 2.5 years
- type 2 metering installations: 1 year (or 2.5 years if check metering installed)
- type 3 metering installations: between 2 and 5 years depending on annual energy transferred
- type 4 metering installations: 5 years

Implementation costs for the remainder of the metering fleet can be minimised by:

- 'grandfathering' the remaining type 4, 4A, 5 and 6 metering installations from providing five minute data until they are replaced
- enabling AEMO to profile 30 minute interval data from these type 4 and type 5 metering installations into five minute trading intervals (in accordance with the metrology procedure)

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329 Type 4 meters at a transmission network connection point or distribution network connection point where the relevant financially responsible Market Participant is a Market Generator or Small Generation Aggregator are required to generate five minute data.

330 Tables S7.3.2 and S7.3.3

- AEMO continuing to profile type 6 accumulation meters for settlement.

As discussed in Chapter 6, the Commission considers that 'grandfathering' type 4, 4A and 5 meters is likely to allay the concerns of many stakeholders who noted the costs involved in replacing or reprogramming the existing Victorian AMI meters. Under the draft rule, these meters will not be required to be reconfigured to provide five minute data unless they are replaced.

Each meter that will be required to measure five minute data must have pattern approval by the National Measurement Institute. As described in Chapter 6, pattern testing ensures the performance of the meter under a range of environmental conditions.[331]The Commission understands that, if additional testing is required, the majority of meters will be able to receive pattern approval within a year.

New and replacement meters

As discussed in Chapter 6, over time it is important that the metering fleet becomes increasingly sophisticated to support a range of market and consumer products and services as well as five minute settlement. Therefore it is necessary that new and replacement meters must be able to generate five minute data and that existing meters are not replaced with a meter of a lower functionality. These new and replacement meters must also have pattern approval by the National Measurement Institute.

The metering approach outlined above and in Chapter 6 is complementary to the 'competition in metering' rule changes.[332] That allows for a market-led roll-out of interval meters at the lowest possible cost. A concern raised by Energy Queensland is that mandating a rollout of five minute capable meters for small customers over a limited timeframe would undermine the business case of this metering change.[333] The Commission considers that these concerns should be addressed by maintaining the 'grandfathering' approach to small customer meters, and given that most new meters are five minute capable. The 'grandfathering' approach should also minimise the initial impact of having 'six times' the data going through the meter communication network and being stored by meter data providers.

7.3.4 IT system requirements

Moving to a standard of five minute resolution data will require information system and process changes for most market participants.

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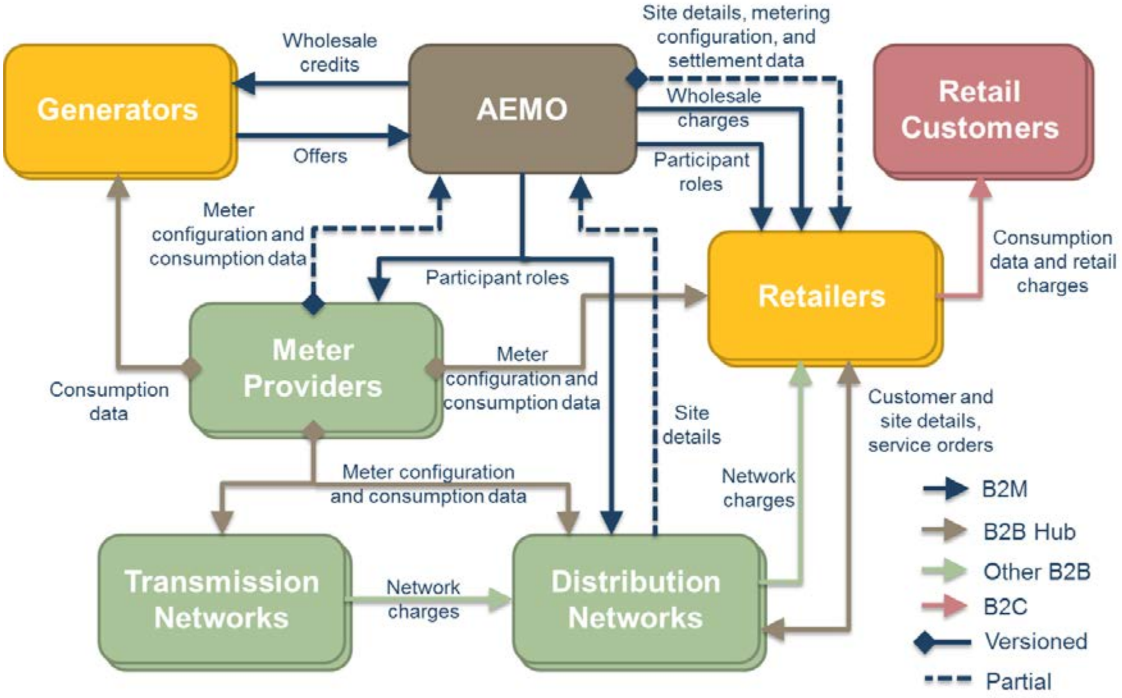
331 The metrological and technical requirements of electricity meters by the National Measurement institute is available at: http://www.measurement.gov.au/.

332 AEMC, National Electricity Amendment (Expanding competition in metering and related services) Rule 2015; National Energy Retail Amendment (Expanding competition in metering and related services) Rule 2015. See also: AEMC, http://www.aemc.gov.au/Rule-Changes/Expanding-competition-in-metering-and-related-serv, viewed 1 September 2017.

333 Energy Queensland, directions paper submission, p. 3.

The information flows in the NEM are illustrated in Figure 7.2. It shows that the IT systems of AEMO, MDPs, generators and retailers would be most affected by a move to five minute settlement, as discussed in the second working group paper.[334]The changes mostly relate to system upgrades to handle five minute resolution metering data and to manage five minute bidding into the wholesale market. For example, changes would be needed to MDP systems for collecting, cleaning and storing metering data, and retailer systems for wholesale market settlement and potentially for billing of customers.

Figure 7.2 NEM information flows



IT system upgrade costs are anticipated to be large one-off costs. Stakeholders have indicated that costs are in the tens of millions of dollars for each affected organisation, but have argued that a more accurate estimate would only be possible once the detailed design is known. Furthermore, ongoing costs may or may not be larger than business as usual, which is likely to include costs relating to such things as licensing, databases, application software, hardware and storage. AEMO indicated that their ongoing costs could amount to around $2 to $7 million, but have not specified if they are higher than their current ongoing costs.[335]

334 AEMC, Five Minute Settlement Working Group: *Working Paper No. 2: Design choices, implementation and transition*, Sydney, 1 December 2016 pp. 20-22. See also Australian Energy Market Operator, *Five minute settlement working paper*, November 2016.

335 AEMO, directions paper submission, p. 4.

Table 7.2 IT systems affected by the rule change

Market participant	IT systems
Generators	settlement; risk management; trading; reporting; data collection and storage
Retailers	settlement; risk management; trading; billing[336]; reporting; data collection and storage
Market load (large users)	settlement; risk management; trading; reporting; data collection and storage
Metering data providers (MDPs)	settlement; reporting; data collection and storage; meter data management system; market transactions system
Network service providers (TNSPs and DNSPs)	settlement; billing; reporting; data collection and storage; network planning system
AEMO	settlement; risk management; trading; billing; reporting; data collection and storage; structure of EMMS Data Model tables

The cost of an IT system upgrade is likely to be significant and there will be practical challenges and risks associated with the upgrade. An appropriate transition timeframe should assist in mitigating some of these challenges and risks, and allow for the costs to be reduced. This would for example be possible if any changes required from introducing five minute settlement, could be incorporated into a wider IT system upgrade.

The Commission acknowledges that upgrading the IT systems for the various types of market participants in the NEM is a non-trivial task and would be expected to take a significant amount of time.

There was a wide variation in the estimated implementation timeframe provided by stakeholders, who indicated a range from 2 to 5 years would be required for all the required IT system changes to be in place. In further consultation, AEMO indicated that it can implement the changes in three years. However, most generators and retailers argued that three years is not a sufficient time. They highlighted the complexity of the system changes required, and that in certain instances it would require a complete overhaul of some IT applications. Further discussions with stakeholders indicated that many of their applications tend to be bespoke (some built in-house) and quite fragmented.

Some stakeholders also indicated that the limited availability of skilled IT contractors and vendors in Australia to manage the changes for such a vast number of IT systems could be problematic. For example, Stanwell mentioned they have 40 applications, 12

336 Only affected if the retailer chooses to bill on a 5 minute basis.

database, 5 flat files, 17 spreadsheets and 3 modelling tools that would be affected by the five minute settlement rule change and that are related to the trading function.[337]

7.3.5 Transition

Under the NEL, the AEMC must make a rule as soon as practicable after publishing its final rule determination. However, the AEMC can make a rule that does not come into effect straight away. Therefore the Commission can determine that the commencement date for a rule to implement five minute settlement can be at some point in the future in order to allow for an appropriate transition period.

As noted, implementing five minute settlement will affect contracting arrangements, metering and IT systems. However, as discussed above, there is the potential for both the one-off costs associated with adapting contracts, metering and IT systems, and any ongoing costs, to be mitigated or reduced. This can be done through the adoption of a suitable transition period prior to five minute settlement being implemented.

The timeframe related to implementation will influence:

- the level of disruption to the wholesale contract markets with respect to:
  - the extent and one-off cost of contract renegotiation to take into account five minute settlement
  - the expected reduction in the supply of cap contracts and flow-on price effects to consumers
- the size of one-off metering and IT system adaptation costs.

For example, a transitional timeframe would allow for:

- the expiry of most existing contracts and the negotiation of new contracts, which would include provisions to take into account the future implementation of five minute settlement
- existing and new entrant generators to fully or partially address any potential risk of supply shortages of cap contracts
- necessary metering upgrades to coincide with routine scheduled maintenance or replacement therefore avoiding additional staff mobilisation charges
- the normal IT system development cycle to enable five minute settlement compatible systems to be implemented at reduced additional cost
- AEMO to provide a test environment for market participants to trial five minute bidding and five minute settlement. AEMO have indicated that if the final rule is

337 Stanwell, directions paper submission, p. 2.

made it intends to conduct industry-wide testing for a period of three to six months prior to the commencement of five minute settlement.[338]

Therefore, the costs and risks of implementing five minute settlement could be mitigated through a suitable transition period. Selecting an optimal transition period involves identifying a timeframe that is short enough to capture the expected benefits of moving to five minute settlement, while reducing the associated costs and risks.

7.4 Commission's position

The Commission acknowledges the concerns of market participants in relation to both the magnitude of the costs and the timeliness within which the required changes to support the implementation of five minute settlement can be made. There was a broad range of cost information provided by stakeholders. The Commission accepts that there will be large costs incurred in relation to the changes required to financial contracts, metering and IT systems to implement five minute settlement. In particular, IT system upgrades are likely to involve large one-off costs and present significant practical challenges.

However, the size of the estimated costs appears small when compared with the size of the annual NEM transactions ($16.6 billion in 2016-17) and the up to $90 billion future investment costs required in the NEM. Further, given the size of these costs, it will only take a very small enduring increase in efficiency in operation and investment from the improved price signal to significantly outweigh any cost.

It is therefore the Commission's view that the enduring benefits of aligning dispatch and settlement at five minutes (as detailed in chapter 3) will quickly outweigh the large one-off implementation costs, and any ongoing costs. The adoption of five minute settlement will contribute to the achievement of the National Electricity Objective (NEO), and promote the efficient operation and use and investment in electricity services for the long term interests of consumers.

The Commission is also of the view that a transition period can be used to mitigate the costs and the risks associated with implementing five minute settlement. The Commission has sought more detailed information on the benefits, costs and risks of the implementing five minute settlement from affected stakeholders and this feedback has informed the Commission's draft determination.

The length of the selected transition period is a function of:

- the time to transition contractual arrangements
- the time for industry to update systems, processes and metering
- the benefit that may be achieved by having five minute settlement sooner.

338 AEMO, Five minute settlement: High level design, September 2017, pp. 30-31.

Transition length and start date

The analysis above shows that:

- 18 months to 4 years is required for the expiry of most existing contracts that would be affected by five minute settlement, noting that the bulk of ASX and reported OTC trades have delivery periods of less than 24 months. It is acknowledged that there are some long-dated contracts in the market that have tenors of up to 10 years or more. Consideration of the different trading arrangements shows that there are avenues potentially available to parties to negotiate to vary those contracts that endure beyond a transition period.
- Aligning the requirement to provide five minute data with the maximum times between tests and inspections of the different categories and configurations of metering installations (one to five years depending on meter type) would reduce the marginal cost of reconfiguring or replacing interval meters.
- Not requiring type 5 meters and most type 4 meters that were installed before 1 December 2018 to capture and provide 5 minute data (unless those meters are replaced) will reduce the cost and implementation effort and allow time for additional pattern approval, if required.
- Stakeholders have suggested a wide range of estimates for the time required to implement necessary IT system changes (ranging from two to seven years), noting that AEMO will likely be able to mobilise IT expertise and adapt all of its bespoke systems within a three year timeframe.

To address concerns raised about the costs and risks of implementation, the draft rule has set a transition period of three years and seven months. This reflects the shortest time that the Commission believes is possible to enable market participants and AEMO to manage the significant implementation risks, such as the large IT system changes. It also provides a timeframe within which new generation could be built if required, risks around the potential for shortages in supply of contracts are likely to be addressed, and solutions to outstanding system security and reliability issues should be developed. Therefore if the Commission makes a final rule that reflects the draft rule, we will recommend that market participants begin implementation as soon as possible.

The Commission has considered a number of potential start dates (aligned with the start of a quarter) for the five minute settlement to commence. The table below indicates the benefits and drawbacks of each option.

Table 7.3 Start date

Potential start date	Time since rule made (28 November 2017)	Pros and cons
Friday, 1 January 2021	3 years and 1 month	• the earliest quarter close to the proposed 3 year transition timeframe • end of first half of financial year • public holiday • summer holiday period • possible market volatility if unusually hot weather
Thursday, 1 April 2021	3 years and 4 months	• still relatively close to proposed 3 year transition timeframe • 1 day before Easter holiday weekend • possible stable market (autumn)
Thursday, 1 July 2021 (proposed start date)	3 years and 7 months	• moving further from proposed 3 year transition timeframe • no public holiday • start of new financial year: aligns with wholesale and retail contract rollover • possible market volatility if unusually cold weather
Friday, 1 October 2021	3 years and 9 months	• moving further from proposed 3 year transition timeframe • 1 day before holiday weekend for Qld, NSW, ACT and SA • possible stable market (spring)

If the Commission makes a final rule that reflects the draft rule, it will commence on Thursday, 1 July 2021. This is mainly because the commencement date would align with the financial year contract rollover period.

During the transition period:

(a) NEM participants must have:

  (i) upgraded type 1, type 2 and type 3 high voltage meters to be capable of preparing and recording five minute data and, if required, undergo additional pattern testing for this service

  (ii) applied to AEMO for an exemption from complying with the data storage requirements for type 1, type 2, type 3 and type 4 meters installed prior to 1 July 2021 where the meter will be able to otherwise meet the requirements of the NER

  (iii) upgraded type 4 meters at a transmission network connection point or distribution network connection point where the relevant financially responsible Market Participant is a Market Generator or Small Generation Aggregator to be capable of preparing and recording five minute data and, if required, have additional pattern testing for this service

  (iv) implemented IT system upgrades to be capable of handling five minute bidding and offering, and five minute settlement

  (v) put a process in place to ensure that from 1 December 2018, all new and replacement type 4 meters are capable for preparing and recording five minute data and have pattern approval for this service

(b) AEMO must have:

  (i) adapted its profiling processes to allow the energy from remaining type 4, type 4A, type 5 and type 6 meters to be settled on a five minute basis

  (ii) updated its IT systems

  (iii) consulted and amended its relevant procedures, methodologies and guidelines by 1 December 2020

(c) It is anticipated that:

  (i) most legacy contracts will have rolled off and new contracts will accommodate a future implementation of five minute settlement

  (ii) during the transition period, AEMO will provide a test environment for five minute bidding and five minute settlement

This approach attempts to balance the benefits of five minute settlement while managing the transitional costs and risks.

Abbreviations

AEC	Australian Energy Council
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AFMA	Australian Financial Market Association
AMI	advanced metering infrastructure
ARENA	Australian Renewable Energy Agency
CBA	cost-benefit analysis
CCGT	combined cycle gas turbine
COAG	Council of Australian Governments
DER	distributed energy resources
FCAS	frequency control ancillary service
IT	information technology
LNSP	Local Network Service Provider
MCE	Ministerial Council on Energy
MDP	metering data provider
MNSP	market network service provider
NEL	National Electricity Law
NEM	national electricity market
NEO	national electricity objective
NER	national electricity rules
NSLP	net system load profile
NSP	network service provider

OCGT	open cycle gas turbine
OTC	over-the-counter
PASA	projected assessment of system adequacy
PIAC	Public Interest Advocacy Centre
PoE	probability of exceedance
PPA	power purchase agreement
RERT	reliability and emergency reserve trader
RSA	Russ Skelton & Associates
RSSR	Reliability Standard and Settings Review
SCADA	supervisory control and data acquisition
SRA	settlement residue auction
SRMC	short run marginal cost
TasCOSS	Tasmanian Council of Social Service

A Summary of other issues raised in submissions

This appendix sets out the issues raised in the consultation on the directions paper to the Five Minute Settlement rule change that are relevant to this rule change request. The AEMC's response to each issue is provided. If an issue raised in a submission has been discussed in the main body of this document, it has not been included in this table.

Stakeholder	Issue	AEMC response
General comments		
EDMI	The AEMC could also consider the effect of changing technology and changing demands into the future. The possible upgrade of meters and systems can bring a range of benefits beyond those directly related to five minute settlement. (p. 1)	Chapter 3 details why five minute settlement provides an improved price signal that would be technology neutral and that over time, five minute settlement will result in a more efficient generation mix and lower cost to consumers. As outlined in Chapter 6, submissions to the direction paper commented on the range of benefits that five minute metering would bring, particularly with respect to network operations.
Major Energy Users	The AEMC has, in previous rule change proposal discussions, provided a view that it considers that the market as it is currently structured provides "workable" competition. If the current market structure provides adequate incentives for both the new technologies and the existing technologies, then it must be assumed that the current market is "workable" and does not need change. (pp. 6-7)	A market structure that is workably competitive can still be improved. A workably competitive market structure does not mean the market is producing perfectly efficient market outcomes. It simply means there is enough competition that the market does not need to be subjected to regulation to control market power and price. As outlined in Chapter 3, The Commission’s view is that 30 minutes settlement is leading to inefficient pricing outcomes and distorting operational and investment decisions. Further, it provides a disincentive for potentially more efficient new technologies from entering the market. These distortions are likely to increase over time due to the prevailing market conditions in the NEM. 30 minute settlement may therefore make the market less workably competitive over time. This will ultimately result in

Stakeholder	Issue	AEMC response
		consumers paying more than the otherwise would have as there would be a relatively less efficient mix of technologies in the market. The adoption of five minute settlement represents an improvement to the existing workably competitive market. It will increase the efficiency of operational and investment decisions in the market.
Major Energy Users	The Directions paper then observes that the incidence of price spikes has moved to dispatch intervals earlier in the settlement period and the 5 minute settlement rule is needed to address this change in market bidding. The MEU questions whether this reason is sufficient to warrant the changes when the market is seen to be "workable" as it currently operates. (p. 7)	The issue of five minutes improving outcomes of the workably competitive market is addressed above. Further, Chapter 7 addresses how the enduring benefits of five minute settlement (as detailed in Chapter 3) will quickly outweigh one-off costs and any ongoing costs.
Energy Queensland	Acknowledges that the NEO does not require the consideration of greenhouse gas emissions when making a rule, this proposed rule is likely to result in a less efficient environmental outcome. (p. 6)	Emissions policy is a matter for governments. There are multiple factors that influence the generation mix in the NEM and therefore the carbon emissions attributable to the electricity sector.
Benefits		
Aurora Energy	The magnitude of the proposed rule change is significant and careful consideration is required to ensure that the benefits of the proposed rule change will outweigh the costs. Based on the information provided to date, Aurora Energy considers that this case is yet to be made. (p. 1)	The Commission acknowledges that the proposed rule change is complex. Chapter 7 addresses how the enduring benefits of five minute settlement (as detailed in Chapter 3) will quickly outweigh these one-off costs and any ongoing costs. Chapter 7 also highlights how the proposed three year and seven month transition period will reduce costs and mitigate the implementation risks associated with the change.
Aurora Energy	It is unclear whether one of the key stated benefits of the proposed rule change, to improve market entry for fast-response generation, would be realised in Tasmania given the current structure of the Tasmanian wholesale market. As such, Aurora	The draft rule is designed to improve efficiency in the national wholesale electricity market. The structure of the Tasmanian wholesale market is a matter for the Tasmanian government.

Stakeholder	Issue	AEMC response
	energy is concerned that the proposed rule change has the potential to simply impose additional costs on Tasmanian customers with no commensurate benefits. (p. 1) It is unclear whether the stated benefits of the proposed rule change would be realised in the Tasmanian wholesale market given the current structure of this market with one large generator and predominantly hydro-generation. (p. 3)	
Major Energy Users	While the AEMC approach identifies the detriments of the change (e.g. potential reductions of cap contracts causing higher prices for consumers and the costs of implementing the change), it contends that these issues can be addressed through a staged transition without addressing the fundamentals of the impacts on price that consumers will face in the short and medium terms. While the National Electricity Objective is written with the focus of the long term interests of consumers, this does not mean that the interests of current consumers should be disregarded, as the actions of current consumers will impact on the interests of future consumers. (p. 5)	The Commission is not, as suggested here, disregarding the interests of current consumers in making draft rule. The Commission is concerned about both the short- and long-term impact on consumers in the market. In considering the impact on the cap contract market, Chapter 4, shows it is unlikely to be material even in the short term. Further, the transition period proposed in Chapter 7 further mitigates the risk of any potential short term impact. The Commission also does not view this rule change as creating any issues of inter-generational inequity. In considering the long term interests of consumers here, it is envisaged that the current consumers are also for the most part likely to be the future consumers.
International experience		
AEC	It is important to note that the FERC decision does not stipulate that these markets implement five minute dispatch and settlement, only that these be aligned to the same time period. As some US markets currently use five-minute dispatch, with either 30 or 60 minute settlement, this appears to be presumed to be advocating for five-minute dispatch and settlement. It is equally possible that dispatch and settlement could be aligned on different timeframes, such as five minutes or even 30 minutes. (p.	Stakeholders have confirmed the point made in the directions paper - that the "benefits of aligning dispatch and settlement have been acknowledged by a range of international energy market authorities". The Commission notes that the international context provided in the directions paper was intended to only be informative. The

Stakeholder	Issue	AEMC response
	3)	Commission understands that there are differences in market design overseas and acknowledged that in the directions paper. The overseas experience has not formed the basis for motivating the current proposed change in Australia.
AEC	In addition, in the US (with the exception of Texas), the UK and parts of Canada, energy markets have capacity markets attached also. These markets, with their differing time periods, differing market price caps and attached capacity markets operate on a fundamentally different basis to the NEM. The AEC is concerned that the overseas experience will be used as one of the justifications for the five minute settlement change proposed here in Australia, when this is not an appropriate conclusion. (p. 3)	
ERM Power	The FERC decision does not specify that five-minute settlement be used. These markets also operate on a fundamentally different basis to the NEM. We urge the AEMC to recognise that five-minute settlement has not been implemented in a pure energy-only market anywhere in the world. In Alberta, where alignment of settlement and dispatch was being considered, at a number of different time periods, the market is first moving from energy only to a capacity market to ensure secure and reliable energy to consumers. (p. 6)	
Origin Energy	Recent efforts to address the misalignment between settlement and dispatch timeframes in international electricity markets are unique and do not provide adequate justification for reforming the NEM. (p. 4)	
Origin Energy	The AEMC has noted a range of overseas markets, where regulators and market bodies are either in the process of aligning dispatch and settlement timeframes or at least recognise the merit in doing so. While this may be true, it does not provide adequate justification for pursuing such a reform in the NEM, particularly when you consider the rationale for reform is heavily influenced by the characteristics unique to each market. (p. 7)	

Stakeholder	Issue	AEMC response
Origin Energy	It is also worth noting a number of US electricity markets, including those with five minute dispatch and settlement, have some form of capacity market or regulated capacity requirement in place. In these circumstances, the role of spot markets is primarily to guide near term operational decisions rather than incentivise investment in generation capacity. (p. 8)	
Stanwell	Doing something because others are doing it is a poor rationale for a major change. To the extent that international experience is incorporated into the Commission's decision making, Stanwell considers that it should inform both the incentive for alignment and the ultimate destination of that realignment. (p. 24)	
Alternatives		
Arrow Energy	While Arrow is not supporting this change, Arrow wonders why other timeframes for settlement are not being examined (a view also raised by other participants in earlier submissions). For example, would 15 min settlement intervals align with the operating profile of more generation alternatives and demand-side participants? (p. 8)	Sun Metals' rule change request identified the problem as the misalignment of the NEM dispatch and settlement intervals, with five minute settlement the proposed solution. In its consultation paper published in May 2016, the Commission consulted on alternatives solutions, including options to align dispatch and settlement at different intervals, such as 15 or 30 minutes (see pp. 22-24). Claims that the Commission has not considered 15 minute settlement are, therefore, incorrect. The Commission has noted in this draft determination that since demand and supply vary continuously, ideally the price signal would vary continuously as well. A market where the price signals provide incentives to respond to supply and demand changes over the shortest timeframe practicable, will drive more efficient wholesale market outcomes. The five minute dispatch interval is relatively granular by international standards. As it captures the key physical features of the power system for that time interval, five minute prices are expected to provide signals for the efficient
Meridian	Why 5 minutes? Have other settlement periods or mechanisms, been considered that encourage new technologies to emerge, without the risks of the change under debate currently? Will we be having a similar debate in years to come on 1 minute pricing? (p. 1)	
Major Energy Users	While the MEU can see there are benefits from aligning the dispatch and settlement periods, it is concerned that the AEMC has focused purely on just changing the settlement period to 5 minutes. While accepting that this was the basis of the rule change proposal, a number of responders to the review process	

Stakeholder	Issue	AEMC response
	have also suggested that the dispatch period could also be changed so that aligned dispatch and settlement periods might be longer than 5 minutes, to 15 minutes for example. That the AEMC has not even contemplated such a change has introduced significant disquiet amongst stakeholders, especially those consumers which are currently active in providing demand responses in the NEM but would be unable to provide such demand side responses should 5 minute settlement be introduced. The MEU considers this oversight needs to be addressed. (p. 3)	operation of, and investment in, generation and load. A longer dispatch interval, such as 15 or 30 minutes, would create the potential for larger deviations from expected supply and demand between runs of the central dispatch algorithm. All other things being equal, a greater volume of regulation frequency control ancillary services (FCAS) would be required to keep the system in balance. This arrangement would be higher cost, and therefore less efficient, than dispatching every five minutes. Alignment at 15 minutes would also include more substantial changes to IT systems as it would require wholesale changes to settlement, dispatch and the ancillary service markets. One minute dispatch and settlement may be beneficial as, in theory, the price signal would even more accurately reflect the continuous changes in supply and demand. However, the implementation costs involved would likely be much greater than five minute settlement. The capability of the available technology (telemetry and computation power) would also need to be evaluated. Under the existing dispatch process, participants do not receive dispatch target until 20-50 seconds after the dispatch interval has started. This would be unworkable if the length of the dispatch interval was only one minute. The implementation effort, if feasible, would seemingly be greater than both five minute settlement and 15 minute alignment. The Commission intends that the forthcoming Frequency control frameworks review will allow it to undertake this comprehensive review of the structure of existing FCAS markets.
Snowy Hydro	Alternative alignments of dispatch and settlement periods have not been considered. The alignment of dispatch and settlement cycle should not be limited to 5 minute dispatch / 5 minute settlement. If a change is deemed by the Commission to have net benefits then serious consideration should be given to 15 minute dispatch / 15 minute settlement, which would have less adverse consequences due to the physical characteristics of the existing generation mix. (18 May, p. 3)	
Snowy Hydro	If ramping capability is desired to accommodate a different generation plant mix with intermittent generation then a better course of action is to introduce new market ancillary services products. (18 May, p. 2)	The Commission considers that since the NEM market design already features five minute dispatch, it would be more sensible to remove the distortion introduced by the 30 minute averaging rather seek to correct this by layering on more complexity.

Stakeholder	Issue	AEMC response
AEC, supplementary report by Russ Skelton & Associates	It is proposed that AEMO measure the accuracy of the pre-dispatch forecast by comparing prices forecast with actual prices realised and that they provide routine reports for sample dispatch intervals. For example AEMO could be required to report routinely on the comparison of actual prices realised in each dispatch interval (or dispatch intervals above some price threshold such as $300/MWh) with forecast prices from 3 of the rolling pre-dispatch forecasts that covered that dispatch interval (i.e. the price realised at 1000 might be compared to the pre-dispatch forecast made at 0955, 0930 and 0905). In addition AEMO should be required to store the data for all of the pre-dispatch forecasts that were made for each realised price. This data should be made available to market participants to undertake their own analysis. It is anticipated that a rule change request will be made for this proposal. (p. 6)	The Commission has looked into this issue in the draft rule determination in relation to the non-scheduled generation and load rule change. In relation to the accuracy of AEMO's demand and price forecast accuracy, the Commission found: • demand forecasts are historically generally accurate at dispatch, which results in an efficient amount of generation being dispatched • while AEMO's price forecasts are not as accurate as the demand forecasts, this is to be expected as the price forecasts are a signalling mechanism to allow market participants to make and adjust their generation and consumption decisions ahead of dispatch. When spot prices are forecast to be above $300/MWh there is generally a market response that leads to actual spot prices being lower than forecast. In relation to whether the forecast inaccuracy that does occur was caused by price responsive loads or non-scheduled generators, the Commission found: • the actions of non-scheduled generators and large price responsive loads were clearly not the only or necessarily the primary cause of forecast error and not all non-scheduled generators or load contribute to forecast inaccuracy, in particular price error • in relation to the causes of forecasting inaccuracy, the analysis indicated contributions from a number of sources, including: the actions of scheduled generators, in particular in relation to price forecasting; and, general forecasting issues related to the

Stakeholder	Issue	AEMC response
		capabilities of AEMO's demand forecasting model and the accuracy of forecasts for intermittent generation and unregistered generation (i.e. that below the 5 MW registration threshold). There is an existing obligation for AER to report on variation between forecast and actual price outcomes. They do this in the weekly electricity report. AEMO does keep the historical data and it is available via the P5MIN_REGIONSOLUTION table of the MMS.
EDMI	There is scope to consider beyond five-minute settlement and consider possible future benefits of even more regular settlement times. While clearly the current rule change cannot consider directly technologies that are either nascent or undeveloped, EDMI submits that it can take these into account when assessing costs v benefits, as well as incorporating drafting changes that may allow flexibility moving forward. (p. 2)	More regular settlement times were not identified in the rule change request but could be considered by the Commission in future if raised. Sections 2.3 and 3.3.4 explains that technology neutrality is an important guiding principle in the Commission's decisions.
Costs		
ERM Power	The AEMC must be mindful of the costs of installing the new kinds of generation technology needed to respond within five minutes. This would be expected to include battery storage systems, fast-start gas turbines, and other options such as diesel generators or pump hydro. Suggestions have also been made that existing generators incapable of starting within five minutes could install batteries to dispatch into the grid until the existing generator is synchronised with the grid. These options all involve substantial upfront capital costs as well as ongoing maintenance costs. These costs will come through in terms of generators' bids into the market, potentially leading to higher generation costs. (p. 13)	Market participants are best placed to evaluate and manage the costs and risks of investment.

Stakeholder	Issue	AEMC response
SA Water	The reduced liquidity in caps would potentially affect generators more than retailers. Augmentation of existing generation facilities to meet a five minute settled market could come at a cost to the generator. This cost would past through to the contracting entities and ultimately result in cost increases to the consumer. (p. 5)	The analysis in Chapter 4 shows that participants should still be in a position where they will be able to effectively manage wholesale market risks. In particular, peaking generators will still have strong incentives to sell caps. The analysis also suggests that even if there is a short term increase in cap contract prices from five minute settlement, it is likely to be immaterial.
Implementation		
Hydro Tasmania	The need to update systems for all participants would also raise material implementation risks. This would be factored into consumer pricing; this needs to be clearly understood and compared against other perceived consumer benefits. (p. 2)	The need to update systems for all participants is non-trivial and the Commission has assessed this in evaluation the costs and benefits of the proposed rule change in the draft rule determination. In Chapter 7, the Commission acknowledges the costs and risks associated with implementation, and in order to mitigate these, have proposed a three year and seven month transition period. It is expected individual businesses would only recover those costs that are consistent with the efficient industry-wide system costs.
Infigen Energy	Given the significant work streams being undertaken by the AEMC in the areas of system security, reliability, gas markets and retail competition as well as the South Australia's government's battery deployment initiative it would be prudent to delay a decision on the move to a five minute settled market. This will allow time to observe how the cost of new technology comes down and how they will ultimately integrate into the broader energy system. (p. 1)	Chapter 5 assesses any system security and reliability impacts from five minute settlement. The Commission recognises there are potential risks to system security and reliability with the introduction of five minute settlement. However, given the large amount of work currently being undertaken to address system security and reliability issues, and the developments in the market, the Commission is satisfied that there is no direct threat to system security or reliability from making the rule change. Additionally, if the Commission makes a final rule that reflects the draft rule, the transition period of three years and seven months prior to five minute settlement commencing will provide time for system security issues to be further addressed or resolved.

Stakeholder	Issue	AEMC response
Stanwell	The Rules currently require a large number of actions to be undertaken for each Trading Interval, which is defined as being 30 minutes. The proposed change to five minute settlement could be legally implemented in a number of ways with different impacts on these required actions. A "tidy up" of the existing rules may be a rational precondition imposed by the Commission under the transition roadmap described in Section 2.4. Stanwell would welcome the Commission stating their position on such issues prior to making a rule change in this instance. (p. 22)	As discussed in section 6.3.7, the AEMC cannot make a conditional rule.
Investment		
AEC	The whole issue of system security is further exacerbated by the regulatory risk introduced by changing the NEM's operating basis in such a fundamental way. Since the rule changes will have a retrospective adverse effect on existing plant, it is likely that this risk will be recognised when funding is sought for new technologies. Battery supply companies have reported that they are successful in securing funding and developing their product in the existing market, therefore there seems to be little justification for changing the market rules in an attempt to foster technologies which can address a perceived, but not proven, market need. (p. 3)	Chapter 5 addresses any system security and reliability impacts from five minute settlement, particularly in respect of concerns that the rule, if made, would: • encourage greater volumes of fast ramping capability that is invisible to AEMO, making it harder for AEMO to manage system security • cause gas-fired generators to exit the market, reducing both system security and reliability. Chapter 2 outlines the summary of reasons for making the rule. Chapter 3 in assessing benefits highlights that a particular concern with thirty minute settlement is that generators are responding to a 30 minute price rather than the efficient five minute price. This is distorting current market outcomes, and risks distorting market outcomes further in the future.
Reliability		

Stakeholder	Issue	AEMC response
AEC, supplementary report by Russ Skelton & Associates	Without any changes, as a result of increased levels of both demand response and unscheduled generation, in part resulting from the 5-minute settlement rule change, the accuracy of the pre-dispatch forecast will further deteriorate and make it increasingly difficult for market participants to effectively respond to variations in market price and demand. This will certainly reduce the efficiency of the market and may also result in higher prices and reduced supply reliability. (p. 4)	Chapter 6 explains the reasons for the draft rule requiring market participants to submit dispatch bids and offers for five minute trading intervals for both their initial offers and for any rebids. Five minute bidding improves price discovery. As five minute bid data will be used as an input into the pre-dispatch forecasts, it will lead to more accurate pre-dispatch forecasts.
Bidding behaviour		
Major Energy Users	A shortcoming in the Directions paper is that there is no assessment which looks at whether the rule change will change the dynamic which sees the high price in one dispatch interval and, if the same conditions continue, for the high price to continue into subsequent dispatch intervals. (p. 7)	Chapter 3 addresses these issues.
Prices and volatility		
Arrow Energy	Until new generation is installed in the NEM that can switch on and start exporting to the grid almost instantly and sustain output on a scale to reliably support the NEO, changing to 5 min settlement may lead to higher wholesale electricity prices. (p. 5)	Chapter 4 assesses the impact on the price of cap contracts in the short term and finds that even in the worst case scenario there is likely to be a minimal impact from five minute settlement. Over time, the alignment of dispatch and settlement at 5 minutes should reduce incentives to induce high prices and volatility, leading to reduced hedging costs. Further, Chapter 7 highlights that the transition period of three years and seven months should mitigate any costs and risks associated with the implementation.
Energy Networks Australia (ENA)	Energy Networks Australia recommends that any move to a five-minute regime should consider the impact of this change in demand metrics on transmission prices. In particular, the potentially significant short-term volatility in revenues that would need to be recovered from customers which exhibit peaky loads.	The Commission considers that five minute settlement would better align generators' bidding strategies with the efficient outcome of the market. Reduced incentives to induce high prices and volatility would lead to reduced hedging costs for retailers and would lead to reduce costs for consumers.

Stakeholder	Issue	AEMC response
	(p. 4)	
Energy Networks Australia	The proposal to move to five minute settlement intervals may impact the terms of existing Connection & Access Agreements. In addition, the Rule change proposal is likely to impact locational prices and the rate of change limited by the side constraint (refer NER Clause W6A.23.4(b)(2)). In terms of cost reflective prices for certain customers, the proposal is likely to increase the gap between the true locational price and the side-constrained locational price. (pp. 8-9)	The draft rule includes a transition period of three years and seven months. It is anticipated that by the five minute settlement commencement date existing contracts will have been reviewed and possibly renegotiated to accommodate a future implementation of five minute settlement.
Policy landscape		
ERM Power	We consider it premature for the AEMC to make a decision on such a fundamental aspect of the market as settlement timing while a review of the operations of the NEM is underway. (p. 1)	Part 7, Division 3 of the National Electricity Law sets out the procedures that the AEMC must follow when making a rule in response to a rule change request. Chapter 5 assesses any system security and reliability impacts from five minute settlement. The Commission recognises there are potential risks to system security and reliability with the introduction of five minute settlement. However, given the large amount of work currently being undertaken to address system security and reliability issues, and the developments in the market, the Commission is satisfied that there is no direct threat to system security or reliability from making the rule change. Additionally, if the Commission makes a final rule that reflects the draft rule, the transition period of three years and seven months prior to five minute settlement commencing will provide time for system security issues to be further addressed or resolved.
EnergyAustralia	It is not easy to assess whether five minute settlement will alter bidding behaviour and hedging strategies, or encourage investment in more flexible generation, load or demand response until the broader policy framework is settled. (p. 4)	
EnergyAustralia	The theoretical benefits of aligning dispatch and settlement are clear but we suggest this rule change should be considered after at least the Finkel review and the response from governments, to ensure coordination of outcomes. (p. 1)	
SACOSS	Would like to see all the current market and technical reviews 'settle' before making such a significant change. (p. 24)	
Origin Energy	Origin's concern is that if implemented in three years as currently proposed, the alignment of settlement and dispatch will have a destabilising effect on the market at a time when the NEM is	

Stakeholder	Issue	AEMC response
	already undergoing a significant transformative period. (p. 1)	
Metering		
Energy Networks Australia	A number of transmission sites remain grandfathered under the Rules (transitional Rule 9.39). Under this clause, any change to the metering installation aside from normal repair and maintenance would trigger a full replacement of the metering installation. (p. 7) As raised in the response to question 7(b), changes to grandfathered metering installations would trigger a full replacement of metering assets. This appears to be an unintended consequence of the Rule change proposal. To address this matter, the AEMC should consider extending the transitional arrangement to allow for the required upgrade of the meter itself without triggering the requirement to replace the full metering installation. (p. 8)	Rule 9.39 provides that the transitional metering provisions in Schedule 9G1 apply to Queensland in respect of Chapter 7; and that the transitional arrangements of clause 9.39 will apply to meters that, as at 1 October 1997, complied with the Queensland Grid Code. This clause also states that the transitional arrangements in clause 9.39 will only apply so long as "no part of the metering installation has been modified or replaced since 1 October 1997" (excepting normal repair and maintenance). However, the rest of clause 9.39 has been deleted (i.e. there are no transitional arrangements in clause 9.39 that apply to such meters). Therefore, it appears that there are no transitional arrangements in rule 9.39 that apply to these meters. The general transitional arrangements of Schedule 9G1 remain in the rules, and apply generally to metering installations commissioned before 13 December 1998 (without reference to whether the meter has been modified or replaced).
Energy Networks Australia	The AEMC should consider and clarify how outages to replace or upgrade meters as a consequence of the Rule Change should be treated under performance reporting and National Energy Consumer Framework obligations, whether planned or as a result of a meter failure. (p. 4)	Participants are responsible for their own compliance obligations.
Energy Networks Australia	The proposed reform appears to create the risk of replacement or retrofitting costs for a significant number of AMI meters in the Victorian jurisdiction. Additionally, the Commission should recognise that metering competition for small customer sites will be deferred in Victoria until at least the next regulatory control period and take this into account when considering transitional	Chapter 6 details the Commission preferred metering implementation. The draft rule does **not** require all other types 4, 5 and 6 meters that are already installed to provide five minute data at the commencement date. The data from these meters will be profiled to five minute trading intervals by AEMO using net system

Stakeholder	Issue	AEMC response
	arrangements as part of this rule change. (p. 4)	load profiles.
Ipen	Interval metering is now widely deployed and will become steadily more common in future. It should be configured to measure five minute data for energy and availability and quality parameters, such as voltage, waveform purity and supply availability. (p. 2)	This issue was not directly identified in the rule change request but could be considered by the Commission in future through a separate rule change process.
System security		
Energy Networks Australia	ENA noted that the proposed changes could lead to a marked increase in dispatch volatility, with implications for the Basslink interconnector's flows. This may result in voltage control in northern Tasmania becoming a tangible issue. It is anticipated that should there be greater real-time volatility in dispatch, this could amplify the existing issue of voltage control in this part of the NEM. (p. 4)	Five minute settlement would better reflect underlying supply/demand fundamentals. Any resulting volatility would simply reflect the underlying supply/demand imbalance.
Risk management		
SA Water	Companies participating in SRAs and ASX traded hedge derivatives will be affected. The proposal to continue to settle these contracts on a 30 minute basis would be misaligned with everything else settled on a 5 minute basis, and therefore would be difficult to reconcile. (p. 5)	As noted in Chapter 7, the draft rule provides a 3 year and 7 month transition period within which participants can adapt their contractual arrangements to five minute settlement.
Transition		
Energy Consumers Australia	The AEMC needs to establish a governance framework to ensure that the developments required to support five minute settlement are occurring. That could include the provision of facilities through which market participants could experiment with bidding behaviour. (pp. 8-9)	If the Commission makes a final rule that reflects the draft rule, AEMO will likely undertake market readiness planning and implementation. This is reflected in section 8.5 of AEMO's High level design document that accompanies this report.

Stakeholder	Issue	AEMC response
Other		
CS Energy / Intelligent Energy Systems	Report entitled: *A package of improvements for the NEM auction* Arrangements within the half hour trading fail to implement marginal pricing principles in many ways, including: • the process of averaging 5 minute prices for settlement • the artificial step changes in price that occur between trading interval and, potentially, between dispatch intervals • the completely different treatment of Frequency Control Ancillary Services (FCAS) which are based on enablement rather than performance • distorted (as with causer pays) and at worst ineffective (as with contingency FCAS cost allocation); and the lack of any current mechanism to value and encourage inertia and fast frequency response. We propose an upgrade package which takes the form of an additional service. It would have the effect of converting the current distorted energy and FCAS pricing into a smooth price trajectory which dynamically adjusts to promote frequency and Time error stability under a range of disturbances. Participants responding to these marginal price signals will help keep the system secure and reliable. The package would also would support the emerging need to promote and support inertia and fast frequency response. It could be implemented in stages, but relatively quickly if the commitment were made.	IES' proposed implementation for five minute settlement via an additional ancillary service – the Ramping Ancillary Service, or RAS – involves the use of operational SCADA data to profile metering data for settlement purposes. This option was considered by the Commission but ultimately an implementation involving five minute resolution metering data was chosen instead for reasons provided in section 6.3.2. The Commission considers that the drawbacks of the using SCADA are: • accuracy, reliability and basis of measurement of SCADA data • consistency of SCADA data with the National Measurements Act • availability of SCADA data for demand side participants and small generators. The other suggestions are outside the scope of Sun Metals' rule change request, but are likely to be considered through the Commission's system security work program. The Commission noted in its final report on the System Security Market Frameworks Review that a re-examination of the existing FCAS arrangements should be undertaken as a priority. It considers that a wider program of work should then be conducted with a view to reconsidering and redeveloping robust FCAS markets for the long term. The Commission intends that the forthcoming Frequency control

Stakeholder	Issue	AEMC response
		frameworks review will allow it to undertake this comprehensive review of the structure of existing FCAS markets, supported in a technical capacity by work undertaken by AEMO.

B Legal requirements under the NEL

This appendix sets out the relevant legal requirements under the NEL for the AEMC to make this draft rule determination.

B.1 Draft rule determination

In accordance with s. 99 of the NEL the Commission has made this draft rule determination in relation to the rule proposed by Sun Metals..

The Commission's reasons for making this draft rule determination are set out in sections 2.2 to 2.5 of this draft rule determination.

A copy of the more preferable draft rule is attached to and published with this draft rule determination. Its key features are described in section 2.1.

B.2 Power to make the rule

The Commission is satisfied that the more preferable draft rule falls within the subject matter about which the Commission may make rules. The more preferable draft rule falls within s. 34 of the NEL as it relates to:

- the operation of the national electricity market;
- the activities of persons (including Registered participants) participating in the national electricity market or involved in the operation of the national electricity system.

Further, the draft rule falls within the matters set out in schedule 1 to the NEL as it relates to:

- the setting of prices for electricity and services purchased through the wholesale exchange operated and administered by AEMO, including maximum and minimum prices
- the methodology and formulae to be applied in setting prices referred to above
- the payment of money for the settlement of transactions for electricity purchased or supplied through the wholesale exchange operated and administered by AEMO
- the regulation of persons providing metering services relating to the metering of electricity
- the calculation or estimation of use of electricity.

B.3 Commission's considerations

In assessing the rule change request the Commission considered:

- its powers under the NEL to make the rule;
- the rule change request;
- submissions received during first and second round consultation; and
- the Commission's analysis as to the ways in which the proposed rule will or is likely to, contribute to the NEO.

There is no relevant Ministerial Council on Energy (MCE) statement of policy principles for this rule change request.[339]

The Commission has not considered the revenue and pricing principles because the Commission considers that these are not relevant to this rule change request.

The Commission may only make a rule that has effect with respect to an adoptive jurisdiction if satisfied that the proposed rule is compatible with the proper performance of AEMO's declared network functions.[340] The more preferable draft rule is compatible with AEMO's declared network functions because it leaves those functions unchanged.

B.4 Northern Territory considerations

From 1 July 2016, the NER, as amended from time to time, apply in the Northern Territory, subject to derogations set out in Regulations made under Northern Territory legislation adopting the NEL.[341] Under those Regulations, only certain parts of the NER have been adopted in the Northern Territory.[342]

The draft rule amends clause 6.20.1 of Part J of Chapter 6 of the NER. Part J of Chapter 6 will apply in the Northern Territory from 1 July 2019 unless the Northern Territory modifies the application of that clause in the Northern Territory before that date.

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339 Under s. 33 of the NEL the AEMC must have regard to any relevant MCE statement of policy principles in making a rule. The MCE is referenced in the AEMC's governing legislation and is a legally enduring body comprising the Federal, State and Territory Ministers responsible for Energy. On 1 July 2011 the MCE was amalgamated with the Ministerial Council on Mineral and Petroleum Resources. The amalgamated council is now called the COAG Energy Council.

340 Section 91(8) of the NEL.

341 National Electricity (Northern Territory) (National Uniform Legislation) (Modifications) Regulations.

342 For the version of the NER that applies in the Northern Territory, refer to : http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/National-Electricity-Rules-(Northern-Territory).

As the more preferable draft rule either does not currently apply in the Northern Territory or, for the new Chapter 10 definitions, applies to parts of the NER that have not yet been adopted in the Northern Territory, the Commission has not assessed the proposed rule against additional elements required by Northern Territory legislation[343].

B.5 Civil penalties

The Commission's draft rule amends the following rules of the NER:

- clauses 3.8.4(c) and (d) – notification to AEMO by Scheduled Generators and Market participants of their available capacity
- clause 3.9.7(a) – compliance with AEMO dispatch instructions to constrain on a generator
- clause 3.12A.4 – rebid of capacity under restriction offers.

These rules are currently classified as civil penalty provisions under Schedule 1 of the National Electricity (South Australia) Regulations (Regulations).

The Commission cannot create new civil penalty provisions. However, it may recommend to the COAG Energy Council that new or existing provisions of the NER be classified as civil penalty provisions.

The Commission will be recommending to the COAG Energy Council that the above clauses should continue to be classified as a civil penalty provisions and therefore does not propose to recommend any change to their classification to the COAG Energy Council. This is because a breach of these rules could have a material impact on NEM settlement and operation, and classifying these provisions as civil penalty provisions will encourage compliance by the relevant parties.

The Commission's draft rule also amends clause 3.8.22A of the NER. This clause is currently classified as a rebidding civil penalty provision under clause 6(2) of the Regulations. The Commission will be recommending to the COAG Energy Council that amended clause 3.8.22A continue to be classified as a rebidding civil penalty provision in the Regulations. The classification of clause 3.8.22A as a rebidding civil penalty provision reflects the significant financial gain that may result from a breach of this provision, and the material impact that a breach of this provision may have on the operation and integrity of the NEM. It will also encourage relevant parties to comply with this provision.

343 For the version of the NER that applies in the Northern Territory, refer to : http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/National-Electricity-Rules-(Northern-Territory).

B.6 Conduct provisions

The Commission's draft rule does not propose any changes to conduct provisions.

C Supplementary material for Chapter 4

C.1 Responsiveness of existing generation

Existing generators could change the way in which they operate to maximise their revenue under five minute settlement. A summary of the potential responses are provided below.

Responding from rest

The responsiveness of generators can be observed through market data describing the ability of generators to respond from rest and when they are already running. One way of observing responsiveness from rest is through the fast start inflexibility profiles that fast start generators submit as a component of their offers and rebids.[344] When generators are online and running, responsiveness can be observed via ramp rates, and maximum and minimum output levels.

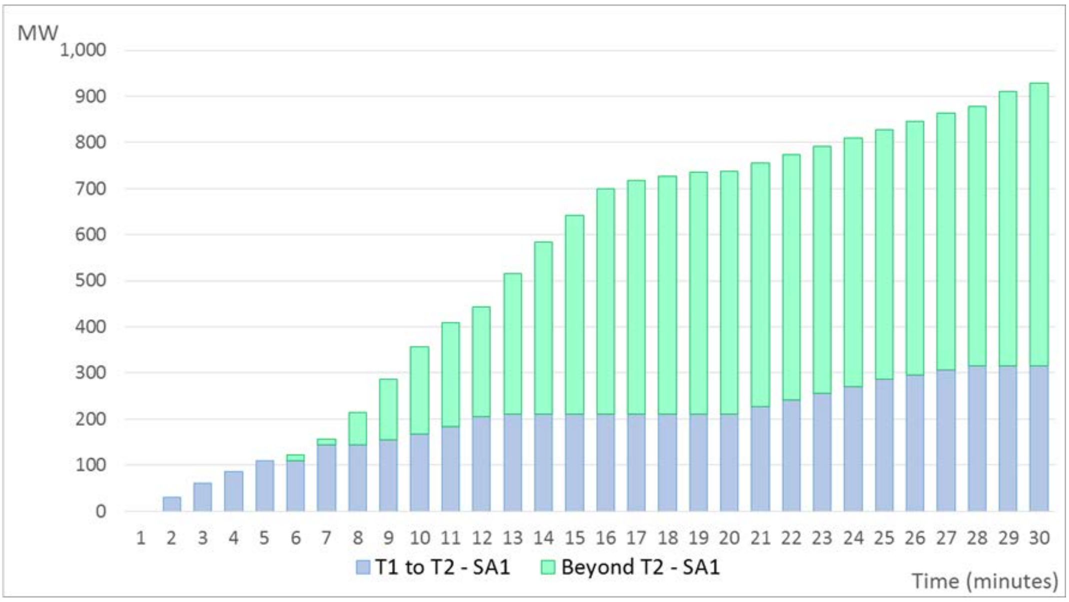
An indicative illustration of the potential response from rest can be observed by extracting the fast start profiles for all scheduled, fast start generators for a single day.

Figure C.1 below shows this analysis for all fast start generators in South Australia on a day in May 2016. It assumes that all fast start generators are offline and simultaneously receive a start instruction from AEMO. The generators are assumed to follow their fast start inflexibility profiles to their minimum output levels, than ramp at their specified ramp rates beyond this point. The latter is show in green and the former in blue.

Figure C.1 shows that in South Australia on the day of the analysis, 109 MW of capacity was available within a five minute period, increasing to 929 MW over the half hour.

344 Fast start inflexibility profiles have 5 parameters: minimum load, time to synchronise (T1), time to ramp to minimum load (T2), minimum time above minimum load (T3), and time to ramp down (T4). See: AEMO, *Fast-start Inflexibility Profile, process description*, October 2014.

Figure C.1 Theoretical response from fast start plant in South Australia



The same analysis was undertaken for each NEM region and the corresponding charts are presented in Appendix 4.3 of Working Group Paper 1, which is available from the Five Minute Settlement project page on the AEMC website.[345] This analysis is based on fast start profiles from a single day and ramp rates have been assumed at nameplate ratings.[346]

The analysis provides an indicative result that there is limited fast start capacity in the NEM that can respond from rest within a five minute period. In South Australia and Queensland there is a small amount of scheduled capacity that can provide energy within five minutes. In other regions, the potential responses from rest were in the order of six to 10 minutes, with no fast start generators capable of providing energy from rest within five minutes.

Ramping online plant

The other response that can be provided is from generators that are already online. This would typically include coal-fired generators, some combined-cycle gas turbine (CCGT), and fast start generators if they are already running.

For this analysis, the historical ramping of scheduled generators was calculated by comparing, for every dispatch interval between January 2015 and December 2016, the difference in dispatch targets from the previous five minute interval.[347] The results

345 AEMC, *Five Minute Settlement Working Group: Working Paper No.1*, 12 October 2016, pp. 39-40.

346 It does not include network or economic constraints, nor factor in the time for AEMO to send dispatch instructions. It may also underestimate the potential response of fast start plant as non-scheduled generators, many of which are reciprocating engines, are not included in the analysis. AEMO registration data indicates that there is 740 MW of non-scheduled, reciprocating engine capacity in the NEM.

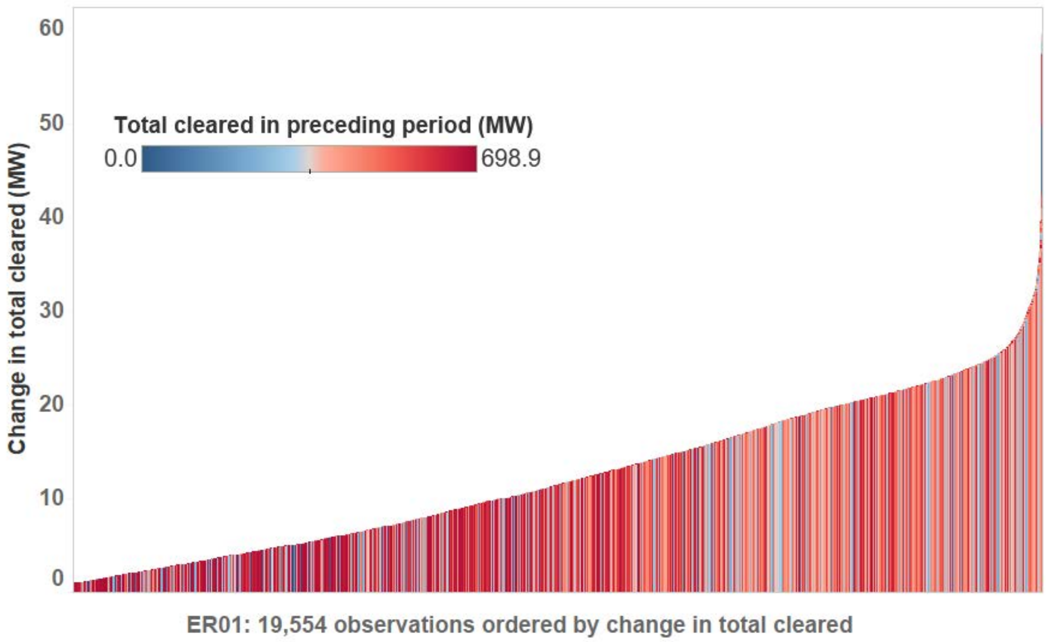
347 Differences in Total Cleared MW.

show that generators demonstrate a range of ramping capabilities, which are generally dependant on the operating level at the start of the dispatch interval in question.

The following charts show the change in output in every dispatch interval when power output increased by more than 1 MW. The bars are sorted in ascending order and coloured based on the initial output at the start of the dispatch interval. Blue indicates an initial condition close to zero, while red indicates that the unit is close to full capacity.

Figure C.2 below shows that baseload coal-fired plant (e.g. Eraring) has historically not ramped very much over individual dispatch intervals. Most of the observations are red because Eraring is a baseload plant and ramping takes place between relatively high levels of output.

Figure C.2 Historical five minute ramping of Eraring unit 1 (2016)



Hydro and gas-fired generators have demonstrated a wider range of ramping capability. The following figures for Tumut 3 (hydro) and Oakey unit 2 (OCGT) are provided as examples.

Figure C.3 Historical five minute ramping of Tumut 3 (2016)

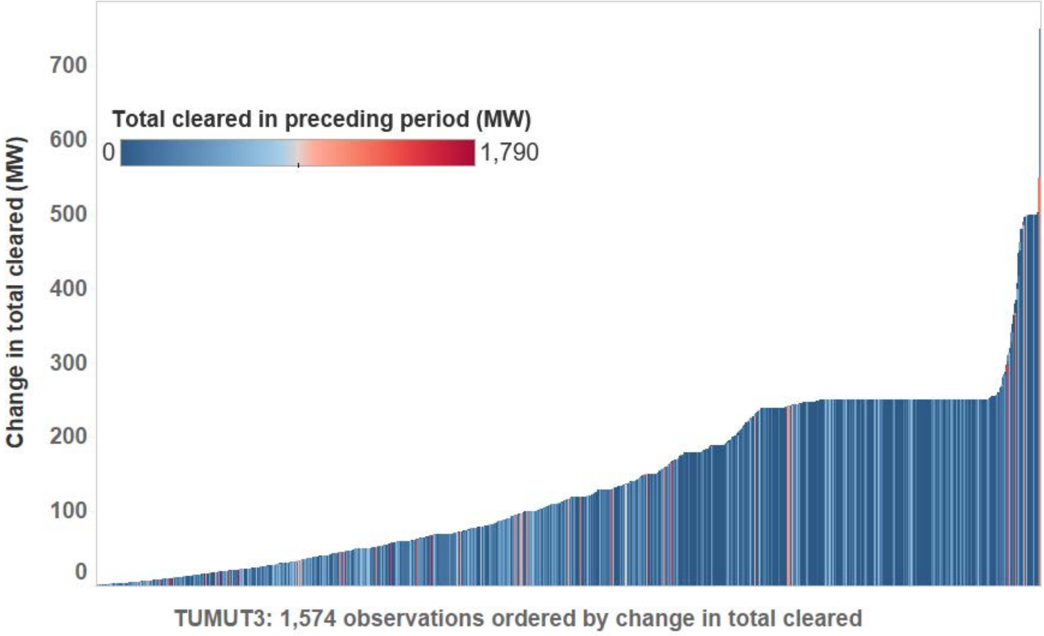
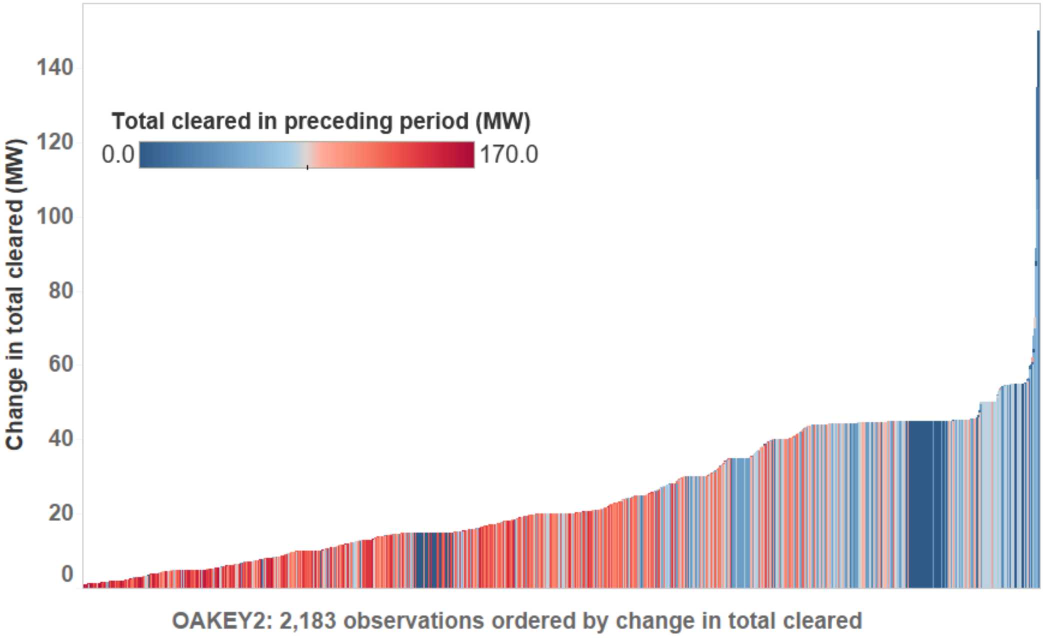


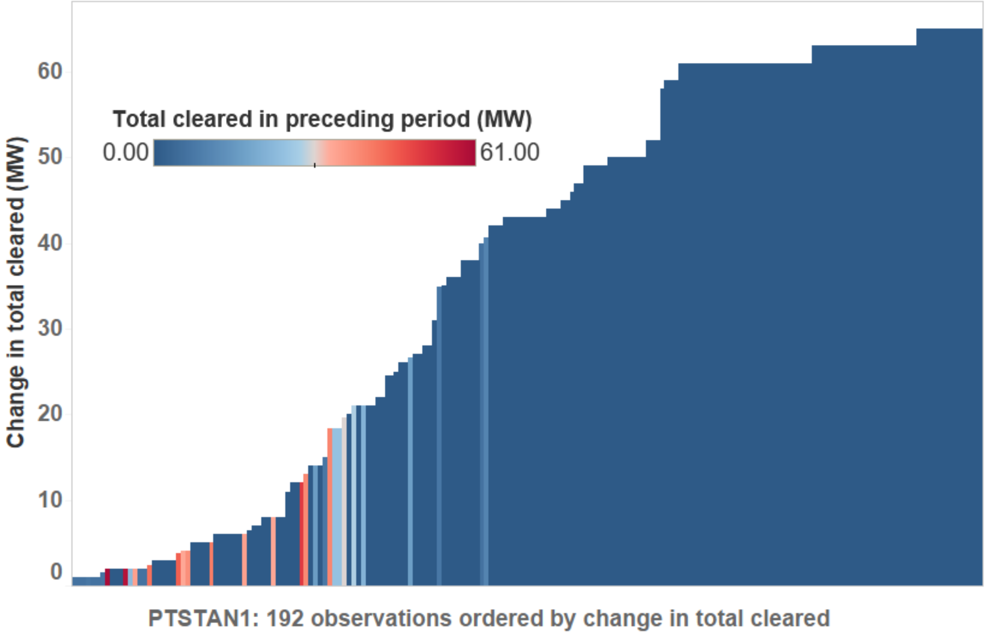
Figure C.4 Historical five minute ramping of Oakey unit 2 (2016)



In contrast to Figure C.2, there are more blue observations in these figures, reflecting the fact that more of the observed responses from these generators occur from rest, or relatively low output levels. In 2016, Tumut 3 often achieved changes in total cleared power of 250 MW between consecutive five minute dispatch intervals, and changes over 500 MW (corresponding with ~28 per cent of rated capacity) on some occasions.

Figure C.5 shows the same analysis for the diesel generator Port Stanvac. Much of the observed ramping is between zero and full output within individual dispatch intervals.

Figure C.5 Historical five minute ramping of Port Stanvac (2016)



This analysis shows that responses in the hundreds of megawatts in five minute periods can be provided by existing generators in the NEM, though there may be additional costs associated with faster ramping.

Another factor to consider is that generators are paid on the basis of energy provided to the market, rather than the output level that they achieve by the end of a dispatch interval. Scheduled generators are expected to ramp linearly between dispatch targets and are penalised through the cost recovery mechanism for regulation frequency control ancillary services (FCAS) if they deviate from this trajectory.

To avoid this penalty, a generator that responds from rest is effectively constrained to an average output for the dispatch interval of 50 per cent of the dispatch target.[348] In certain circumstances, it may be beneficial for a generator to deviate from the assumed linear trajectory as the additional wholesale market revenue is greater than the penalty. However, the way in which the cost recovery mechanism currently operates makes it difficult for generators to make this trade-off.[349]

348 For example, a 100 MW receives a dispatch target to ramp from 0 MW to 100 MW. Assuming it reaches 100 MW by the end of the five minute period, it will have delivered (5/60)/2*100 MW = 4.17 MWh of energy, which is equivalent to a 50 MW unit running at 50 MW for five minutes. In practice, the energy delivered would be lower than this as dispatch instructions are not received by generators until 15-50 seconds after the dispatch interval has commenced.

349 Deviations from the linear trajectory are calculated on a four second basis and then averaged over each five minute period to generate five minute performance factors. These are summed over a 28 day period to calculate the contribution factor to be applied to allocate regulation FCAS costs in the upcoming 28 day period.