



Australian Energy Market Commission

RULE DETERMINATION

National Electricity Amendment (Five Minute Settlement) Rule 2017

Rule Proponent

Sun Metals Corporation Pty Ltd

28 November 2017

**RULE
CHANGE**

Inquiries

Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

E: aemc@aemc.gov.au

T: (02) 8296 7800

F: (02) 8296 7899

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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.

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Summary

The Australian Energy Market Commission (AEMC, or Commission) has made a final 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 final 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 final 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, solar and energy storage at the same time as the 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 final 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 five minute settlement 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 wholesale spot price exposure. 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 and secure financing, while also providing incentives for generators to be available to generate, contributing to reliable supply. For retailers, contracts provide the wholesale purchase cost stability necessary to deliver price stability for consumers, and allow 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. The sale of these contracts also underpins the financing of much of the existing fast response generation capacity. 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 implementing five minute settlement. 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. In July 2017, AEMO 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 announcements and investment decisions highlight the speed with which new technologies can be implemented in the face of emerging supply shortfalls.

Additionally, the final rule sets a transition period of three years and seven months prior to five minute settlement commencing. This provides time for potential system security issues to be further studied and 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 final rule reflects this position and its key features are as follows:

- Five minute settlement will commence on Thursday, 1 July 2021. This is 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 five 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 five 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 provide 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 provide five minute data from the commencement date of the rule.
- The final rule does *not* require type 4 (other than other than 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), type 4A, type 5 and type 6 meters that are already installed to record and provide five minute data at the commencement date. The data from these meters will be profiled to five minute trading intervals by AEMO.
- From 1 December 2018, all new and replacement type 4 metering installations will need to be capable of recording and providing five minute data. These meters must be configured to record and provide five minute data from 1 December 2022 at the latest.
- From 1 December 2019, all new and replacement type 4A metering installations will need to be capable of recording and providing five minute data. These meters must be configured to record and provide five minute data from 1 December 2022 at the latest.
- 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 and 3 meters and 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 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.

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 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 annual NEM 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. The Commission has observed that the distortion created by 30 minute settlement has increased in recent years, and is expected to become even greater over time in the absence of this change. 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 final rule features 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.

The Commission acknowledges the breadth and depth of implementation required and therefore recommends that market participants begin transitioning to five minute settlement without delay in consultation with AEMO.

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.

Requests for modelling and CBA

Some stakeholders requested that the Commission undertake a formal cost-benefit analysis (CBA), supported by market modelling, of five minute settlement. While market modelling and, occasionally, CBAs are used by the Commission to inform its decision making, there is no formal requirement under the National Energy Law (NEL) to undertake either in response to a rule change request.

Ultimately, the Commission in this instance opted against detailed market modelling of five minute settlement, following discussions with consultants that offer these services. This is primarily because such modelling is unlikely to provide useful information due to the many assumptions that would be required, and limitations in the length of time that could be modelled.

The Commission considered the cost estimates provided by AEMO and industry, and acknowledges that there are likely to be some large one-off costs to implement five minute settlement. Nonetheless, potentially large benefits are expected to arise from removing the distorted 30 minute price signal, which will endure over time. Given the size of NEM transactions in 2016/17 was \$16.6 billion, only a relatively small increase in the efficiency of operation and investment over time is required to outweigh the costs.

The Commission also notes that to the extent industry participants believed such modelling was appropriate, there was opportunity for them to undertake their own CBA and market modelling, however they have chosen not to do so.

Relationship with other market reforms

It has been suggested that other regulatory and market change processes – such as Reliability Frameworks Review, Inertia Ancillary Service Market rule change, Frequency Control Frameworks Review, Finkel Review recommendations and National Energy Guarantee proposal – should be allowed to settle before the Commission makes a decision on five minute settlement.

The Commission's view is that five minute settlement is likely to provide a net benefit under a range of different market design scenarios and it is therefore appropriate to make this decision at the current time. As the signal for investment is fundamental to the efficiency of the NEM, if five minute settlement is not implemented, the distortion to operation and investment incentives would persist irrespective of other regulatory changes.

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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
- 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
- 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.

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

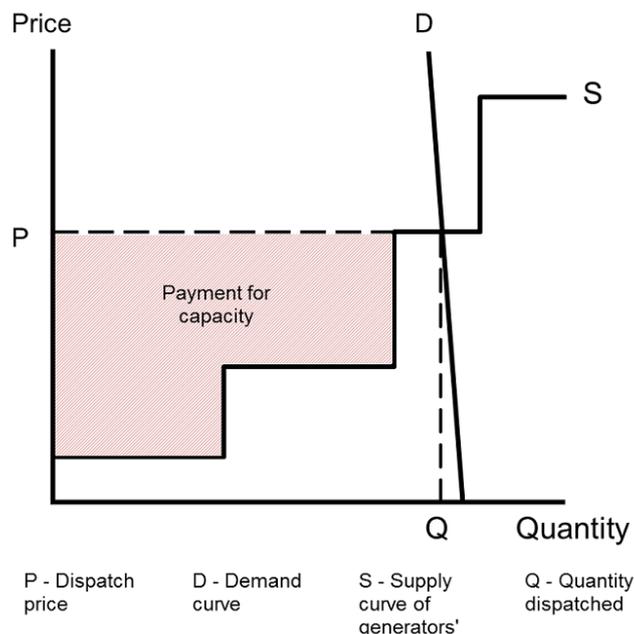
- a central dispatch algorithm that is run for every dispatch interval
- ancillary service markets that correct for deviations within dispatch intervals.

Scheduled and semi-scheduled generators, scheduled loads and MNSPs submit bids or offers to AEMO, signalling their willingness to generate, consume or transport electricity. 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. 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.

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.³ 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 implement, and metering equipment was not sophisticated enough to handle any finer detail than half hourly pricing.⁴

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:

³ 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, $S = (D1+D2+D3+D4+D5+D6) / 6$.

⁴ Five Minute Settlement

- 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 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.

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.⁵ 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.⁶ 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).

⁴ ACCC, *Applications for authorisation - National Electricity Code*, 10 December 1997, p. 60.

⁵ 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.

⁶ This notice was published under section. 95 of the 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. The additional detail had been requested by a number of stakeholders to enable them to more accurately assess the impacts of any move to five minute settlement. 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.

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.

On 5 September 2017, the Commission published a draft rule determination and a draft rule.⁷ Submissions on the draft rule determination closed on 17 October 2017. The Commission received 41 submissions on the draft rule determination of which 18 were submitted late.

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

This final rule determination is set out as follows:

- Chapter 2 provides an overview of the Commission's final rule determination, including its assessment framework and summary of reasons for making the final rule. It also sets out the key features of the final rule
- Chapter 3 identifies the in-principle benefits of five minute settlement

⁷ The draft rule determination was published under s. 99 of the NEL.

- 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 final rule determination
- Appendix B sets out the relevant legal requirements under the NEL for the Commission to make this final rule determination
- Appendix C provides supplementary material for Chapter 4.

2 Final rule determination

The Commission's final rule determination is to make a more preferable final rule. The more preferable final 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 final rule also:

- changes the resolution for bidding and offering into the NEM from a 30 minute to a five 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.

The Commission's reasons for making this final rule determination are set out in section 2.4

This chapter outlines:

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

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

2.1 The Commission's final rule determination

The more preferable final rule made by the Commission is attached to and published with this final rule determination. The key features of the more preferable final rule are:

Commencement

The final rule will commence on Thursday, 1 July 2021. The transitional provisions will commence on 19 December 2017.

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 five 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 five 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 Projected Assessment of System Adequacy (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.
- Provides AEMO with the discretion to publish, together with its forecast *spot prices*, details of the expected sensitivity of the forecast *spot prices* for each *trading interval* to changes in the forecast load or generating unit availability. This is in addition to the requirement for AEMO to publish, together with its forecast *spot*

prices, details of the expected sensitivity of the forecast *spot prices* for each *30-minute period* to changes in the forecast load or generating unit availability.

- 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 Regulator (AER) 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 Data Provider* to ensure that type 1, 2 and 3 *metering installations* record and provide five minute data from the commencement date.
- Requires the *Metering Data 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* record and provide 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* record and provide 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 and 3 *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.
- Empowers AEMO to exempt a *Metering Provider* from complying with the data storage requirements for types 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* installed prior to 1 July 2021 and where it is reasonably satisfied that

the *Metering Provider* will be able to otherwise meet the requirements of the NER. For avoidance of doubt, AEMO is unable to grant an exemption for type 4 meters at all other connection points.

Transitional rules

- Introduces an obligation on AEMO to amend and publish its relevant procedures to apply from the commencement date by 1 December 2019.
- Introduces an obligation on the *Information Exchange Committee* to make an *Information Exchange Committee Recommendation* to change the *B2B Procedures* to take into account the amending rule by 1 July 2019.
- Introduces an obligation on the AER to amend and publish its relevant documents to apply from the commencement date by 1 December 2019.
- Exempts type 4 *metering installations* installed prior to 1 December 2018 from providing five minute data until they are replaced.
- Exempts type 4A *metering installations* installed prior to 1 December 2019 from providing five minute data until they are replaced.
- Requires new or replaced type 4 *metering installations* (other than 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*) installed between 1 December 2018 and the commencement date to record and provide five minute data from 1 December 2022 at the latest.
- Requires new or replaced type 4A *metering installations* installed between 1 December 2019 and the commencement date to record and provide five minute data from 1 December 2022 at the latest.
- 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 and 3 *metering installations* and 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* 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.

Other consequential changes in the final rule

- Introduces a new definition '*intervention pricing 30-minute interval*' in relation to the \$5,000 compensation thresholds for AEMO directed interventions.

- Maintains the current setting of the *modified load export charge* (MLEC)*cost reflective network pricing* (CRNP) methodology by allowing the MLEC to be developed in relation to *30-minute periods* over the previous regulatory year.
- With respect to billing for distribution services, enables charges for distribution services to be calculated from either *metering data* or *settlements ready data* for type 4 *metering installations*.

2.2 Rule making test

2.2.1 Achieving the national electricity objective

Under the NEL 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 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 s. 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 more 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 final rule will, or is likely to, better contribute to the achievement of the NEO for the following reasons:

- the final 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

⁸ Section 88 of the NEL.

⁹ Section 7 of the NEL.

- 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
- the final 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.
- **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. Arrangements should be designed so that market participants can effectively manage their price risk exposure. 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.
- **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. Any changes to the NEM market design should occur in such a way that participants can continue to make efficient decisions in relation to buying and selling 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 should be considered. These involve once-off costs associated with the transition and potential on-going costs associated with the new regime.

2.4 Summary of reasons

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

- **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 around 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. That is, there is 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 the more efficient five minute settlement pricing under 30 minute settlement is redistributed to less flexible generators. These generators 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 settlement 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 consumers 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 be 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 appear small however 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 of looking to promote effective competitive markets. Five minute settlement:

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

The expectation is that by aligning dispatch and settlement at five minutes, it will promote a more competitive wholesale market and efficient lower generation mix over the longer term. Consumers will in future experience the benefit of lower retail prices, as wholesale costs typically account for around one third of a consumer's bill, and will have greater incentives to participate in demand response activities.

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 Stakeholders' views

3.2.1 Consultation paper and directions paper submissions

The majority of submissions to both the consultation paper and directions paper broadly acknowledged the theoretical problem with having misaligned dispatch and settlement periods.¹⁰ However, many of those who expressed support for the theory behind five minute settlement also indicated strong opposition to the change going ahead.¹¹

Many stakeholders considered that there would be benefits from an improved price signal for flexible technologies, especially new and emerging technologies such as

¹⁰ 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.

¹¹ E.g. Directions paper submissions: Energy Queensland, p. 1; Origin Energy, p. 4.

energy storage.¹² For example, AGL Energy and Tesla considered that moving to five minute settlement would help to more effectively harness increased demand response capability, battery storage opportunities and a greater renewables-based generation profile.

Some stakeholders considered that five minute settlement would be more technology neutral than the current arrangements; others considered that this characterisation was inaccurate. Energy Consumers Australia and the Clean Energy Council thought that the current rules are framed around the way existing technology operates and feature incumbency privileges.¹³ Others, including Arrow Energy and Major Energy Users, considered that five minute settlement would not be technology neutral as it would likely promote new technology over existing generation, especially gas-fired generation.¹⁴

Contrasting views were also expressed on the impact that five minute settlement would have on demand side response.¹⁵ The Australian Energy Council (AEC), ERM Power, Major Energy Users, and Snowy Hydro asserted that there would be a reduced incentive for demand response activities as most activities require more than five minutes to implement.¹⁶ ERM Power submitted that five minute settlement would "all but destroy the existing demand response in the NEM".¹⁷ In contrast, others thought that five minute settlement would benefit those seeking to engage in demand response.¹⁸ EnerNOC submitted that there would be increased incentives for technological advances and innovative business models from retailers and independent service providers.¹⁹

Stakeholders also commented on potential benefits from changed bidding incentives under five minute settlement. Some thought that the Bidding in Good Faith rule change had already addressed strategic bidding issues, so there was a reduced benefit from moving to five minute settlement.²⁰ Others considered that strategic rebidding

12 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.

13 Directions paper submissions: Clean Energy Council, p. 5; Clean Energy Council, directions paper submission, p. 3.

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

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

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

17 ERM Power, directions paper submission, p. 8.

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

19 EnerNOC, directions paper submission, p. 3.

20 E.g. Origin Energy, consultation paper submission, p. 2; Arrow Energy, directions paper submission, p. 1.

remained a problem in the market.²¹ 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 thought to be unclear.²²

Some stakeholders cited the Finkel Review and other regulatory and reform process currently underway.²³ ERM Power, Origin Energy and SACOSS considered it to be premature for the AEMC to make a decision on five minute settlement before other reviews have been settled.²⁴

There was a view among some stakeholders that a detailed cost benefit analysis (CBA) of the proposed rule change should be conducted before proceeding to the draft determination stage.²⁵

3.2.2 Draft determination submissions

Support for the Commission's position

The draft determination set out the Commission's views on the likely benefits of moving to five minute settlement. A broad range of stakeholders supported the view that five minute settlement would have significant, enduring benefits relative to the current arrangements.²⁶ There was a general view among these stakeholders that five minute settlement would provide an improved incentive for flexible resources, leading to lower prices and less spot price volatility over time. It was observed that the growing share of solar and wind energy will lead to increased demand for flexibility in the long term.²⁷

The South Australian Government considered that five minute settlement would allow for the value of new generation technologies to be clearly communicated to the market.²⁸ The AER, Clean Energy Council and Uniting Communities also cited the improved incentives for flexible technologies as a benefit of five minute settlement.²⁹ There was a view that five minute settlement would increase the uptake of new energy

21 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.

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

23 E.g. EnergyAustralia, directions paper submission, p. 1.

24 Draft determination submissions: ERM Power, p. 1; Origin Energy, p. 1; SACOSS, p. 24.

25 Directions paper submissions: AEC, p. 2; Energy Queensland, p. 2; Aurora Energy, p. 1; Origin Energy, p. 1; Major Energy Users, p. 22; Snowy Hydro, supplementary submission, p. 2; ERM Power, p. 6.

26 Draft determination submissions: AEMO, p. 1; AER, p. 1; ARENA, p. 2; AESA, p. 1; CEC, p. 1; ECA, p. 1; Lyon Group, p. 1; PIAC, p. 1; South Australian Government, p. 1; Sumo Power p. 1; Tesla, p. 1; Uniting Communities, p. 2.

27 E.g. ARENA, draft determination submission, p. 2.

28 South Australian Government, draft determination submission, p. 2.

29 Draft determination submissions: AER, p. 1; Clean Energy Council, pp.1-2; Uniting Communities, p. 5.

technologies.³⁰ The AER and the Australian Energy Storage Alliance cited likely competition benefits from fast response new entrants.³¹

Uniting Communities submitted that five minute settlement is likely to increase the efficiency of the NEM, "meaning that consumers will benefit...in the medium to longer term if not more immediately".³² Similarly, Alinta Energy considered that five minute settlement would allow for more efficient outcomes for the market and consumers in the long run.³³

Opposing views

Other stakeholders were of the view that the case for change had not been made and that the benefits identified in the draft determination were too theoretical.³⁴ Hydro Tasmania and Major Energy Users submitted that the Commission has not provided any evidence of the benefits.³⁵ Major Energy Users indicated concern that the Commission's draft decision was "based purely on economic theory and hope".³⁶ The Tasmanian Government cited "significant uncertainty" as to whether five minute settlement would be in the best interests of consumers (and, in particular, Tasmanian consumers).³⁷ Alinta Energy submitted that the benefits are "still somewhat theoretical and ambiguous over the short term".³⁸ ERM Power suggested that the Commission look beyond economic theory and consider the current vulnerability of the market to withstand such a change.³⁹

Some stakeholders reiterated the view that a detailed CBA is required in order to justify the rule change.⁴⁰ The Tasmanian Government indicated that a comprehensive CBA should also include assessment at a regional level, reflecting the particular circumstances of each of the jurisdictions.⁴¹ In contrast, Energy Consumers Australia noted that a CBA is not the standard required for the AEMC to make a rule.⁴²

30 Draft determination submissions: Lyon Group, p. 2; PIAC, p. 1; Tesla, p. 2.

31 Draft determination submissions: AER, p. 1; AESA, p. 2.

32 Uniting Communities, draft determination submission, p. 2.

33 Alinta Energy, draft determination submission, p. 2.

34 E.g. Draft determination submissions: ERM Power, p. 2; Major Energy Users, p. 4; Hydro Tasmania, p. 1; AFMA, p. 2; Snowy Hydro, p. 2.

35 Draft determination submissions: Hydro Tasmania, p. 1; Major Energy Users, p.6.

36 Major Energy Users, draft determination submission, p. 8.

37 Tasmanian Government, draft determination submission, p. 1.

38 Alinta Energy, draft determination submission, p. 6.

39 ERM Power, draft determination submission, p. 2.

40 Draft determination submissions: Energy Queensland, p. 2; Hydro Tasmania, p. 1; Aurora Energy, p. 5; ERM Power, p. 6; Snowy Hydro, p. 5; Tasmanian Government, p. 1; Major Energy Users, p. 6.

41 ERM Power, draft determination submission, p. 6.

42 Energy Consumers Australia, draft determination submission, p. 1.

Concerns were raised about the cost of replacing existing generation capacity with fast start technologies.⁴³ The AEC submitted that, "existing peaking generators, which are technically unable to respond within five minutes, will withdraw from the market due to their inability to respond to needle peaks".⁴⁴ Similarly, Major Energy Users thought that, "plant that cannot respond with (sic) the five minute settlement period, will be effectively barred from the market, biasing the market towards faster start plant and [presenting] a barrier to lower cost slower start plant".⁴⁵ Arrow Energy thought that, "the AEMC may require large volumes of fast start technologies to enter the market...for the rule change to remain effective".⁴⁶

Stakeholders again questioned the Commission's decision to implement five minute settlement at a time when there are so many other reforms taking place.⁴⁷ These include the Reliability Frameworks Review, Inertia Ancillary Service Market rule change, Frequency Control Frameworks Review, Finkel Review recommendations and the recently proposed National Energy Guarantee. Major Energy Users submitted that five minute settlement be deferred, modified or not enacted, pending development of the National Energy Guarantee policy. On the other hand, Energy Consumers Australia was of the view that the National Energy Guarantee (NEG) will be enhanced by aligning dispatch and settlement.⁴⁸

Similar arguments to the earlier consultation rounds were made in relation to demand response. Major Energy Users continued to be of the view that five minute settlement would "remove much of the demand side responsiveness that is already provided".⁴⁹ ERM Power considered there to be a strong case that five minute settlement will cause no change in demand response, or even a decrease.⁵⁰

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)

⁴³ E.g. Energy Queensland, p. 3; ERM Power, p. 6.

⁴⁴ AEC, draft determination submission, p. 2.

⁴⁵ Major Energy Users, draft determination submission, p. 20.

⁴⁶ Arrow Energy, draft determination submission, p. 3.

⁴⁷ Draft determination submissions: Aurora Energy, p. 3; Hydro Tasmania, p. 2; Snowy Hydro, p. 4; Energy Queensland, p. 4; EnergyAustralia, p. 3; Tasmanian Government, pp. 2-3.

⁴⁸ Energy Consumers Australia, draft determination submission, p. 2.

⁴⁹ Major Energy Users, draft determination submission, p. 18.

⁵⁰ ERM Power, draft determination submission, p. 5.

- 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.

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 operating costs ahead of those with higher operating 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,⁵¹ 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 consumers 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.

⁵¹ 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 than 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).

Small consumers, 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 consumers 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.

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 any market power they might have. 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.⁵²

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 – wholesale prices need to reflect not just the marginal costs of

⁵² 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.

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. Similarly, when prices are negative due to surplus supply, discretionary loads (including energy storage) and flexible generation can derive a benefit from consuming more, or generating less.

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.

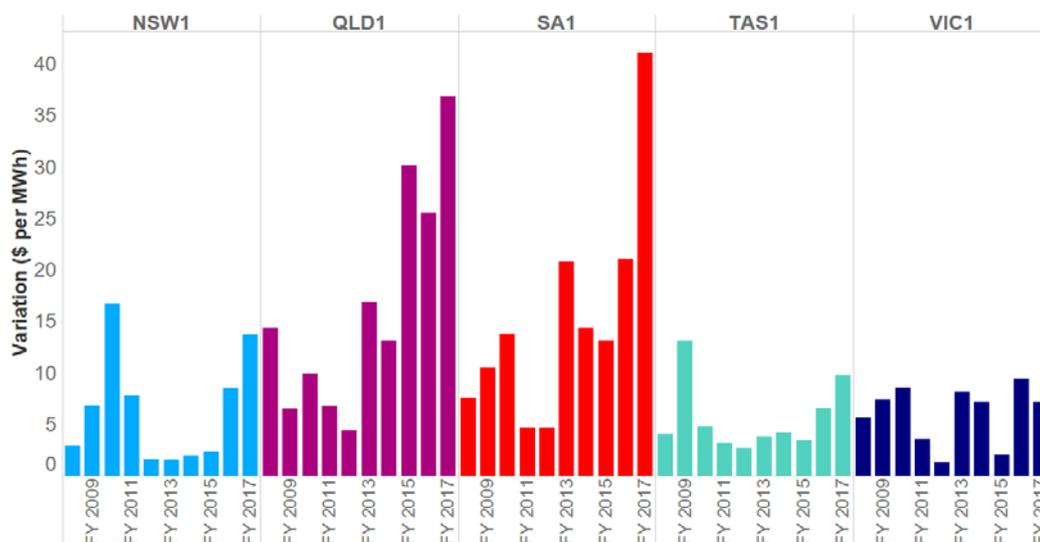
Price spikes that are an outcome of supply-demand conditions are important indicators of the physical condition of the market. The more closely prices reflect the physical condition of the market, the more efficient the price signals. The following section assesses the ability of 30 minute average prices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

Distortions in electricity wholesale price signals

The directions paper presented analysis on variation between the settlement price and the individual dispatch interval prices. The difference between the settlement and dispatch interval price 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.

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. 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.

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 2016/17.⁵³

⁵³ 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

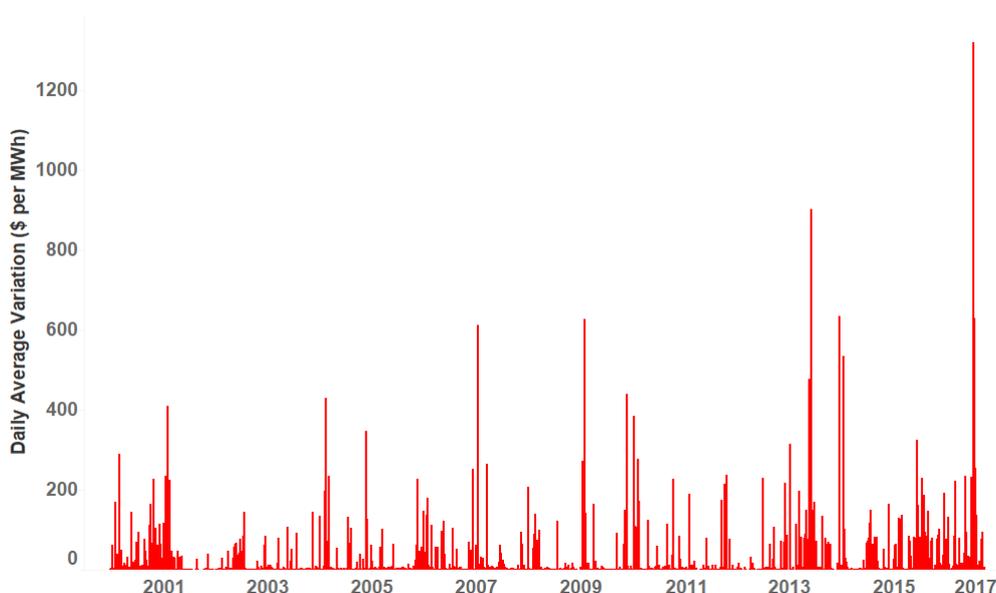
Region and year	Absolute variation (\$/MWh)	Average regional price (\$/MWh)	Percentage variation
SA 2015/16	21.1	67	31%
SA 2016/17	41.1	108	38%
QLD 2015/16	25.6	64	40%
QLD 2016/17	36.9	93	40%

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, highlights the magnitude of the average daily variation for South Australia and how it has increased over time.⁵⁴ 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.

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.⁵⁵ The Commission considers that the fact that price spikes are more likely to occur in the first and the last dispatch intervals cannot easily be explained without consideration of strategic bidding behaviour.

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, 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

⁵⁴ AEMC, *Five Minute Settlement*, directions paper, 11 April 2017, p. 43.

⁵⁵ 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.

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 2016.⁵⁶ 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.⁵⁷

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 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 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.

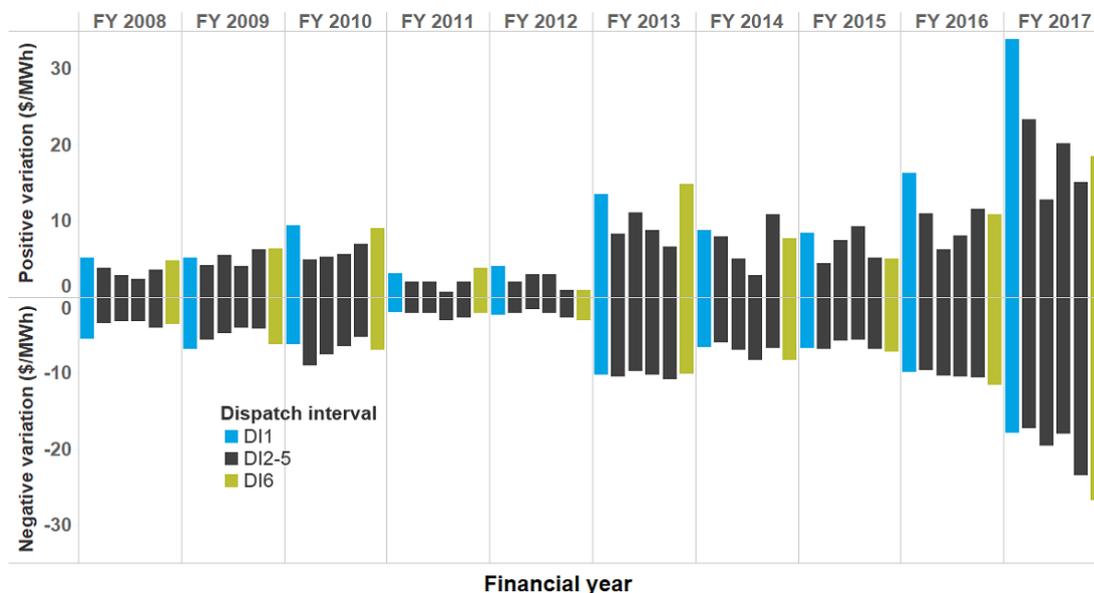
Figure 3.3 shows the average annual volume weighted variations between the five minute prices relative to the 30 minute prices in each dispatch interval since 2008 for South Australia. This figure is based on a similar methodology to Figure 3.1 above, though in this case the average variation between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

⁵⁶ 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.

⁵⁷ Directions paper submissions: Snowy Hydro, p. 2; Arrow Energy, p. 2; Major Energy Users, p. 7.

working paper 1, this trend is present in all regions in the NEM and most distinct in Queensland and South Australia.⁵⁸

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 of the rule change.⁵⁹ 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.⁶⁰

'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

⁵⁸ Five Minute Settlement Working paper 1, pp. 18, 37.

⁵⁹ Seed Advisory, *The Five Minute Settlement Rule Change Proposal – Review of the Australian Energy Market Commission's Directions Paper*, 29 May 2017, p. 45.

⁶⁰ *Ibid*, p. 38.

share the benefit of the price spike.⁶¹ 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.⁶²

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.⁶³ 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 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.

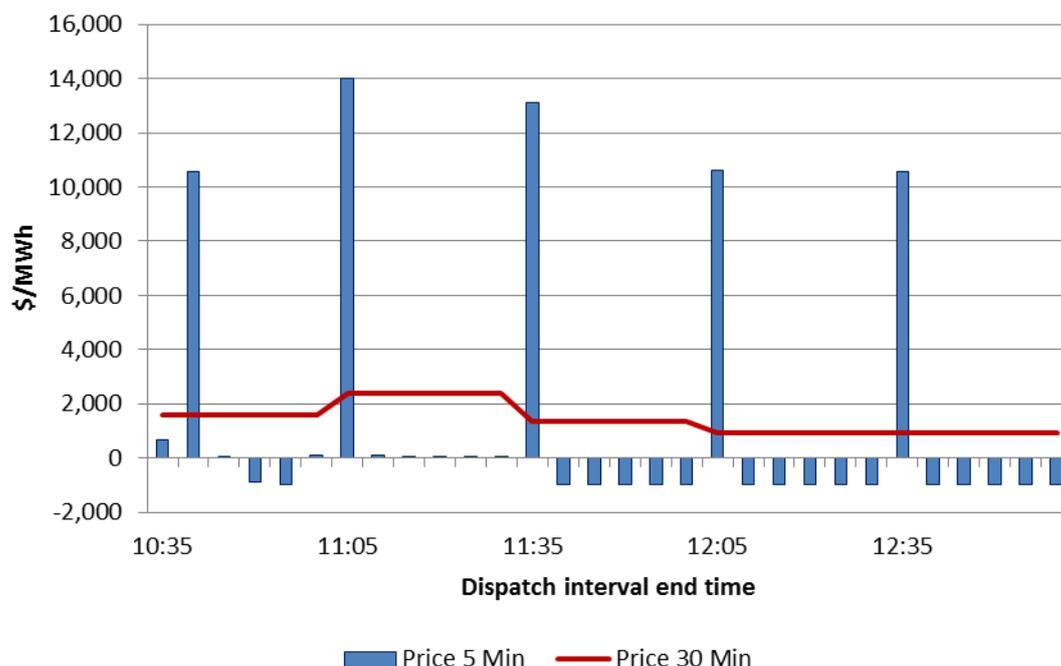
Figure 3.4 below illustrates the type of incentives that arise from the distorted price signal that the mismatch of dispatch and settlement creates. The chart compares the five trading intervals from 10.30am to 1.00pm on Tuesday 21 March 2017 in South

⁶¹ AEMC, *Five Minute Settlement*, directions paper, pp. 17-18 and 34-35.

⁶² This is further discussed in the Commission's directions paper, p. 36.

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.⁶⁴ While the Commission acknowledges that regional factors have contributed to historical price outcomes, it also sees the potential for the conditions to South Australia (for example, 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.⁶⁵ 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

⁶³ AER, *Electricity spot prices above \$5,000/MWh – New South Wales & Queensland*, 10 February 2017, published 5 May 2017.

⁶⁴ Directions paper submissions: Arrow Energy, p. 6; Infigen Energy, p. 2; SA Water, p. 2; Snowy Hydro, p. 8.

⁶⁵ Russ Skelton & Associates, *Materiality of problem or magnitude of benefits*, Five Minute Settlement Public Forum, May 2017, p. 6.

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.⁶⁶

The initial price spikes followed by low – or negative – prices have also been perceived by some stakeholders as serving the interests of consumers. For example, Major Energy Users was 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. 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". This view was reinforced in a submission on the draft determination, which argued that, "the incentive to reduce the ability to exercise market power implicit in 30 minute settlement, will no longer apply [under five minute settlement]".

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. 'Piling in' is an example of generators competing to deliver volume rather than competing on five minutes, as a high 30 minute price has already been assured by the early price spike. The Commission is of the view that competition among generators should be expected to put downward pressure on wholesale prices in all dispatch intervals. Five minute settlement is expected to promote this more effective competition by removing the common reference point provided by 30 minute settlement.

In summary, 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.

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.

⁶⁶ Major Energy Users, draft determination submission, p. 12.

The Commission considers that the historic volatility observed in five minute dispatch prices under 30 minute settlement is unlikely 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.⁶⁷ 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.⁶⁸

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

Distortions to demand response

The Commission is concerned about the potential for 30 minute settlement to increase the incidence of allocatively inefficient consumption decisions. Two examples of this are:

1. Since the 30 minute settlement price is not known until 25 minutes into a trading interval, there may be confusion as to whether the 30 minute price will be high enough to warrant load curtailment or low enough to continue production. This can result in curtailment when the 30 minute price is below the business's willingness to pay, or the business not curtailing when the price was actually higher than their willingness to pay.

⁶⁷ For example see directions paper submissions: SACOSS, slides 5, 10-16, 24; Infigen, p. 3; Stanwell, p. 21.

⁶⁸ Energy Consumers Australia, consultation paper submission, p. 3.

2. To avoid a high 30 minute price event, it is necessary for a demand response to occur for the full half hour to derive the most benefit. This may result in excessive load curtailment if the physical requirement of the power system had been for a shorter demand reduction (or supply increase). Similar to the 'piling in' phenomena discussed above, 30 minute settlement may also result in demand responses up to 25 minutes after the dispatch interval where a high price signalled it was needed by the power system.

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.⁶⁹

For large commercial and industrial consumers that are in some way exposed to wholesale market prices, the wholesale electricity market pricing outcomes directly affects allocative efficiency.⁷⁰ Small consumers, 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 consumers is ultimately guided by the retail tariffs consumers 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.

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.

⁶⁹ EnerNOC, directions paper submission, p. 3.

⁷⁰ 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.

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,⁷¹ while the estimated replacement cost of the current 45 GW of NEM generation assets are estimated to be in the order of \$130 billion.⁷²

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. As of June 2017, there was almost 1.4 GW of committed wind and solar generation projects, and a further 19 GW in proposed wind and solar developments.⁷³ There is already greater physical variation on the supply side due to 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.⁷⁴

These conditions mean that there will be both an increasing need and opportunity for technologies that are capable of short term supply-demand balancing. This role is expected to be performed by both existing participants and new entrants. The Commission acknowledges that there is already a large amount of aggregate ramping capability in the NEM. Analysis shows that in 2016 there was, on average, hundreds of megawatts of ramping capability in each dispatch interval in each region of the NEM.⁷⁵ However, much of this capacity will be retired in the coming decades. Analysts also project the deployment of hundreds or thousands of MWs of energy storage in the next few years.⁷⁶ Therefore, enabling the wholesale price to accurately signal the efficient need for investment in, and efficient operation of, such technologies is becoming critical.

⁷¹ AEMO, National electricity market fact sheet, 2017, p. 1.

⁷² This estimate is based on 45 GW 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.

⁷³ AEMO, Generation Information, July 2017.

⁷⁴ 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>.

⁷⁵ AEMC, *Five Minute Settlement*, directions paper, 11 April 2017, pp. 47-48.

⁷⁶ Bloomberg New Energy Finance (1 GW/2 GWh by 2021) and Morgan Stanley (6 GWh by 2021) estimates.

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 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.⁷⁷ 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

⁷⁷ A range of examples were provided in Section 4.5 of the Commission's directions paper.

- aggregation and control of behind the meter energy storage resources.

Contrary to the views of some stakeholders, the Commission does not expect that five minute settlement will cause the withdrawal from the market of large amounts of generation capacity, or create a need for this generation capacity to be immediately replaced with fast start technologies. Rather, the changes due to five minute settlement are expected to be incremental. A key reason for this is that revenue opportunities are still expected to exist for peaking generation from selling hedging contracts and providing system security services. These topics are covered in Chapters 4 and 5 of this determination.

Further, not every resource in the market must be capable of providing a response within five minutes. This is already the case in that not every resource is currently required to provide a response within 30 minutes to be effective in the NEM. The Commission expects that increasingly flexible technologies and generation configurations (for example, gas plus battery) will be able to achieve greater revenue. However, at some point the additional investment in flexibility will not provide a commensurate return.

Price signals will influence the type of technology installed, as well as the timing, scale and location of investments in response to changing market conditions. 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. Conversely, five minute settlement will promote investment in a more efficient amount of flexible technologies, leading to more effective competition in meeting balancing and peak energy needs than would be the case under 30 minute settlement.

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 potential for economic viability 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 consumers in the longer term will pay higher prices for electricity than they otherwise should over a sustained period of time.

It has been suggested that other regulatory and market change processes – such as Reliability Frameworks Review, Inertia Ancillary Service Market rule change, Frequency Control Frameworks Review, Finkel Review recommendations and National Energy Guarantee proposal – should be allowed to settle before the Commission makes a decision on five minute settlement. The Commission's view is that five minute settlement is likely to provide a net benefit under a range of different market design scenarios and it is therefore appropriate to make this decision at the current time. As the signal for investment is fundamental to the efficiency of the NEM, if five minute settlement is not implemented, the distortion will persist irrespective of other regulatory changes.

In the case of the Finkel Review, the five minute settlement rule change was referred to in the final report, so the recommendations were made with regard to the possibility of five minute settlement being implemented. To the extent that five minute settlement impacts on the Finkel Review recommendations, the Commission expects that rather than affecting the benefits of five minute settlement, it is more likely to change the scope of that work required to address the recommendations. For example, if five minute settlement was to stimulate greater volumes of demand response, then further mechanisms to facilitate demand response may not be needed.

Some of the regulatory processes underway may increase rewards for providing (or, alternatively, introduce disincentives for not providing) services in support of system security and reliability outcomes. For example, the NEG is proposed to operate through a requirement on retailers to enter into contracts with 'dispatchable' and low emissions technologies. The Commission considers that potential system security and reliability mechanisms would complement the existing NEM spot market arrangements rather than replace them. Hence, NEM spot prices will continue to be a decisive input into investment decisions for the foreseeable future.

Five minute settlement would also be complementary to a range of other market designs. For example, in a dual settlement arrangement (e.g. day-ahead market) the

existing intervals for dispatch and settlement would be maintained, so the distortion in investment incentives due to 30 minute settlement would still lead to a less efficient generation mix relative to five minute settlement. Further, even with a capacity market, accurate spot prices would continue to be important to signal the flexibility requirements of the power system as it is difficult to reflect these requirements via a capacity payment.

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 consumers 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.⁷⁸

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.

⁷⁸ 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.

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 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.⁷⁹ 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,⁸⁰ and for simplicity ignoring project financing costs, the per cycle capital cost of the battery storage equates to around \$300/MWh.⁸¹

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.

⁷⁹ 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.

⁸⁰ 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.

⁸¹ 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.

Figure 3.5 and Figure 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 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

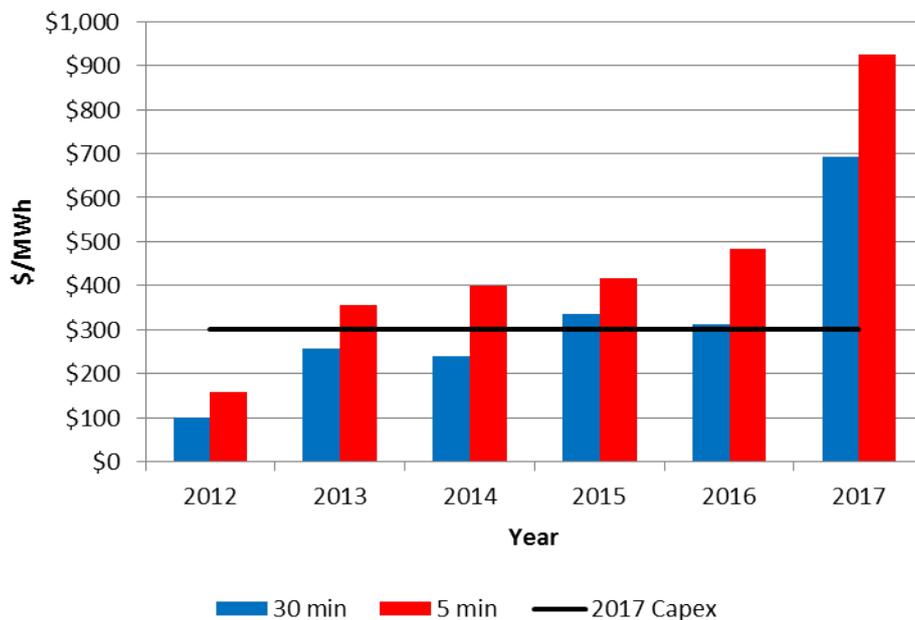


Figure 3.6 Battery net arbitrage value – South Australia 2012-2017

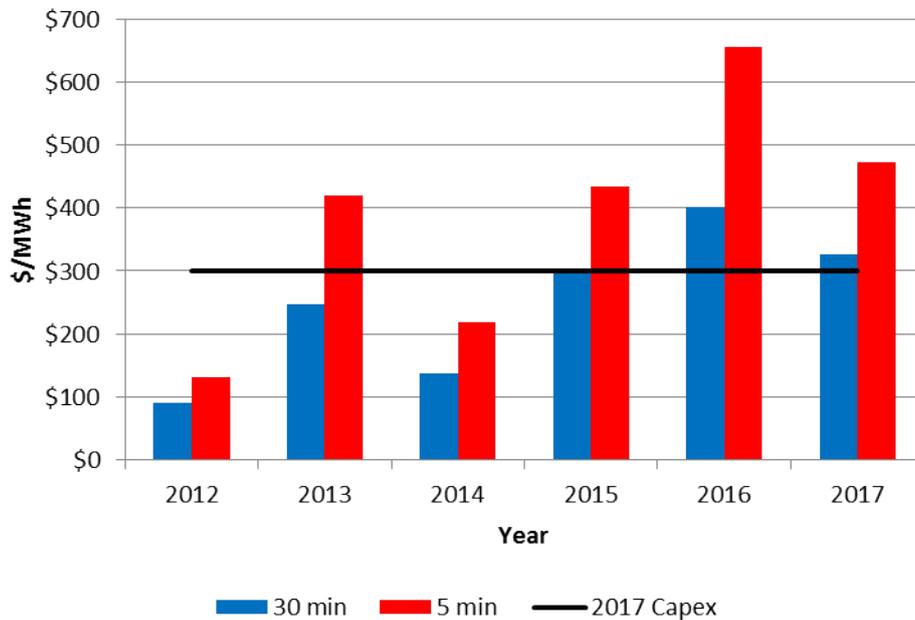
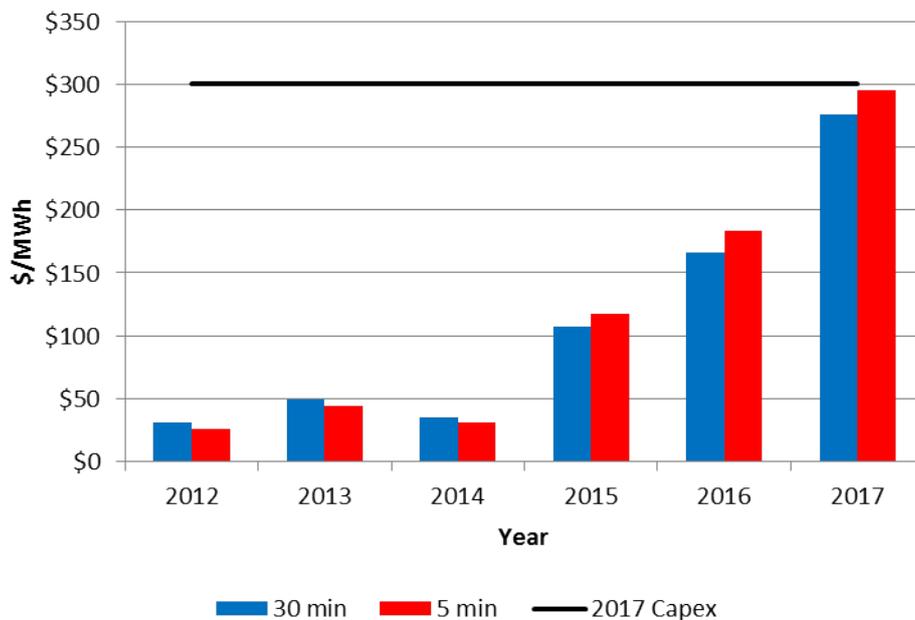


Figure 3.7 shows the same information for the New South Wales region. It demonstrates that even in a region with relatively low price volatility, the choice of five minute or 30 minute settlement would be a relevant factor for those considering capital investments in battery storage.

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 gas generation investment, there would be a strong incentive to deploy aero derivative turbines or internal combustion engines 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.⁸²

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.⁸³

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

⁸² 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 (for example, 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.

⁸³ 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.

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 consumers and demand side service providers face are in line with the needs of the power system. This requires that consumers or service providers are able to receive the full reward for the value and services they provide to the market. The Commission considers that five minute settlement better aligns consumers' 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.

Modelling and CBA

As noted above, some stakeholders considered that the benefits identified in the draft determination relied too heavily on economic theory. These stakeholders have also submitted that a formal CBA should be conducted, supported by detailed modelling. The reasons provided for undertaking this modelling include: to better understand the impact on the wholesale market, quantify the magnitude of the benefits, understand potential bidding behaviour, and determine a suitable commencement date.⁸⁴

⁸⁴ Draft determination submissions: ERM Power, p. 6; Major Energy Users, p. 8; AGL Energy, p. 1. Directions paper submissions: SA Water, p. 1; Energy Queensland, p. 6; EnergyAustralia, p. 7.

While market modelling and, occasionally, CBAs are used by the Commission to inform its decision making, there is no formal requirement under the NEL to undertake either in response to a rule change request. This was acknowledged by Energy Consumers Australia.

Ultimately, the Commission has in this instance opted against detailed market modelling of five minute settlement. This is primarily because such modelling is unlikely to provide useful information. This view is based on conversations throughout the project with consultants that offer market modelling services, and the Commission's experience with market modelling from a large number of other rules changes and reviews.

Modelling wholesale market outcomes involves many assumptions.⁸⁵ Commercial strategies are particularly difficult to model as they are largely opaque to those outside of the individual businesses. When the change being modelled is minor relative to the complexity of the system – for example, the retirement of a generator – historical observations can be a reasonable approximation of future behaviour. However, as the scale of the change increases, historical observations become less reliable and more assumptions must be made. This is the fundamental challenge that would be faced when modelling five minute settlement.

Existing models rely on historical bidding data to construct typical bid curves, or provide the modelled generators with several bid options. Historical bidding data would not represent how generators would behave under five minute settlement, so some other methodology would be required. As bidding behaviour is an input to market modelling, it would be an inappropriate way to assess potential five minute settlement bidding behaviour, as has been suggested.

Multiple consultants indicated to the Commission that there would also be computational constraints in modelling five minute settlement, even once bidding assumptions had been decided. This would have limited the modelling horizon to one year, or less. Separate consultants for the AEC and Origin Energy also acknowledged that it would be difficult to achieve a meaningful result from market modelling.⁸⁶

The Commission's view is that given the limitations in both the input assumptions and modelling horizon, market modelling would not provide useful information on five minute settlement. The assumptions, methodology and results would inevitably be disputed by those on either side of the debate, meaning that stakeholders would be no closer to agreeing on the merits, or otherwise, of the rule change. Limited, short term modelling would also risk providing misleading estimates of the magnitude of any enduring dynamic benefits from five minute settlement.

On this basis, the Commission considers that there is no value in undertaking the type of market modelling or formal CBA suggested. The Commission also notes that to the

⁸⁵ For example, physical characteristics, commercial strategies (including bidding), demand, fuel costs, capital costs, and government policies.

⁸⁶ Directions paper submissions: Russ Skelton & Associates, report for the AEC, 25 May 2017, pp. 5-6; Seed Advisory, report for Origin Energy, p. 19.

extent industry participants believed such modelling was appropriate, there was opportunity for them to undertake their own CBA and market modelling, however they have chosen not to do so.

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

4.1.1 Consultation paper and directions paper submissions

A key concern of some stakeholders was 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. These stakeholders were of the view that the availability of hedging contracts would be reduced by moving to five minute settlement, leading to the remaining contracts costing more.⁸⁷ They considered that the biggest impact would be on 'cap' contracts, although 'swap' contracts would also be affected.⁸⁸

The explanation 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.⁸⁹

Alongside the directions paper the Commission published a consultant report by Energy Edge that estimated an annual reduction in the volume of traded cap contracts of 23 per cent, or 625 MW.⁹⁰ Stakeholders were generally of the view that the Energy Edge analysis was conservative and had underestimated the actual impact on cap

⁸⁷ Directions paper submissions: AFMA, pp. 3-6; Hydro Tasmania, pp. 1-2; Infigen, p. 3; Arrow Energy, p.10; Origin Energy, p.2; Snowy Hydro, pp. 1-2; Aurora Energy, p. 4; Major Energy Users, p. 34.

⁸⁸ 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.

⁸⁹ Directions paper submissions: Arrow Energy, p. 2; Flow Power, p. 2; Major Energy Users, p. 20; Origin Energy, p. 10.

⁹⁰ Energy Edge, *Effect of 5 Minute Settlement on the Financial Market*, March 2017.

volumes.⁹¹ 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.⁹²

A common concern was that the reduction in the liquidity of contracts would be detrimental for smaller, second tier retailers.⁹³ 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.

Some existing market 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.⁹⁴ Others, including the Clean Energy Council and Energy Consumers Australia thought that these participants would be able to adapt to the change.⁹⁵ Tesla and Wärtsilä indicated that their respective product offerings could provide an effective physical hedge for five minute cap contracts.⁹⁶ EnerNOC noted that businesses can use controllable resources behind the meter to offset the need to buy caps.⁹⁷ Mojo Power, Meridian Energy Australia and the South Australian Government also thought that behind the meter resources could be used for risk management purposes.⁹⁸

4.1.2 Draft determination submissions

Stakeholders' views appeared to be largely unchanged in submissions on the draft determination. Those opposed to five minute settlement again raised concerns in relation to the impact on contract liquidity, especially cap contract liquidity.⁹⁹ Those in support of the change continued to be of the view that participants would still be able to manage wholesale market risks under five minute settlement.¹⁰⁰

Alinta Energy indicated that it agreed with the Commission's position that there would still be incentives for creating risk management products, but that it may take several

⁹¹ Directions paper submissions: Snowy Hydro, p. 11; Origin Energy, p.2; Energy Queensland, p. 3; ERM Power, pp. 2, 11; EnergyAustralia, p. 9.

⁹² Directions paper submissions: Snowy Hydro, p. 11; Marsden Jacobs, pp. 36-37.

⁹³ 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.

⁹⁴ Directions paper submissions: AFMA, p. 4; Energy Queensland, pp. 10-11; Infigen, pp. 6-7; Origin Energy, p. 2; Snowy Hydro, p. 19.

⁹⁵ Directions paper submissions: Clean Energy Council, p. 4; Energy Consumers Australia, p. 6.

⁹⁶ Directions paper submissions: Tesla, p. 3; Wärtsilä, p. 2.

⁹⁷ EnerNOC, directions paper submission, p. 4.

⁹⁸ Directions paper submissions: Mojo Power, pp. 3-4; Meridian/Powershop, p. 2; South Australian Government, p. 1.

⁹⁹ Draft determination submissions: AEC, pp. 1-3; ERM Power, p. 3; Energy Queensland, p. 2; Hydro Tasmania, pp. 2-3; Tasmanian Government, p. 2.

¹⁰⁰ E.g. Draft determination submissions: Tesla, p. 2; PIAC, p. 1.

years for ample liquidity to exist.¹⁰¹ Origin Energy and Sumo Power also thought that the contract market would adapt and alternative products would emerge, but that it would take time for this to occur.¹⁰²

Energy Queensland thought that swap contracts would be compromised because fast start peaking generators would not be able to support a baseload plant that experiences an outage.¹⁰³ AFMA noted that the draft determination had not addressed its concerns in relation to swaps and futures.¹⁰⁴

Those who commented on the alternative risk management options identified by the Commission mostly had a negative view. In a report for the AEC, Seed Advisory concluded that only aero derivatives units are capable of providing replacement capacity within three years.¹⁰⁵ Aurora Energy thought that the alternatives suggested were speculative and untested.¹⁰⁶ Arrow Energy also submitted that the new technologies have not been thoroughly tested, proven or regulated in Australia.¹⁰⁷ Similarly, ERM Power thought that the Commission was being "very optimistic", while ENGIE described the Commission's decision as "a gamble that a new solution will emerge" and "a risky leap of faith".¹⁰⁸ CSR commented that battery storage is still in the early stages of large scale implementation.¹⁰⁹ Origin Energy said that the potential contribution of battery storage to cap contract is unproven.¹¹⁰ Major Energy Users considered that the Commission had overestimated the ability of new technologies by not "assessing in detail whether engineering can deliver the change".¹¹¹

Stakeholders also made a number of specific comments on the Commission's qualitative analysis which are addressed below.

101 Alinta Energy, draft determination submission, p. 5.

102 Draft determination submissions: Origin Energy, p. 5; Sumo Power, p. 1.

103 Energy Queensland, draft determination submission, p. 2.

104 AFMA, draft determination submission, p. 2.

105 Seed Advisory, *Five Minute Settlement: Threshold Conditions*, report for the AEC, 1 September 2017, p. 24.

106 Aurora Energy, draft determination submission, p. 3.

107 Arrow Energy, draft determination submission, p. 3.

108 Draft determination submissions: ERM Power, p. 4; ENGIE, p. 1

109 CSR, draft determination submission, p. 2.

110 Origin Energy, draft determination submission, p. 1.

111 Major Energy Users, draft determination submission, p. 4.

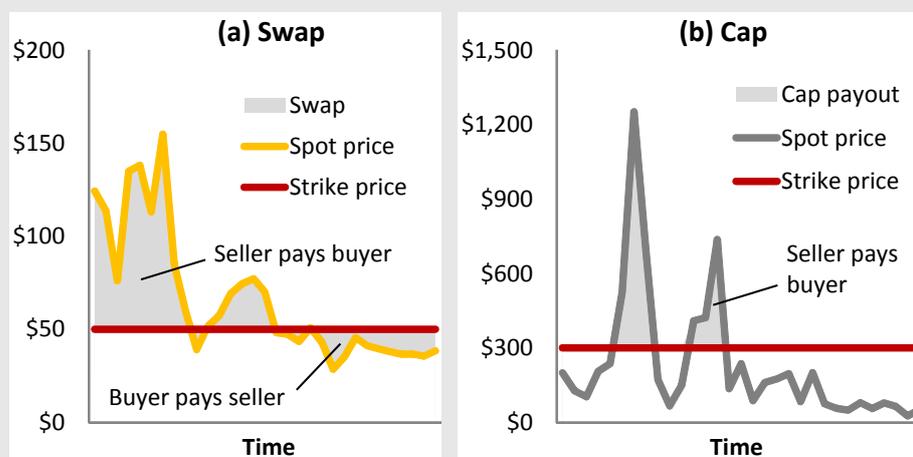
Box 4.1 Swap and cap contracts explained

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 Figure 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 strategy¹¹² 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.¹¹³

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

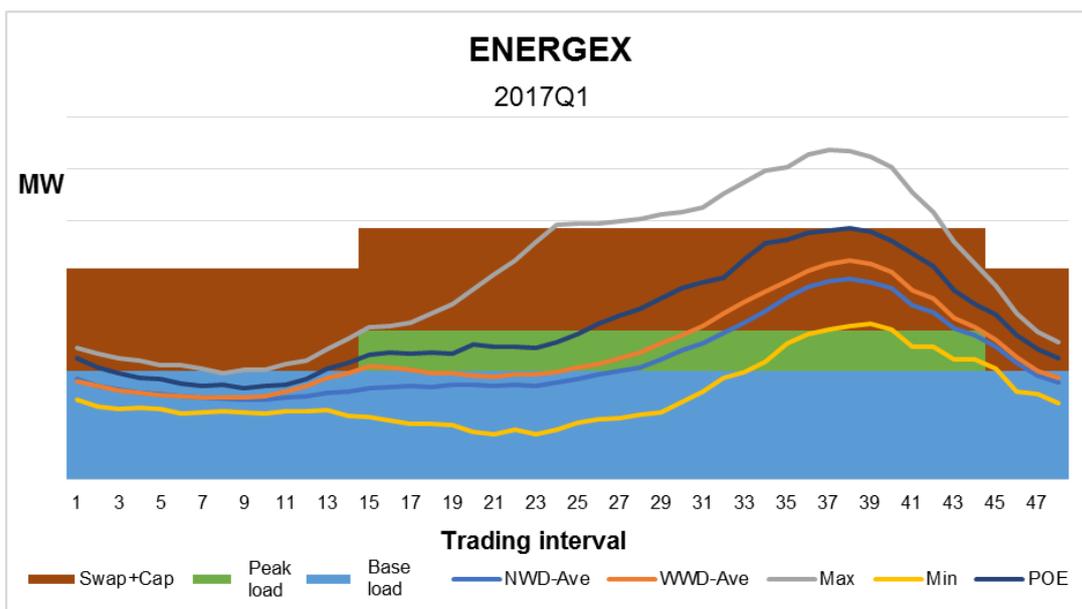
¹¹² Energy Edge, *Ibid*, p. 10.

¹¹³ 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.¹¹⁴ 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 Australian Stock Exchange (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. South Australia was not chosen for this hypothetical example as the low volume of trading on the ASX, especially for cap contracts, means that the published prices are often not based on actual trades.

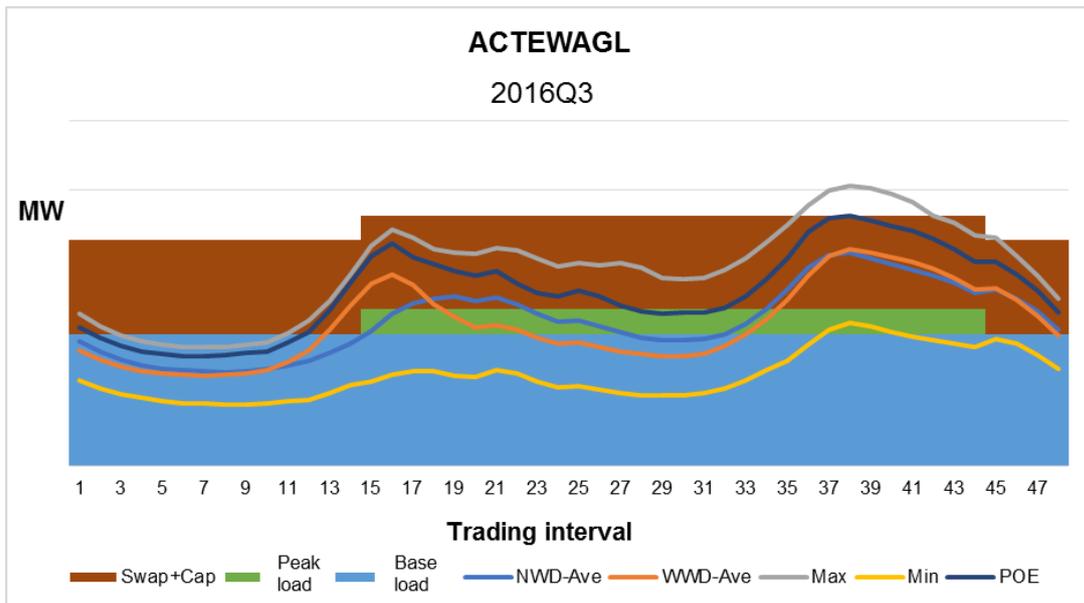
Figure 4.2 SEQ NSLP hypothetical hedging strategy for 1st quarter 2017



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.

¹¹⁴ 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.¹¹⁵ 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.¹¹⁶

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

¹¹⁵ 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.

¹¹⁶ 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.¹¹⁷ 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.¹¹⁸

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 instead of the 46 per cent difference in the equivalent period originally calculated by Energy Edge, the difference in the intrinsic value of caps was only 10 per cent for South Australia. Therefore, the intrinsic value of five minute caps in South Australia for the period of January 2015 to March 2017 was 10 per cent, not 56 per cent, as suggested by the AEC.¹¹⁹

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.

¹¹⁷ Energy Edge, *ibid*, pp. 40-42; Russ Skelton & Associates, p. 23.

¹¹⁸ 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.

¹¹⁹ AEC, draft determination submission, p. 1.

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
2017Q2	\$0.00	\$0.05
2017Q3	\$0.00	\$0.00
AVERAGE	\$0.04	\$0.96

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 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.

The Commission considers that these results presented in Table 4.1 are a worst case scenario representing the upper bound of the potential impact on average portfolio prices. Under five minute settlement, cap sellers would be incentivised to keep five minute prices below \$300. The Commission expects that with five minute settlement, rather than 30 minute settlement, behavioural change by cap sellers will result in five minute prices being 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 was reproduced in the draft determination and is also reproduced in the final determination 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.

These two methodologies are discussed below, followed by a response to analysis prepared by Seed Advisory, in a report for the AEC. Seed Advisory estimated a 1,600 MW reduction in traded cap contracts and 2,900 MW of generation capacity withdrawals.

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 also shows 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.¹²⁰ It found that 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. These include consistency with other analysis done¹²¹ and 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.¹²²

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%

¹²⁰ AEMC, *Non-scheduled generation and load in central dispatch*, draft determination, 20 June 2017, Appendix D.

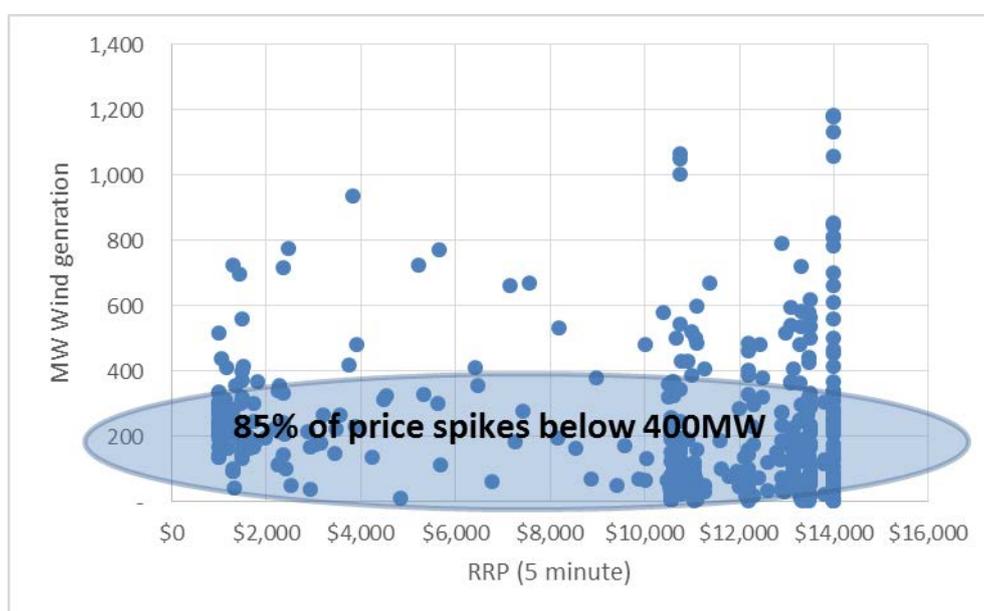
¹²¹ Energy Edge and Russ Skelton & Associates (March 2017) reports.

¹²² 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.

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.

In the case of South Australia, these simple demand-based metrics appear to be a less effective prediction tool for high price events. This 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 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.¹²³

Figure 4.6 South Australia wind generation versus five minute prices



In submissions on the draft determination, the AEC, Origin Energy and Snowy Hydro expressed a view that higher volumes of wind and solar generation result in more unexpected price spikes. This is not necessarily true, as wind energy forecasts may be used in conjunction with other metrics to predict high price events in South Australia. Figure 4.6 indicates a positive correlation between low wind output and high price events. Further, statistics on the accuracy of AEMO's Australian Wind Farm energy Forecasting System show that for 2016/17, the normalised mean absolute error for the South Australian forecast was around 6-7 per cent 24 hours ahead, falling to 3-4 per cent one hour from dispatch.

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

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

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.

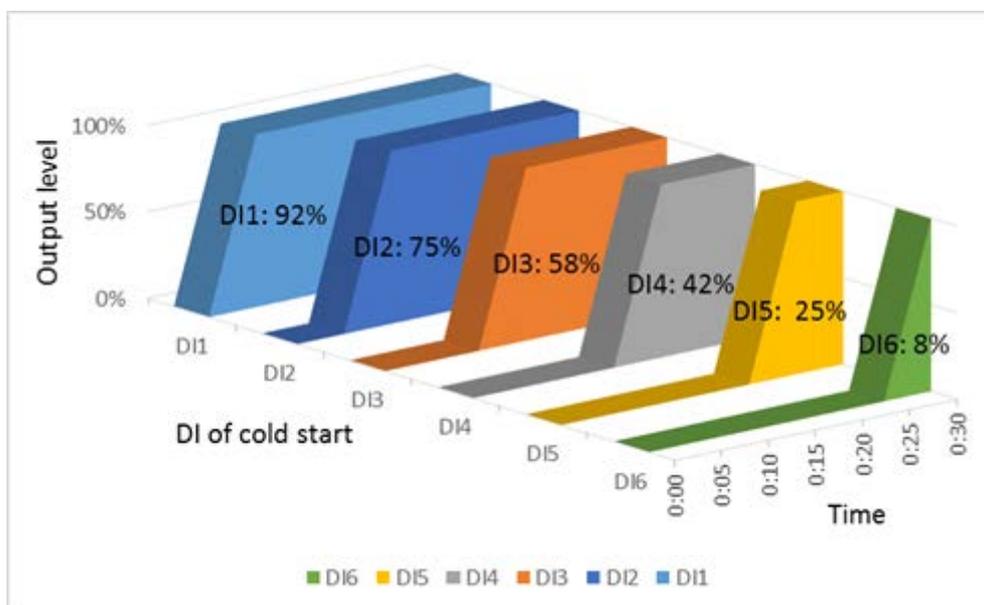
The 'cold start' strategy under 30 minute settlement

One of the factors influencing a generator's willingness to sell contracts (including caps), is the physical ramp rate a unit can achieve.¹²⁴ 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.

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



¹²⁴ 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.

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.¹²⁵

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
- 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.¹²⁶

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.¹²⁷ It also shows the percentage of these \$1,000/MWh intervals when the generator was not at zero output at the start of the

¹²⁵ Average amount of energy that could be delivered within a half hour = $(92\% + 75\% + 58\% + 42\% + 25\% + 8\%) / 6 = 50\%$.

¹²⁶ 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.

¹²⁷ Victoria was excluded as there were only four dispatch intervals in 2016/17 where the prices were above \$1,000/MWh.

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.

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 on the directions paper, Snowy Hydro indicated that a defensible 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.

Snowy Hydro subsequently claimed that the statement that generators are already running at the start of high price intervals is "clearly false" because its generators have low capacity factors, ranging from 0.2 to 19 per cent.¹²⁸ Capacity factor, as Snowy Hydro acknowledges, represents the amount of time in a year that a unit is online. However, it does not provide any information on, a) *when* the unit was online, or b) what the loading level of the unit was when it was online.

For example, Snowy Hydro's Tumut 3 power station had a 2.9 per cent capacity factor for 2017, yet was, on average, generating at 114 per cent of its registered capacity at the *start* of intervals in 2016/17 when prices were above \$1,000/MWh. This shows that capacity factor is not a useful indicator of whether a unit is generating in anticipation of price spikes.

The results in Figure 4.8 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 generally lower average loading levels for South Australian generators may reflect factors aside from start-up and ramp rates. For example, a peaking generator may be at zero output during a price spike due to planned or unplanned maintenance, fuel availability issues, because they are long on generation (i.e. hedge contracts < rated capacity), or because they have anticipated the likelihood of a price spike to be very low. The 54-63 per cent loading levels for Torrens Island likely reflects:

- the size of the power station relative to regional demand, and
- that there are eight individual units, some of which are likely to be off for maintenance (even if there are price spikes) owing to the age of the plant.

ERM Power suggested that the Commission consider what the price was in the prior dispatch interval or intervals to see if it was already clear that the half hour would settle over \$300/MWh.¹²⁹ To investigate this, the Commission looked at the average loading levels at the beginning of price spikes occurring in the first dispatch interval of a half hour.

¹²⁸ Snowy Hydro, draft determination submission, p. 6.

¹²⁹ ERM Power, draft determination submissions, p. 3.

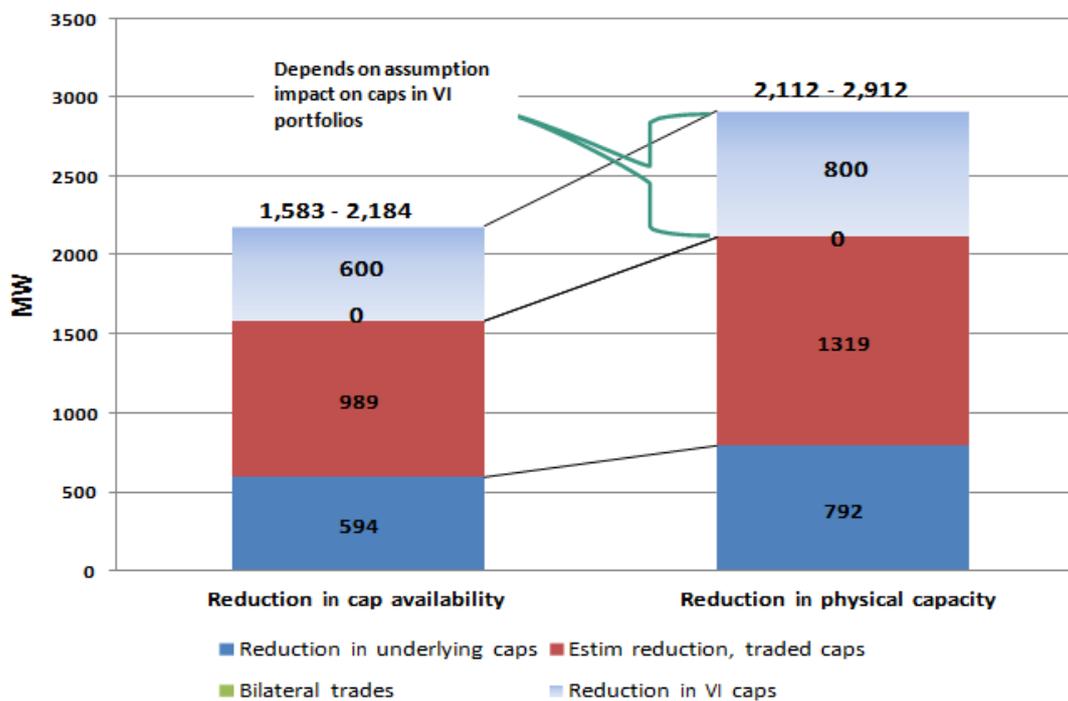
The analysis showed that the dispatch interval of the spike did not make a material difference in average loading level. Across all the power stations in Figure 4.8, the average loading for the first dispatch interval was 56 per cent, compared to the average for every price spike (all dispatch intervals) of 61 per cent. The Commission therefore considers that the results in Figure 4.8 are also representative of the average loading level at the start of dispatch intervals when it was not clear that the half hour would settle above \$300/MWh.

Seed Advisory analysis

In a report for the AEC, Seed Advisory (Seed) estimated the reduction in cap contract availability and corresponding impact on physical generation capacity from five minute settlement by taking the Energy Edge analysis and making a series of additions and adjustments. The result was a finding that there would be a 1,600 MW reduction in traded caps and 2,100-2,900 MW of generation capacity withdrawals.

The results of the Seed analysis are summarised in Figure 4.9, taken from the Seed report.¹³⁰

Figure 4.9 Seed Advisory cap contract and physical capacity estimates



The Commission's response to this analysis is as follows:

- Reduction in underlying caps (594 MW): This is a reduction of 34 MW, down from the 625 MW calculated by Energy Edge, on account of the liquidity ratio

¹³⁰ Seed Advisory, *op. cit.*, p. 9.

(traded caps/physical demand) in South Australia being less than one.¹³¹ This appears to be a rational adjustment, but is small in magnitude.

- Reduction in traded caps (989 MW): Seed allege that Energy Edge understated the impact on cap market liquidity by only considering underlying caps. However, the purpose of dividing by the liquidity ratio in the Energy Edge analysis was to estimate the volume of cap contract that were held to maturity. Contracts that are not held to maturity – such as unexercised options, closed futures positions and zero netted positions in over-the-counter (OTC) markets – provide no hedging value; they are merely a reflection of market liquidity. While a higher volume of traded caps contract may reflect a greater ability to purchase caps, it is not a measure of the volume of risk management products employed by retailers and large energy users.
- Reduction in vertical integration (VI) caps (600 MW): This is an estimate of the reduced effectiveness of peaking generators operated in vertically integrated portfolios (e.g. AGL, EnergyAustralia, Origin). The 600 MW figure appears to be arbitrary and to be based on analysis that does not consider how peaking generators are operated in portfolios, nor what the impact of five minute settlement on these portfolio assets might be. Hence, it is difficult to establish the value of this number as the actual number could be higher or lower.
- Reduction in physical capacity (2,112-2,912 MW): The Seed report states that the capacity impact will be greater than the impact on caps (underlying, traded and VI) because generators are unlikely to sell 100 per cent of their capacity in caps. Seed apply what they call the "N-1 rule", whereby a peaking generator would only sell 75 per cent of its rated capacity in caps.¹³² The Commission accepts that peaking generators would sell less than 100 per cent of their capacity in caps – Energy Edge listed reasons why \$300/MWh capture would be less than 100 per cent on p. 47 of their report. Nevertheless, it is illogical to apply this adjustment to each of the components defined in the Seed analysis for the following reasons:
 - 594 MW in delivered caps: The Energy Edge methodology already accounts for the physical capture of \$300/MWh prices that peaking generators have been able to achieve: "if a generator is only able to physically capture 75 per cent of the pay-off of caps through its generation, then we have assumed that it would only sell caps covering 75 per cent of its generation

¹³¹ A liquidity ratio of less than 1 means that the total volume of ASX/OTC trades are less than physical, regional demand. This likely reflects vertical integration (VI) and some consumers being unhedged.

¹³² The 75 per cent figure comes from: 1. In explaining their methodology, Energy Edge said that, "if a generator is only able to physically capture 75% of the pay-off of caps through its generation, then we have assumed that it would only sell caps covering 75% of its generation capacity" (emphasis added). 2. ENGIE took this as a 'rule of thumb', stating in its directions paper submission that, "Energy Edge also note that a generator would normally not sell cap contracts for more than 75% of its physical capacity." 3. Seed attributes the 75 per cent to ENGIE and calls it the "N-1 rule": "ENGIE suggests a ratio of sold caps to total capacity of 0.75:1".

capacity".¹³³ Since this is already captured by the methodology, there is no need to adjust the 594 MW figure for "N-1".

- 989 MW in traded caps: The 989 MW reflects caps not traded to maturity. For this reason, no physical capacity is required to defend these caps. The correct number for the reduction in physical capacity is zero MW.
- 600 MW in VI portfolios: Given the arbitrary way in which this figure has been produced, it is unclear whether it needs to be adjusted by "N-1" to reflect physical capacity. As 600 MW was picked to be similar to Energy Edge's result, there is potentially also no need for any further adjustment because the Energy Edge methodology already accounts for the physical capture of \$300/MWh prices.

Further, the Commission considers that it is unrealistic to assume that there would be such a large reduction in physical capacity. The theoretical reduction in underlying and VI caps would presumably be spread across a large number of generators, based on their ability to capture five minute price spikes. The Commission questions, even if the cap contract sales were to be reduced by ~23 per cent (Energy Edge average), whether it would be prudent to withdraw the whole plant from the market.

Summary: ability of peaking generators to sell caps

The Commission has considered the 'cold start' strategy identified by Snowy Hydro, the Energy Edge analysis of historical generator behaviour, and the Seed Advisory adjustments to the Energy Edge analysis.

The 'cold start' strategy assumes that most of the time price spikes are unexpected, and that generators are regularly in an offline state at the start of the intervals when a price spike occurs. Both have been shown to be inaccurate assumptions.

A simple analysis of regional demand, wind generator output in South Australia, and prices above \$1,000/MWh suggests that these metrics are potential predictors of high prices. Further, the analysis of loading level of peaking generators at the start of dispatch intervals above \$1,000/MWh in 2016/17 shows that peaking generators tend to already be online and are often generating at high output levels.

The Commission is of the view that the Seed analysis of cap contract availability and impact on physical generation capacity does not provide any new information that the Commission did not already possess from the Energy Edge analysis.

The Commission considers that the Energy Edge analysis provides a more accurate account of the impact on cap contract liquidity from moving to five minute settlement. However, it potentially overestimates the impact on cap contracts. The analysis did not factor in any changes in generator behaviour, or the transition period between the final determination and commencement of five minute settlement. For these reasons, the

¹³³ Energy Edge, *Effect of 5 Minute Settlement on the Financial Market*, March 2017, p. 47.

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. They will therefore be more effective at capturing five minute price spikes than the historical analysis would suggest. The transition period ahead of five minute settlement commencing will allow for participants to prepare and adapt, which will further improve their ability to maximise profit under the new settlement arrangements.

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 (for example, 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, pumped storage hydro (PSH), 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.¹³⁴ 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.

¹³⁴ For example: AGL Energy's virtual power plant, Greensync, Reposit Power.

Most of the comments received focussed on options 3-5. As noted in section 4.1, many stakeholders had a negative view, citing the various shortcomings of energy storage (an immature technology), aero derivative turbines (a start time greater than five minutes) and PSH (a long construction time).

The Commission's view is that the stakeholders opposed to five minute settlement have been overly pessimistic in the assessment of the above options. Some of the views put forward appear to be inconsistent with the rate of technological change occurring in the energy industry. The Commission provides the following comments in relation to the technologies mentioned above:

- Utility-scale batteries. The Seed Advisory report finds that batteries are unlikely to replace cap market capacity within three years because the economic model is unfavourable.¹³⁵ However, unsubsidised large battery projects are already being announced.¹³⁶ The Commission expects that considerable industry learning will take place via the projects funded by ARENA and jurisdictional governments. Major Energy Users commented that batteries only provide an arbitrage service, so need a generator to recharge.¹³⁷ The Commission notes that a battery could be charged using wind or solar energy that could otherwise have been surplus to the system requirement. Further, evidence suggests that large batteries will, at least initially, be collocated with other generation assets to take advantage of existing infrastructure, and be operated in portfolios with other technologies. ARENA noted that a relatively small battery would be required to cover the ramp up period for an older gas generator.¹³⁸ This would overcome the perceived drawbacks of operating a gas peaking generator under five minute settlement.
- Pumped storage hydro. Seed conclude that PSH could be a strong candidate for replacing the capacity and energy supplied by OCGT generation, but consider it unlikely that a project could be constructed within a three years transition period.¹³⁹ The Commission considers this to be an accurate assessment. Two prospective PSH projects are EnergyAustralia's Cultana, and Genex Power's Kidston project. The former has a suggested lead time of 4-5 years, while for the latter a construction time of 2.5 years is anticipated.¹⁴⁰
- Gas (aero derivative turbines or internal combustion engines). Major Energy Users, ERM Power and Origin Energy questioned the suitability of aero

135 Seed Advisory, *op. cit.*, p. 21.

136 CEFC, *CEFC finances new milestone in energy storage in a South Australia energy project*, 13 November 2017.

137 Major Energy Users, draft determination submission, p. 22.

138 ARENA, draft determination submission, p. 4.

139 Seed Advisory, *op. cit.*, p. 24.

140 Cultana: EnergyAustralia, *Cultana Pumped Hydro Project: Knowledge Sharing Report*, September 2017. The report indicated that the project could be in service by 2023. EnergyAustralia expects a final investment decision to occur towards the end of 2018. Kidston: smh, *Queensland's Snowy 2.0 pumped hydro expands*, 22 October 2017.

derivative turbines for operating under five minute settlement.¹⁴¹ They observed that this technology is limited in the energy that can be provided within five minutes. The Commission is of the view that these generators would still be effective under five minute settlement as they can ramp up in anticipation of price spikes, in the same way that generators do now (as observed in section 4.2.3). Aero derivatives and internal combustion engines do not have start penalties, so are more economical for using in this way than most existing OCGT units. As noted above, batteries could be used in a portfolio with existing or new peaking generators to cover a contract position while a gas generator ramps up.

- Demand response to reduce cap requirement. ERM Power, Seed Advisory and Major Energy Users commented on the practicalities of procuring demand response. ERM Power indicated that it is difficult to secure firm volumes and timing, while Major Energy Users was concerned that more demand response corresponds with more curtailment and lower productivity for end users. While the Commission acknowledges that these challenges are real, it considers that these are existing challenges that industry participants are dealing with already. As noted by ARENA, aggregated portfolios are one way of increasing the firmness of the response.¹⁴² Improvements and cost reductions in technology, also identified by ARENA, are expected to facilitate more demand response activity. The Commission observes increasing volumes of demand response. For example:
 - the ARENA-AEMO demand response round including 160 MW of response within 10 minutes (some of which will be able to respond faster if required)
 - AGL's Liddell replacement proposal including up to 100 MW of demand response,¹⁴³ and
 - Origin Energy's demand response trial with large customers, that "combines smart software that predicts market prices with a clever business model that allows flexible customers to be rewarded"¹⁴⁴.

There are also both local and international business models that involve demand response from residential consumers.¹⁴⁵

- Aggregation of distributed storage. The Seed report states that "there are no aggregated behind the meter resources bid into the NEM currently".¹⁴⁶ While it is correct that behind the meter resources, by definition, are not bid into the

141 Draft determination submissions: Major Energy Users; p. 21; ERM Power; pp. 5-6; Origin Energy, p. 1.

142 ARENA, draft determination submission, p. 5.

143 AGL Energy, *2017 AGM Presentations*, p. 21.

144 Origin Energy, *Origin to trial demand management with large customers*, 11 October 2017.

145 For example, Zen Ecosystems (Aus/US), Nest (US), OVOEnergy/VCharge (UK).

146 Seed Advisory, *op. cit.*, p. 22.

energy market (although they could potentially be offered into the FCAS markets), there already exist a number of providers of software to optimise distributed resources.¹⁴⁷ ARENA is funding projects involving the aggregation of distributed energy resources (i.e. AGL's VPP, Reposit Power GridCredits trial and Greensync's deX platform).¹⁴⁸ The Seed report also states that a battery system would need to be "export capable" to replace a peaking generator. However, this ignores the value that could be created by using a battery to reduce the energy that a customer is drawing from the grid. There is a reasonable prospect that there will be a material volume of distributed energy storage within the next few years. Bloomberg New Energy Finance forecasts 2 GWh of energy storage capacity by 2021, of which 74 per cent is behind the meter, while Morgan Stanley analysis suggests a cumulative installation of 6 GWh of behind the meter energy storage by 2021.¹⁴⁹ Reposit Power submitted that the size of the NEM energy storage market could be 3.5 GW by 2021.¹⁵⁰

The Commission observes that businesses are already working to understand how they will use new technologies. There is a reasonable prospect that the sorts of trials and projects referenced above will continue and existing uncertainty around using new technologies for risk management will have been addressed by the time five minute settlement commences in 2021.

The Commission considers that, collectively, the alternative risk management options will mitigate any reduction that could occur in cap volumes from existing peaking generators. For this reason, the Commission does not expect that there will be a material adverse impact for swap contracts as the role currently played by peaking generators will be filled by existing and, potentially, new hedge product and technology offerings under five minute settlement. 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.¹⁵¹ 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."

¹⁴⁷ Reposit, Greensync, Sunverge, Evergen, Redback, Sonnen and Gelli.

¹⁴⁸ ARENA, draft determination submission, p. 5.

¹⁴⁹ Bloomberg New Energy Finance, 2017 Global Energy Storage Forecast, 15 November 2017; Morgan Stanley Research, Renewables & Batteries, 6 June 2017.

¹⁵⁰ Reposit Power, draft determination submission, p. 1.

¹⁵¹ Directions paper submissions: Energy Queensland, p. 4; Hydro Tasmania, pp. 1-2; Snowy Hydro, p. 10; Stanwell, p. 24.

For this reason, it was suggested that alignment at 15 minutes could be preferable to five minute settlement.¹⁵² 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 inefficiently 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 threshold.¹⁵³ 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 forecast 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.¹⁵⁴ 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. For this reason, the Commission does not expect that there will be a material, adverse impact for swap contracts.

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

¹⁵² Directions paper submissions: Arrow Energy, p. 8; Major Energy Users, p. 3; Snowy Hydro, p. 3.

¹⁵³ 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.

¹⁵⁴ AEMC, *Reliability Frameworks Review*, issues paper, 22 August 2017, pp. 66-67.

outcomes. Other potential sellers of cap contracts include baseload generators and financial intermediaries.

5 System security and reliability

5.1 Stakeholder views

Submissions to the draft determination reiterated many of the points raised in submissions to the directions paper with respect to the potential impact of moving to five-minute settlement on NEM reliability and security. Broadly, the concerns were in two parts, namely that the rule, if made, would:

- encourage greater volumes of fast ramping capability (for example, 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. It is split between a brief summary of key issues raised on system security and reliability in submissions to the directions paper and those issues raised in submissions to the draft determination.

5.1.1 Effect of batteries on system security

Submissions to directions paper

Submissions to the directions paper had a number of consistent themes with respect to the effect of batteries on system security. Namely:

- Five minute settlement may lead to an accelerated uptake of fast response batteries and demand side response that could be invisible to AEMO as the market operator. This may destabilise the secure operation of the market through sudden changes to frequency and voltage.¹⁵⁵
- A number of stakeholders considered that the rapid introduction of batteries would be likely to lead to over-frequency and under-frequency events. This would require increased enablement of FCAS services, and the potential shedding of load or generation to maintain system security.¹⁵⁶
- AEMO acknowledged the potential operational implications of new, responsive technologies, such as a large coordinated response by batteries to price spikes

¹⁵⁵ Directions paper submissions: Stanwell, p. 5; AEC, p. 2, and supplementary consultant report by Russ Skelton & Associates, 25 May 2017, p. 3; ERM Power, pp. 3; 5-6.

¹⁵⁶ Directions paper submissions: ERM Power, pp. 3; 5-6. AEC, p. 3; Origin Energy, p. 11; ENGIE, pp. 4-6; Snowy Hydro, pp. 2, 16-17. See also Snowy Hydro, report by Marsden Jacobs, p. 1.

impacting on frequency and local voltages. However, it considered that this issue is not directly related to the rule change proposal.¹⁵⁷

Submissions to draft determination

Snowy Hydro submitted that there has been an absence of a considered analysis to understand the material impact of batteries and the need for complementary reforms that would support market efficiency, such as changes to scheduling of generation which would effectively integrate fast response energy storage into the NEM. They argued that such changes need to be in place before implementing the rule change. They submitted that larger or aggregated battery storage providers will continue to operate in an unscheduled manner that will create increased costs, volatility and risks for all market participants and consumers. It will have adverse impacts on frequency control ancillary service costs and system security and reliability.¹⁵⁸

Origin Energy considered that the impact of mass deployment of battery storage on NEM system security is unknown. This could give rise to additional costs. Further, many of the system security work streams are yet to be fully progressed with any associated reforms only likely to be in place for a limited time prior to the proposed implementation date for any rule change. They also submitted that the proliferation of batteries and battery facilities below the 5 MW scheduling limit could still give rise to issues identified by AEMO.¹⁵⁹

Energy Queensland submitted that the proposed rule change may lead to more dynamic demand response, which will have an indirect adverse impact on network management. As the majority of devices likely to be able to manage demand response will be largely electronic and will affect power quality, the proposed rule will lead to a requirement for greater investment in smarter network technology.¹⁶⁰

The Australian Energy Storage Alliance submitted that batteries can, and do, provide effective grid-scale variability management and that the proposed rule change will be helpful in supporting the development of new markets and tools that support a more stable and seamless grid.¹⁶¹

ARENA noted that large scale battery storage projects can be constructed in a short time period (less than six months) once contracts are in place and that batteries can alter output extremely quickly. This makes them valuable in providing system security services and very suitable for operating in a five minute settlement regime.¹⁶² ARENA noted there are projections for strong consumer-led growth in small scale distributed battery storage installations. Such installations are suited to participating in delivering

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

158 Snowy Hydro, draft determination submission, p. 8.

159 Origin Energy draft determination submission, p. 5.

160 Energy Queensland draft determination submission, p. 3.

161 AESA, draft determination submission, p. 3.

162 ARENA draft determination submission, p. 2.

system services via an aggregation model. They consider that five minute settlement would increase the incentive for such schemes, which has the potential to positively contribute to reliability and security.¹⁶³

Tesla submitted that battery energy storage was ready and able to be deployed at scale with a short lead time, thereby assisting in ensuring no disruption to security and reliability in the NEM with the introduction of five minute settlement. Tesla noted potential negative impacts of batteries on system security are already being addressed through work on connection requirements and with enhanced visibility of batteries through the national battery storage register. Further, when aggregated, these distributed assets can provide frequency support.¹⁶⁴

5.1.2 Exit of gas-fired generators

Submissions to directions paper

Submissions to the directions paper had a number of consistent themes with respect to the potential impact of five minute settlement on gas-fired generation. Namely:

- A move to five-minute settlement would reduce returns to gas-fired peaking plant and lead to a withdrawal of supply as such plant is unable to operate effectively within a five minute window.¹⁶⁵
- The reduction in availability of gas-peaking capacity would undermine system security and reliability at least until alternatives to existing peaking generators become available. Further, the firmness of storage capacity is not guaranteed due to the energy constraints of batteries.¹⁶⁶
- A move away from gas-fired synchronous generation also has the potential to negatively affect the availability of system inertia and system strength.¹⁶⁷
- A move to five minute settlement would require reconsideration of the level of the market reliability settings.¹⁶⁸

Submissions to draft determination

Arrow Energy submitted that five minute settlement would increase the risk for gas-fired generators. This could lead to the untimely withdrawal of capacity, potentially at a rate faster than new technologies are adopted, thereby increasing

¹⁶³ ARENA draft determination submission, p. 5.

¹⁶⁴ Tesla, draft determination submission, p. 1.

¹⁶⁵ Directions paper submissions: Hydro Tasmania, p. 1; Major Energy Users, p. 20; Snowy Hydro, pp. 3, 8; AEC, p. 2; Arrow Energy, p. 4.

¹⁶⁶ Directions paper submissions: EnergyAustralia, p. 5; Stanwell, p. 10.

¹⁶⁷ Directions paper submissions: EnergyAustralia, p. 5; Origin Energy, p. 12.

¹⁶⁸ Directions paper submissions: SACOSS, p. 19; ENGIE, p. 3; Infigen, p. 4.

energy prices and threatening reliability of supply.¹⁶⁹ This argument was also supported by Snowy Hydro and the Tasmanian Government.¹⁷⁰

Hydro Tasmania submitted that five minute settlement will reduce the supply of cap contacts and considered that there is insufficient evidence that potential new revenue streams such as system support payments will be able to ensure the viability of existing generators thereby leading to early retirement of existing plant. Hydro Tasmania suggests that a more preferable approach would be to establish a mandatory regime to assess the future suitability of conditions for five minute settlement.¹⁷¹

5.2 Commission's 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 consumers¹⁷²
- reliable transmission and distribution networks
- a secure system.

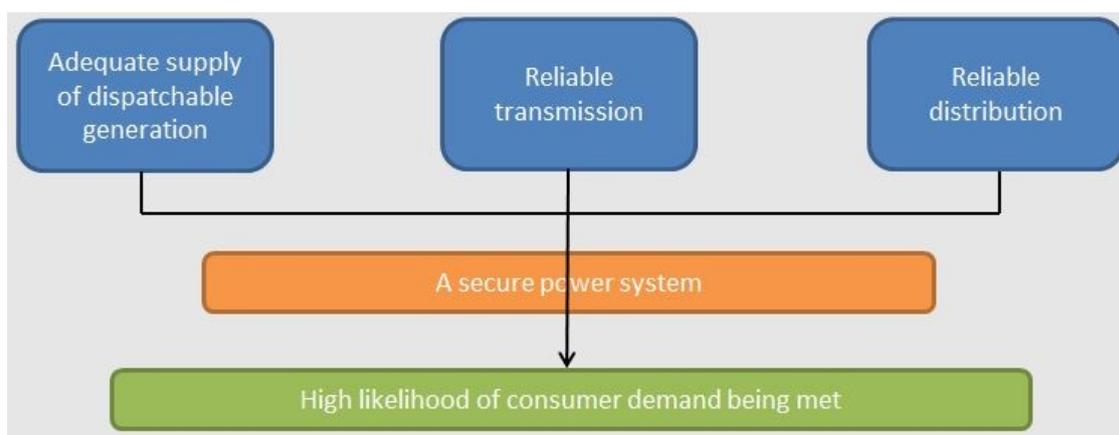
¹⁶⁹ Arrow Energy, draft determination submission, p. 2.

¹⁷⁰ Draft determination submissions: Snowy Hydro, p. 7; Tasmanian Government, p. 1.

¹⁷¹ Hydro Tasmania, draft determination submission, pp. 2-3.

¹⁷² To deliver a reliable supply to consumers it is necessary to have the level of supply 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 AEMO 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 consumers 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 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.

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.

One 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 DER that is not visible and predictable will progressively decrease AEMO's ability to achieve the required reliability outcomes.¹⁷³ The report

¹⁷³ AEMO, *Visibility of Distributed Energy Resources*, January 2017, p. 1.

identified a range of information gaps that exist that need to be addressed, which were summarised as:¹⁷⁴

- 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.¹⁷⁵ 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.¹⁷⁶ It highlighted that there is a need to improve how distributed energy

¹⁷⁴ *Ibid*, p. 3.

¹⁷⁵ AEMO, *Guide to Generator Exemptions & Classification of Generation Units*, 7 July 2017.

¹⁷⁶ 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 increased uptake of distributed energy resources such as rooftop solar systems, battery storage and electric vehicles.

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.¹⁷⁷

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.¹⁷⁸ 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
- placing an obligation on Transmission Network Service Providers (TNSPs) to procure minimum required levels of inertia or alternative frequency control services to meet these minimum levels
- placing an obligation on Transmission Network Service Providers (TNSPs) to maintain minimum levels of system strength.

¹⁷⁷ AEMC, *Distribution Market Model*, final report, 22 August 2017, pp. 47-48.

¹⁷⁸ 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.¹⁷⁹ The pilot will be trialled in Victoria, South Australia and NSW, with demand response capacity expected to be made available from December 2017.¹⁸⁰

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

¹⁷⁹ See <https://arena.gov.au/funding/programs/advancing-renewables-program/demandresponse/>

¹⁸⁰ 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 should minimise the amount, and impact, of unscheduled battery operation as suggested by Snowy Hydro.¹⁸¹ Similarly, battery projects such as the South Australian Government-Tesla project promise to reduce issues related to system security.¹⁸² 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.¹⁸³

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.

The Commission also recognises that Network Service Providers (NSPs) face new challenges with network management given increasing penetration of distributed energy resources and power electronic connected devices and that managing these challenges may have cost implications as claimed by Energy Queensland.¹⁸⁴

However, the Commission notes that the existing network regulation framework provides for cost pass-through for major unexpected efficient costs incurred during the regulatory period minimising the potential financial impact on NSPs. Further, the introduction of such devices is not dependent on the presence of five minute settlement but rather relates to the transformation of the NEM that is already occurring and will continue irrespective of whether five minute settlement is implemented.

The Commission also notes the findings of the joint Energy Networks Australia and CSIRO report into the electricity network of the future which noted the need for NSPs to be responsive to changing demand for traditional services with the potential for lower investment in traditional poles and wires assets leading to a reduction in cumulative total expenditure of over \$100 billion by 2050.¹⁸⁵

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

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

182 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>.

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

184 Energy Queensland, draft determination submission, p. 3.

185 CSIRO and Energy Networks Australia 2017, Electricity Network Transformation Roadmap: Final Report. pp. i-iv.

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.¹⁸⁶ 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 implemented in the face of emerging supply shortfalls, as also noted by ARENA.¹⁸⁷

The Commission acknowledges Arrow Energy's concern that some recent projects have been expedited through government involvement and may not reflect normally achievable development time frames, but considers that intrinsically, projects such as battery storage and small scale gas turbine or reciprocating engine generators can be developed very rapidly and are easily scalable.¹⁸⁸

Chapter 4 in part explores the effect of five minute settlement on existing peaking generation and concludes that efficiently operated peaking generators are likely to remain financially viable under five minute settlement, and will have strong incentives to continue to supply cap contracts rather than materially reducing the supply as suggested by Hydro Tasmania.¹⁸⁹

Further, with respect to the viability of existing gas peaking plant, the Commission notes that if new services are developed in the NEM over time, these may offer additional revenue streams to support existing synchronous generation. The Commission notes that any additional revenue streams will be associated with the provision of services of value to managing the system and it is not clear what, if any, services will be developed at this time. For the foreseeable future, it is expected that the

¹⁸⁶ 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.

¹⁸⁷ ARENA, draft decision submission, p. 2. 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.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>.

¹⁸⁸ Arrow Energy, draft determination submission, p. 3.

¹⁸⁹ Hydro Tasmania, draft determination submission, p. 2.

primary revenue stream for peaking generators will continue to be via the wholesale energy market (and associated energy contract market) which will reflect any scarcity value associated with the dynamic matching of supply and demand and that delaying the introduction of five minute settlement until after the development of secondary revenue streams as suggested by Hydro Tasmania is not required nor is it desirable.¹⁹⁰ As discussed in section 6.7, the Commission has determined that it is appropriate to make the five minute settlement rule at this time, noting also that the Commission cannot make a conditional rule.

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 settings 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.¹⁹¹

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 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 remain financially viable and still have strong incentives under five minute settlement to offer capped contracts (Chapter 4)

¹⁹⁰ Hydro Tasmania, draft determination submission, p. 3.

¹⁹¹ Reliability Panel, *Reliability Standards and Setting Review 2018*, issues paper, 6 June 2017.

- recent gas generation and storage commitments and investment decisions highlight the short timeframe within which new technologies can be implemented in the face of emerging supply shortfalls.

Additionally, 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 for the implementation of five minute settlement. These policy settings relate to demand side optionality, supervisory control and data acquisition (SCADA) systems, metering, bidding resolution, pre-dispatch and the option of a conditional rule change. A full description of the policy settings as reflected in the rule is available in Chapter 2.

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, MDPs, generators and retailers.

6.2 Demand side optionality

6.2.1 Stakeholder views: Directions paper

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) and AusNet Services suggested that there could be some benefits and avoided costs by allowing demand side optionality.¹⁹²

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

- a reduction in efficiency from having both the demand and supply side exposed to settlement, which could improve the price signal and remove distortions from the market¹⁹³
- increased complexity leading to higher costs and administrative burden by doubling the reporting requirements¹⁹⁴
- impact on the contract market by creating two distinct contract markets for five and thirty minute customers.¹⁹⁵

ECA, Energy Queensland, and Infigen all considered demand side optionality as undesirable when considered as an interim measure.¹⁹⁶ 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.¹⁹⁷

6.2.2 Stakeholder views: Draft determination

Submissions on demand side optionality were limited in the draft determination, with those that submitted on the issue supporting the position that there should be no demand side optionality. AEMO, Stanwell and Origin Energy all noted that five minute settlement should be symmetrical and apply to both the demand and supply side to assist in the benefits of the rule change being realised.¹⁹⁸

¹⁹² Directions paper submissions: AusNet Services, p. 6; Energy Consumers Australia, p. 7.

¹⁹³ Directions paper submissions: AEMO, p. 2; ERM Power, p. 9; Ipen Pty LTD, pp. 1-2; Major Energy Users, p. 32

¹⁹⁴ Directions paper submissions: Arrow Energy, p. 8; Energy Queensland, p. 6; Mojo Power, p. 2; Tesla, p. 1.

¹⁹⁵ Directions paper submissions: Arrow Energy, p. 9; Aurora energy, p. 3; Energy Queensland, p. 7.

¹⁹⁶ Directions paper submissions: Energy Consumers Australia, p. 7; Infigen, p. 5.

¹⁹⁷ Energy Networks Australia, directions paper submission, p. 6.

¹⁹⁸ Draft determination submissions: AEMO, p. 4; Origin Energy, p. 2; Stanwell, p. 2.

6.2.3 Analysis

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 draft determination and 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
- increased administrative burden and complexity.¹⁹⁹

In light of these issues, the Commission set out a position that five minute settlement should apply to both supply side and demand side of the market. No additional information was provided in submissions to the draft determination that suggested this position should change.

6.3 SCADA systems

6.3.1 Stakeholder views: Directions paper

The use of 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 submissions to the directions paper.

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.²⁰⁰ EDMI added that SCADA systems were not subject to the same levels of metrological standards as revenue meters.²⁰¹ 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.²⁰² Several other stakeholders stated their support for the use of revenue

¹⁹⁹ AEMC, *Five Minute Settlement*, directions paper, 11 April 2017, Sydney, pp. 77-82; AEMC, *Five Minute Settlement*, draft rule determination, 5 September 2017, Sydney, pp. 88-89.

²⁰⁰ Arrow Energy, directions paper submission, p. 8.

²⁰¹ EDMI, directions paper submission, pp. 3-4.

²⁰² AusNet Services, directions paper submission, p. 4.

metering over SCADA systems for five minute settlement,²⁰³ and Energy Consumers Australia maintained a move to five minute resolution metering would have benefits irrespective of changes to the settlement period.²⁰⁴ 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.²⁰⁵

6.3.2 Stakeholder views: Draft Determination

There was limited commentary from submissions about the use of SCADA systems in the draft determination. Satec Australia suggested it was possible for SCADA to communicate interval data logs for revenue purposes, however noted that the techniques required were not widely adapted.²⁰⁶ Origin Energy suggested that underlying five minute data should be derived from revenue meters rather than SCADA systems.²⁰⁷

6.3.3 Analysis

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 and draft determination,²⁰⁸ 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 a position of using metering instead of SCADA systems to collect settlement data. Whilst Satec Australia suggested SCADA systems may be able to capture data to a

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

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

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

206 Satec Australia Pty Ltd, draft determination submission, p. 1.

207 Origin Energy, draft determination submission, p. 2.

208 AEMC, *Five Minute Settlement*, directions paper, 11 April 2017, Sydney, pp. 86-89; AEMC, *Five Minute Settlement*, draft rule determination, 5 September 2017, Sydney, p. 89.

revenue quality, this does not solve the issue of the consistency of data measurement and the lack of data for demand side participants and small generators.²⁰⁹

6.4 Revenue metering for five minute settlement

The draft determination proposed the benefits of five minute settlement would be maximised by using revenue metering data rather than SCADA data. Revenue metering provides a greater level of accuracy and consistency of information that will lead to more efficient outcomes for industry and consumers.

6.4.1 Stakeholder views: Directions paper

Whilst there was strong support for revenue metering over SCADA systems, stakeholders raised concerns over how this would be implemented. Some stakeholders suggested alternate implementation designs which could minimise costs.²¹⁰ For example, AEMO recommended a staged approach that involves a mandatory implementation across all type 1-3 meters,²¹¹ optional implementation for type 4-6 meters and the development by AEMO of a five minute NSLP for each settlement region. This approach may reduce the requirement for immediate investment imposed by a meter technology rollout and the consequential changes to participants systems.²¹²

Some concerns raised by stakeholders were centred around the physical capability to collect and store five minute data. Energy Networks Australia suggested that most type 1 and 2 meters are able to record five minute data, but do not have the capacity to store the volume of data for the required length of time under the Rules.²¹³ AusNet Services and United Energy suggested that late model meters could be remotely reconfigured, but not all meters would have the memory capacity to store 35 days of two channel interval data.²¹⁴ Jemena provided more detail suggesting that single phase Advanced Metering Infrastructure (AMI) meters could be reconfigured to capture five 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.²¹⁵

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

209 Satec Australia Pty Ltd, draft determination submission, p. 1.

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

211 References to 'meter' type in this determination are references to a "metering installation" type.

212 AEMO, directions paper submission, p. 2.

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

214 Direction paper submissions: AusNet Services, p. 7; United Energy, p.2.

215 Jemena, directions paper submission, p. 2.

back end systems and processes of market participants and AEMO.²¹⁶ Similarly, Energy Networks Australia suggested that the increase in the volume of data being transmitted means more expensive data plans and data storage adequacy.²¹⁷ United Energy highlighted that a firmware change would require rigorous testing for each metering configuration, in addition to substantial application and database changes.²¹⁸ CitiPower and Powercor noted that as a meter provider, their 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.²¹⁹

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.²²⁰

Stakeholders have proposed a range of design options to minimise the metering costs associated with five minute settlement. Several stakeholders proposed excluding existing type 4 and type 5 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.²²¹

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.²²²

Both CitiPower/Powercor and Energy Networks Australia raised concern about distribution network service providers needing to record both five and 30 minute data. This 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.²²³

6.4.2 Stakeholder views: Draft determination

In submissions to the draft determination, several meter manufacturers and meter providers noted their current meters were capable of sufficiently recording five minute,

216 Jemena, directions paper submission, p. 2.

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

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

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

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

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

222 AEMO, directions paper submission, p. 3.

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

and sub-five minute data with most meters holding enough storage to exceed the storage requirements specified in the Rules.²²⁴

However, some networks have raised concerns that a potential sixfold increase in storage needed to retain five minute granularity data may exceed the storage capacity for some type 4A and 5 meters which require 200 days of storage. This is particularly an issue if there are dedicated circuits for controlled load or if other data such as average voltage needs to be stored.²²⁵ AusNet Services proposed three options to resolve this issue, namely:

- remove the requirement for 200 days of storage if the meter is read monthly or remotely read on a daily basis
- change the exemptions in clause 7.8.2(a1) in the draft rule to include type 4A and 5 meters
- allow type 4A and 5 meters to continue collecting 30 minute meter data.²²⁶

Alternatively, EDMI confirmed that all of its type 4 and 4A meters sold since 2010 are capable of being reconfigured to store 200 days of five minute data. EDMI go on to stipulate that it believes their meters would not require additional pattern testing.²²⁷

Origin Energy supported the proposition in the draft determination to grandfather existing type 4²²⁸, 4A, 5 and 6 meters that were installed prior to 1 December 2018.²²⁹ Satec Australia noted that the meter churn that would result from five minute settlement would create an opportunity to further invest innovative electrical metering technologies.²³⁰

However, Landis+Gyr suggested a variation to the grandfathering approach proposed in the draft determination. To remove the risk of stranded assets and provide additional surety of supply, they propose the obligation that new and replacement meters installed by 1 December 2018 must be five minute capable be changed to meters that are manufactured by 1 December 2018 must be five minute capable.²³¹

Landis+Gyr suggested that some metering providers may need to hold inventory with outdated meter firmware and software configurations.

224 Draft determination submissions: EDMI, pp. 2-5; Landis+Gyr, p. 1; Satec Australia Pty Ltd, p. 1; Vector Limited, p. 2.

225 Draft determination submissions: AusNet Services, p. 4; Citipower, Powercor and United Energy, p. 2; Energy Networks Australia, p. 3.

226 AusNet Services, draft determination submission, p. 4.

227 EDMI, draft determination submission, p. 2.

228 Existing type 4 meter that is not at a transmission connection point or a distribution connection point where the relevant financially responsible market participant is a market generator or small generation aggregator.

229 Origin Energy, draft determination submission, p. 7.

230 Satec Australia Pty Ltd, draft determination submission, p. 3.

231 Landis+Gyr, draft determination submission, p. 2.

Landis+Gyr also noted there are some potential risks to achieving firmware changes in the specified timeframe, as many modifications must be done sequentially. Landis+Gyr estimated the full system testing and incorporating of new firmware into the manufacturing supply chain is estimated to be more than six months.²³²

Vector also raised concerns that in the short to medium term, the sixfold increase in meter data storage would mean that other market services may be affected. The services affected include, data for distribution network management and data to ensure safety such as fault location identification.²³³

Some stakeholders raised concerns that if the new and replacement meter rule comes into effect on 1 December 2018, meter data providers would need to have their IT and supporting systems ready for five minute data by this date.²³⁴ Secure noted there would be significant costs associated with a short transition period for communication, back-office and B2B systems.²³⁵ Vector suggested this transition timeframe was asymmetrical and onerous, affecting meter providers that need to configure, test and commission meters, and meter data providers that need to collect and store data which will not be used.²³⁶ CitiPower, Powercor and United Energy suggested an additional 12 month transition period beginning 1 July 2021 should be included in the rule for type 4, 4A and 5 meters to transition to providing five minute data. This would allow additional time for reprogramming, troubleshooting and system modification.²³⁷

Several stakeholders noted the Victorian Government's decision to delay competition in metering until at least 2021. As part of this decision, the Victorian Government will continue to deem type 4 meters as type 5. Several Victorian network operators raised concerns that if these meters were to participate in five minute settlements, they would be restricted by the 200 day storage requirement specified in the Rules that applies to type 5 meters. Submissions from the DNSPs note that whilst these meters are read daily, storing 200 days of five minute data may be beyond the physical capabilities of these meters. These stakeholders all suggested the storage exemption clause in 7.8.2(a1) should be amended to include type 4 and 5 meters to avoid this issue.²³⁸

Jemena and AusNet Services raised the potential for the Victorian Government to decide that meters installed before 1 December 2018 should provide five minute data. They note that the costs to reconfigure these meters, strengthen the communication system and increase data storage to support this implementation would be significant.²³⁹ Similarly, Secure suggest there could be significant upgrade costs

²³² Landis+Gyr, draft determination submission, p. 2.

²³³ Vector Limited, draft determination submission, p. 3.

²³⁴ Draft determination submissions: EnergyAustralia, p. 4; Energy Networks Australia, p. 6; Energy Queensland, p. 2; Secure (Australia), p. 1; Vector, p. 2.

²³⁵ Secure (Australia), draft determination submission, p. 1.

²³⁶ Vector, draft determination submission, p. 2.

²³⁷ CitiPower, Powercor, United Energy, draft determination submission, pp. 2, 5.

²³⁸ Draft determination submissions: AusNet Services, p. 5; Citipower, Powercor and United Energy, p. 4; Energy Networks Australia, p. 4; Jemena, p. 2.

²³⁹ Draft determinations submissions: AusNet Services, p. 5; Jemena, p. 2.

triggered in Victoria from five minute settlement including to the communication network and back-office systems.²⁴⁰

However, in its submission, EDMI sought to clarify that the increase in data transferred from switch to five minutes settlement is not linear. EDMI noted that each transfer of data includes several components in addition to consumption data, including the handshake, security and other overheads. EDMI suggest that this means the increase in data transfers for a shift to five minute would only be a 70 per cent increase and not a 500 per cent increase as stipulated in other submissions.²⁴¹

Energy Queensland and Energy Networks Australia both noted their concern that type 7 meters – which are calculated, not physically metered – would need to be calculated on a five minute basis. Energy Queensland suggested that this would be administratively onerous and costly, whilst providing little value to the wholesale market.²⁴² Similarly, Energy Networks Australia noted that adding five minute granularity to on/off times would provide little benefit. It suggests the change would cost TasNetworks between \$3-5 million to upgrade their systems.²⁴³

AEMO's submission raised the same proposal as in its submission to the directions paper, namely the recording and provision of five minute data from new and replacement mass market type 4 meters²⁴⁴ should be optional. It considered this approach would facilitate:

- reduced technology and implementation costs by reducing the additional cost of processing and storing this data
- increased consumer choice from competitive metering coordinators who offer services to retailers, whilst allowing customers who do not choose to take up five minute services to avoid being negatively impacted
- identification of five minute capable meters through the existing market systems, simplifying identification of capabilities for all parties able to access National Metering Identifier (NMI) standing data
- competition among data providers.²⁴⁵

AEMO also note that there is an order of magnitude difference between the scale of implementation across large metering installations and mass market installations.²⁴⁶

240 Secure, draft determination submission, p. 1.

241 EDMI, draft determination submission, p. 4.

242 Energy Queensland, draft determination submission, p. 3

243 Energy Networks Australia, draft determination submission, p. 4.

244 That is type 4 meters other than those referred to in cl. 7.8.2(b1) of the final rule.

245 AEMO, draft determination submission, p. 5.

246 AEMO, draft determination submission, p. 4.

AGL supported the approach in the draft determination of allowing existing type 4, 5 and 6 meters to be profiled to five minutes, whilst requiring type 1, 2, 3 and some type 4 meters to provide five minute data from the commencement date. Although, AGL did note that this approach may reduce some of the granularity of demand-side information and introduce additional risk in terms of accurate metering.²⁴⁷

Energy Networks Australia proposed sample meters no longer be used to calculate controlled load profiles, suggesting it may result in a more accurate network system load profile.²⁴⁸ Energy Networks Australia also suggested that no specific software change need to be in place or mandated by 1 December 2018, and no five minute data should be required to be provided before 1 July 2021 (or 6 months earlier).²⁴⁹

6.4.3 Analysis

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 <750 MWh	402,767	3%	30 minutes	5 minutes if less than 15 years old	35 days of 30 min data	Remote

²⁴⁷ AGL, draft determination submission, p. 3.

²⁴⁸ Energy Networks Australia, draft determination submission, p. 5.

²⁴⁹ Energy Networks Australia, draft determination submission, p. 6.

Meter type	Number of meters installed	Proportion of total meters	Typical* data measurement setting	Typical* data measurement capability	Typical* data storage capacity	Communication
Type 5 + type 4A** <750 MWh	3,533,127	26%	30 minutes	30 minutes	200 days of 30 min data	Most Victorian Advanced Metering Infrastructure meters are remote, rest are manual
Type 6	9,679,169	71%	Data is accumulated and read quarterly, 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 generally only capable of recording data every 30 minutes. However, some Victorian Advanced Metering Infrastructure (AMI) meters, which are also deemed to be classified 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 noted in the direction paper, remotely read interval meters are usually capable of being remotely reconfigured. This could reduce costs of reconfiguring each meter.²⁵⁰ 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.²⁵¹ Landis+Gyr also raised the need for

²⁵⁰ AEMC, *Five minute settlement*, directions paper, p. 89.

²⁵¹ United Energy, directions paper submission, p. 2.

firmware updates on meters in order to record and process five minute data, estimating more than six months to complete this update on existing stock.²⁵² The draft determination proposed a one year period between 1 December 2017 and 1 December 2018, during which firmware updates for new meters could take place, where required.

In the draft determination and AEMO's High Level Design document, the potential requirement for new and reconfigured meters requiring additional pattern testing for the National Measurement Institute was raised as a potential issue. 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. Further consultation with meter manufacturers suggested that in most modern meters the metrology components of the meter are distinct from the processor. It is the processor which determines the intervals over which data is captured. This suggests that additional pattern testing is unlikely to be required.

Energy Queensland and Energy Networks Australia both raised concerns over the change to the calculation of Type 7 meters from a 30 minute basis to a five minute basis.²⁵³ Both stakeholders suggest the change would be costly, for example TasNetworks suggested the cost would be between \$3-5 million.²⁵⁴ However, moving Type 7 meters to five minute consumption, may encourage a greater efficiency in a sector with relatively low levels of innovation. Further consultation with other distribution network service providers revealed most were unconcerned with the change, with one network service provider suggesting the cost would be some orders of magnitude less than TasNetworks estimation. One stakeholder suggested distribution network service providers were not necessarily restricted in utilising the services of industry peers to provide type 7 data to market if the costs to amend their own systems are prohibitive.

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 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.

252 Landis+Gyr, draft determination submission, p. 2.

253 Draft Determination submissions: Energy Queensland, p. 3; Energy Networks Australia, p. 4.

254 Energy Networks Australia, draft determination submission, p. 4.

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	200 days	10 business days	Quarterly
Type 5			

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

Moving from 30 minute data to five minute data may require meters to have up to 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.²⁵⁵ 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.²⁵⁶

In submissions to the draft determination, several stakeholders raised concern over the capability of type 4A meters to store 200 days of five minute data.²⁵⁷ Type 4A meters are the same as a type 4 meter, except the communications functions have either been disabled at the customer's request, or the property where it is installed has no communications available. These meters are often in rural areas and are checked quarterly, and hence are required to maintain 200 days of storage.

It is acknowledged that there would be minimal value for customers with type 4A meters to have five minute metering for demand response or peak generation. However, there would still be some value in minimising the intraregional settlement residue caused by created from profiling thirty minute data. EDMI's submission stated that all of its meters sold since 2010 have the capability to store 200 days of five minute data.²⁵⁸ Based on indicative discussions with stakeholders, it is the Commission's view that additional storage could be added to a new meter and be released in one to two years.

Some stakeholders also raised concerns over the treatment of Victorian AMI meters, which whilst physically being a type 4, are deemed to be a type 5 meter.²⁵⁹ This means

²⁵⁵ Directions paper submissions: AusNet Services, p. 7; Energy Networks Australia, p. 3; Jemena, p. 2; United Energy, p. 2.

²⁵⁶ AEMO, directions paper submission, p. 3.

²⁵⁷ Draft determination submissions: AusNet Services, p. 4; Citipower, Powercor and United Energy, p. 2; Energy Networks Australia, p. 3.

²⁵⁸ EDMI, draft determination submission, p. 2.

²⁵⁹ Draft determination submissions: AusNet services, p. 5; Citipower, Powercor and United Energy, p. 4; Energy Networks Australia, p. 4; Jemena, p. 2.

the Victorian AMI meters must store 200 days of data to comply with the rules. As most of these meters are read daily, some stakeholders have suggested that the rules distinguish between remotely read type 5 meters and manually read type 5 meters.

However, the distinction between type 4 and 5 meters in the rules is largely to do with this difference of remote and manual readings. Hence distinguishing between remotely read and manually read type 5 meters is redundant, may undermine the original distinction in the rule and could cause confusion.²⁶⁰ Ultimately, the Victorian Government is best placed to address the storage requirements if small customers with AMI meters wish to participate in the five minute market.

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 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 NEM) would not need to incur the costs of meter replacement. This was also suggested as a means to avoid the Victorian AMI meter storage issue.

Existing meters: exemptions

Several stakeholders suggested that to minimise costs of implementation existing type 4 and type 5 meters be exempt from providing five minute data.²⁶¹ 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.

Type 1-3 meters make up only 0.13 per cent 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 provide 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.

²⁶⁰ The continued deeming of AMI meters as type 5 meters after the competition in metering reforms commence on 1 December 2017, is given effect under a Victorian Order in Council.

²⁶¹ Directions paper submissions: AEMO, p. 2; AusNet Services, p. 7; Origin Energy, p. 14; United Energy, p. 2.

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.²⁶² 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,²⁶³ 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 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.²⁶⁴

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

²⁶² AEMO, *Five minute settlement: high level design*, September 2017, pp. 13-14.

²⁶³ AEMO, *Five minute settlement: high level design*, September 2017, pp. 14-16.

²⁶⁴ More detail on this is available in Chapter 3 of AEMO's High Level Design report.

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, the substantive parts of which 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 its submission to the five minute settlement directions paper, Stanwell estimated that 600,000 meters would be replaced over the next five years.²⁶⁵ 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 specifications is likely to create minimal additional costs to meter providers or retailers, as these meters are in most cases already the default meter.

Landis+Gyr submitted that the new and replacement rule proposed in the draft rule be adjusted from all meters that are installed after 1 December 2018 must be five minute capable to all meters that are purchased after 1 December 2018 be five minute capable.²⁶⁶ It argued that this change will avoid meter providers holding stranded assets that are unable to comply with the metering requirements proposed in the draft rule. However, this approach may cause some perverse outcomes by incentivising meter providers to purchase outdated stock before the 1 December 2018 deadline. Additionally, this approach may create compliance issues because it is not practical to trace the manufacturing date of each meter through the National Metering Identifier database.

Controlled load

The controlled load profile is calculated to determine interval metering data for the settlements of type 6 (i.e. accumulation) metering data. In jurisdictions requiring controlled load profiling, the current arrangements established to support the calculation of the controlled load profile require a small population of interval meters

²⁶⁵ Stanwell, directions paper submission, p. 8.

²⁶⁶ Landis+Gyr, draft determination submission, p. 2.

to be installed at connection points that are representative of those that have controlled load arrangements. As the market currently settles on a 30 minute basis, these 'sample' metering installations record 30-minute intervals. The resulting 30 minute profile of the sample metering data is then applied to all other controlled load connection points in the settlements process.

The relevant distributor is required to provide this sample metering data and the associated 30 minute interval data for AEMO to use in the controlled load preparation process. Arrangements for sample metering and controlled load profiles are established in jurisdictional metrology material published in AEMO's Metrology Procedures.

With the move to five-minute settlements, and following the implementation of the Competition in Metering and Related Services, it may be prudent for AEMO to consult with jurisdictions where controlled load profiles have been established to consider the value of maintaining the controlled load profile preparation process or, as suggested by Energy Networks Australia,²⁶⁷ implement alternative methods to account for the settlements of controlled loads with five-minute granularity.

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 suggested they would need to update meter communication infrastructure or increase their bandwidth contracts to handle the sixfold increase in data.²⁶⁸

EDMI's submission to the draft determination noted that data transfer is non-linear. This means the increase in data quantity is around 70 per cent, rather than the 500 per cent suggested by other stakeholders.²⁶⁹

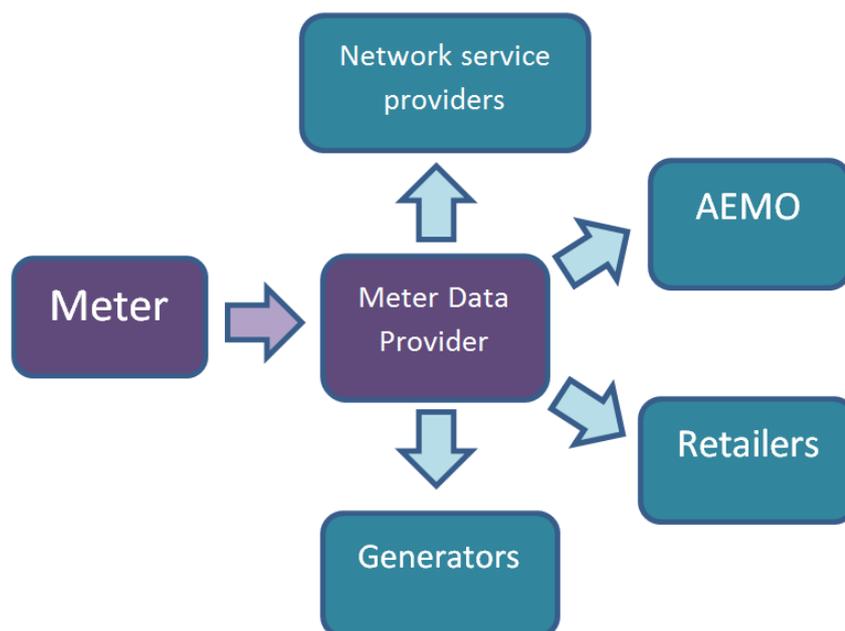
Figure 6.1 illustrates the data flows from the consumer meter to each participant class.

267 Energy Networks Australia, draft determination submission, p. 5.

268 Directions paper submissions: Citipower and Powercor, p. 2; Energy Networks Australia, p. 8; Jemena, p. 2.

269 EDMI, draft determination submission, p. 4.

Figure 6.1 Consumer meter data flows



The benefits of having five minute data include, improved accuracy of pre-dispatch and improved visibility that network service providers will have over usage of their network. 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 and some distribution 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,²⁷⁰ AEMO and retailers may not receive as great a benefit from that five minute granularity, given the MDP and retailer system change costs. In both AEMO's submission to the directions paper and the draft determination,²⁷¹ they suggested that optional data collection from mass market type 4 and 5 meters be allowed to minimise some of the transition costs.

If optional five minute data collection and provision from small customer 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
- potentially increase competition amongst data providers.

²⁷⁰ 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.

²⁷¹ AEMO, directions paper submission, p. 2; AEMO, draft determination submission, p. 5.

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.

The timeframe over which MDPs are able to upgrade their systems to accept five minute data was a concern for several stakeholders.²⁷² Further engagement with network service providers and metering providers during the consultation period suggested that no data requirements should be mandated before industry testing prior to the rule's commencement.

6.5 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.²⁷³ 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.²⁷⁴

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

²⁷² Draft determination submissions: EnergyAustralia, p. 4; Energy Networks Australia, p. 6; Secure (Australia), p. 1; Vector, p. 2.

²⁷³ 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)".

²⁷⁴ 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.

and timely forecast information to Market Participants, in order to allow for responses that reflect underlying conditions of supply and demand.”²⁷⁵

In this context, the draft rule provided for bidding resolution to be reduced to five minutes from the current 30 minutes.

6.5.1 Stakeholder views: Draft determination

Origin Energy agreed that bidding and offering should be done on a five minute basis.²⁷⁶ No other submissions addressed five minute resolution bids and offers.

6.5.2 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	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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

²⁷⁵ National Electricity Rules, clause 3.2.4(2).

²⁷⁶ Origin Energy, draft determination submission, p. 7.

Issue	5 minute settlement / 30 minute bidding resolution (no change to bidding resolution)	5 minute settlement / 5 minute bidding resolution
	approaches	result in decreased rebidding
Compliance	<ul style="list-style-type: none"> • 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 bids, they would continuously need to update their 30 minutes bids 	<ul style="list-style-type: none"> • Avoids potential compliance issues
System costs	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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

Five minute bidding resolution leads to more effective price discovery than retaining 30 minute bidding resolution under five minute settlement. While costs will be incurred by market participants to make the change, the marginal cost may be small given the extent of the changes already required to energy trading software to implement five minute settlement. Five minute bidding resolution is likely to have a minor impact on data processing and also avoids potential compliance issues.

6.6 Pre-dispatch

The NER prescribes that AEMO must prepare and publish a pre-dispatch schedule²⁷⁷ in accordance with the Spot Market Operations Timetable.²⁷⁸

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.

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.

6.6.1 Stakeholder views: draft determination

The draft rule introduced a requirement for the pre-dispatch schedule published by AEMO to have two resolutions. One would be for a 30 minute period, and one for a five minute period. The five minute period would only be in relation to the 60 minute period before the time that the relevant pre-dispatch schedule is published by AEMO.

CSR, ERM Power and the Australian Energy Council submitted that the five minute resolution pre-dispatch should be extended from one hour to three hours or more.²⁷⁹ ERM Power noted that pre-dispatch "will act as a crucial source of information for market participants and for demand response to understand the likely prices in the wholesale market".²⁸⁰

ERM Power and the Australian Energy Council proposed that sensitivities should be published for the five minute resolution pre-dispatch, akin to the sensitivities required for 30 minute resolution pre-dispatch. ERM Power explained that this is because of 'the importance of market operations of the final 60 minutes of pre-dispatch prior to dispatch'.

Stanwell raised several points about the purpose and operability of aspects of the draft rule that related to pre-dispatch.²⁸¹ These issues are addressed in Appendix A.

²⁷⁷ 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.

²⁷⁸ NER, rule 3.8.20.

²⁷⁹ Draft determination submissions: CSR, p. 2; ERM Power, p. 7; Australian Energy Council, p. 4.

²⁸⁰ ERM Power, draft determination submission, p. 7.

²⁸¹ Stanwell, draft determination submission, pp. 4-5.

6.6.2 Analysis

According to AEMO's Pre-dispatch Process Description,²⁸² 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 draft rule provided for a five minute pre-dispatch resolution for a minimum of one hour prior to dispatch. Three stakeholders requested that this be extended by three hours or more. Submissions from ERM Power and the Australian Energy Council indicate that five minute pre-dispatch forecast information granularity is most useful to market participants in the hours prior to the real time dispatch of generation units. Otherwise the 30 minute pre-dispatch schedule (with its accompanying sensitivities) provides sufficient information with which to make decisions about market positions.

Stakeholders also submitted that AEMO be required to publish sensitivities for the five minute resolution pre-dispatch schedule, akin to those currently required for the 30 minute pre-dispatch. Publishing five minute resolution sensitivities would require an understanding of:

- the number and range of scenarios that would be useful to participants
- the accuracy, timing and cost trade-offs in producing sensitivities that AEMO and participants are willing to make.

6.7 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.

6.7.1 Stakeholder views: directions paper

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

²⁸² AEMO, Pre-dispatch process description, July 2010, p. 6.

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.²⁸³

The AEC and ERM Power made similar observations as to the types of conditions and indicators they deemed necessary to be monitored before five minute settlement should be implemented.²⁸⁴ Snowy Hydro argued the 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.²⁸⁵

Origin Energy believed 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.²⁸⁶

6.7.2 Stakeholder views: draft determination

Snowy Hydro maintained its position that a monitoring regime similar to the Optional Firm Access review should be established to assess a suitable time to introduce five minute settlement.²⁸⁷ ERM Power reiterated its argument that the AEMC must delay the introduction of this rule change if new sources of contracts do not develop, or a reduction in overall contract liquidity eventuates.²⁸⁸ Other stakeholders put forward similar views.²⁸⁹

Similarly, the Tasmanian Government submitted that five minute settlement should be delayed "until the uncertainties regarding market impacts are better understood and a detailed cost benefit analysis is carried out that demonstrates likely net benefits across all NEM regions. These are considered essential prerequisites for such a significant rule change."²⁹⁰ It noted that while the AEMC cannot make a conditional rule however "if it elected to not make the rule that it could then make recommendations to (for example) the COAG Energy Council to consider establishing some form of monitoring regime."

283 AEC, directions paper submission, p. 4.

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

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

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

287 Snowy Hydro, draft determination submission, p. 1.

288 ERM Power, draft determination submission, p. 4.

289 Submissions to the draft determination: ENGIE, pp. 1-2; Hydro Tasmania, p. 3.

290 Tasmanian Government, draft determination submission, p. 3.

In contrast, Energy Consumers Australia noted that conditional implementation of five minute settlement would "ignore the incentives for participants to make the changes required as 'preconditions'. The purpose of the transition period is not only to provide time for IT and system changes. It also provides the clear signal that the market arrangements will change and the time for parties to make those changes."²⁹¹

6.7.3 Analysis

The Commission has considered the submissions from some stakeholders that a rule implementing five minute settlement should only be made if certain pre-conditions have been met, including taking a similar approach to the approach the Commission took in assessing Optional Firm Access.

It is important to note however, that the cases where a monitoring regime was recommended by the Commission, for example the Optional Firm Access review and the Victorian Declared Wholesale Gas Market review, were both market reviews²⁹² and not rule changes.

Chapter 2 sets out the reasons why the Commission, as the NEM independent rule maker, has determined that it is appropriate to make the final rule at this time. In short, aligning dispatch and settlement at five minutes includes the following significant enduring benefits relative to the current arrangements:

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

Further, the final rule sets the five minute settlement commencement at 1 July 2021. Chapter 7 examines how the transition period prior five minute settlement starting allows time for the market to adapt without the need for a monitoring regime.

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 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. Such an approach

²⁹¹ Energy Consumers Australia, draft determination submission, p. 1.

²⁹² 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.

would open the determination up to being influenced by the actions of parties that the rule affects. In addition to potentially creating perverse incentives on market participants to influence outcomes that would affect the operation and timing of the rule change, it could also lead to outcomes that are not in the long term interests of consumers.

6.8 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 draft determination, 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, avoiding administrative burden, and the 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 per cent of meters but process over 400 TWh 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 final rule therefore prescribes that type 1-3 meters will need to record and provide five minute data from the commencement date of the rule.

The final 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 provide five minute data from the commencement date. These type 4 meters, of which there are approximately 150, 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 final rule does not require all other type 4-6 meters that are installed before 1 December 2018 to provide five minute data.²⁹³ The data from these meters will be profiled to five minutes by AEMO using the NSLP as described in AEMO's High Level Design report.²⁹⁴

The final rule requires type 7 unmetered loads to be calculated on a five minute basis from the commencement date. Stakeholders had differing opinions of the cost that this would impose on distribution network service providers, noting that DNSPs are able to contract for type 7 calculation services where it is more economical to do so. However, the additional granularity supports the provision of more efficient wholesale outcomes by reducing settlement residue through alignment between consumption and generation levels.

To minimise costs for existing type 1 to 3 and type 4 meters that are required to be reconfigured to five minute granularity from the commencement date, but fall just short of the storage requirement, the final rule empowers AEMO to grant exemptions to a metering provider from the metering storage requirements set out in clause 7.8.2(a)(9) of the rules. This can be done by AEMO if it is reasonably satisfied that the metering provider will otherwise be able to comply with the requirements in Chapter 7 of the Rules.

Some submissions to the draft determination requested this metering storage exemption clause be extended to include type 4A and type 5 meters. However this exemption is focussed on existing meters that are required to comply with the five minute obligation from the commencement date. There are no obligations on other existing type 4²⁹⁵, 4A or 5 meters to provide five minute data. Further, it is expected that new and replacement meters that are installed after 1 December 2018²⁹⁶ should be able to comply with the storage requirements as specified in the Rules.

As most new type 4 meters are capable of recording and providing five minute data already, the final rule requires that all new and replacement meters that are installed will need to be capable of recording and providing five minute data from 1 December 2018.²⁹⁷ This will allow sufficient time for any firmware upgrades and testing of existing meters whilst future-proofing the meter fleet. This will also make it easier for consumers to utilise any new services and products that take advantage of five minute settlement. The Commission was of the opinion that the new and replacement rule should remain on the installation date, rather than the date of purchase. This is because

²⁹³ Type 4A meters that are installed prior to 1 December 2019 are also not required to provide five minute data.

²⁹⁴ AEMO, *Five minute settlement: High level design*, September 2017, pp. 13-16.

²⁹⁵ Other than those referred to in Cl. 7.8.2(b1).

²⁹⁶ 1 December 2019 for type 4A meters.

²⁹⁷ These meters that are installed will only need to provide five minute data by 1 December 2022.

of the complications around enforcement of such a rule and the potential for adverse outcomes.

Concerns were raised by some stakeholders on the ability of type 4A meters to store 200 days for five minutes data. Whilst one meter manufacturer noted all their meters were capable of storing this storage requirement, this is not the case across the industry. In light of this, the Commission was of the view that the five minute capability requirement for type 4A meters should commence from 1 December 2019 to allow sufficient time for additional storage to be added to the relevant meters.²⁹⁸

Meter data systems and processing

The final rule requires that five minute data be collected and used from all new and replacement meters.²⁹⁹ 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 having 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.

However, in light of the concerns raised by AEMO over the costs for small retailers to update their IT systems, the Commission is of the view that new and replacement meters³⁰⁰ installed after 1 December 2018 are only required to provide five minute data from 1 December 2022. This allows for a full 5 year project cycle for an IT system upgrade. This position allows customers with a five minute capable meters that wish to participate in the market earlier to do so, by finding a retailer that can provide this service.

Table 6.4 illustrates the current and future treatment of meters in the NEM, in light of the five minute settlement rule.

²⁹⁸ See cl. 11.103.3 of the final rule.

²⁹⁹ The final rule exempts meters installed prior to certain times from doing this, see cl. 11.103.3 which exempts meters installed before 2018 for all meters other than type 4A and before 2019 for type 4As

³⁰⁰ Other than Type 1-3, 7 and type 4's referred to in Cl. 7.8.2(b1).

Table 6.4 Treatment of meters under five minute settlement

Meter type	Treatment under 30 minute settlement	Treatment of existing meters under five minute settlement	Treatment of new and replacement meters under five minute settlement
Type 1-3	30 minute data collected and used for settlement	5 minute data collected and used for settlement from the commencement date (i.e. 1 July 2021)	5 minute data collected and used for settlement from the commencement date
Type 4 meters*	30 minute data collected and used for settlement	5 minute data collected and used for settlement from the commencement date	5 minute data collected and used for settlement from the commencement date
Other type 4	30 minute data collected and used for settlement	30 minute data collected and profiled to 5 minutes using NSLP for settlement from the commencement date	Meters installed after 1 December 2018 must provide 5 minute data from 1 December 2022 at the latest
Type 4A	30 minute data collected and used for settlement	30 minute data collected and profiled to 5 minutes using NSLP for settlement from the commencement date	Meters installed after 1 December 2019 must provide 5 minute data from 1 December 2022 at the latest
Type 5	30 minute data collected and used for settlement	30 minute data collected and profiled to 5 minutes using NSLP for settlement from the commencement date	Meters installed after 1 December 2018 must provide 5 minute data from 1 December 2022 at the latest
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 from the commencement date	No new type 6 meters are expected to be installed
Type 7	Unmetered loads calculated on 30 minute basis	Unmetered loads calculated on a 5 minute basis from the commencement date	Unmetered loads calculated on a 5 minute basis from the commencement date

* Type 4 meters that are at transmission network connection points or distribution network connection points where the financially responsible market participant is a market generator or small generation aggregator.

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 final rule requires market participants to submit dispatch bids and offers for five minute trading intervals for both their initial offers and for any rebids.³⁰¹ 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 (for example, 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 has determined 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
- 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 should be introduced
- AEMO should have the discretion to publish, together with its forecast spot prices, the expected sensitivity of the forecast spot prices to changes in the forecast load or generating unit availability for the five minute resolution

³⁰¹ Clause 3.8.6.

pre-dispatch. This is in addition to the current requirement for AEMO to publish, together with its forecast spot prices, the expected sensitivity of the forecast spot prices to changes in the forecast load or generating unit availability for each 30-minute period for the 30 minute resolution pre-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. If in future AEMO or market participants think it is desirable, it also gives AEMO the flexibility to:

- increase the outlook period over which the five minute trading interval resolution for the pre-dispatch schedule is published
- publish sensitivities together with forecast spot prices for the five minute resolution pre-dispatch.

The Commission expects that any exercise of this discretion by AEMO would be done through consultation with stakeholders.

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 use of market readiness monitoring during implementation.

The issues related to the potential structural impact that five minute settlement could have on the financial contracts market have already 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 however submit that optional demand side participation in five minute settlement (section 6.2.3) and the use of SCADA data (section 6.3.3) would mitigate implementation costs.

7.2 Implementation assessment

This section is split into the following topics:

- overall implementation costs
- contract market requirements
- IT system requirements
- transition period
- test environment during implementation.

Stakeholder views are explored for each topic, firstly the directions paper submissions and secondly the draft determination submissions. Each topic is then followed by an analysis examining in further detail the:

- costs and practical challenges of implementation
- effect of a transitional arrangement in reducing the costs in relation to contracts, metering and IT systems.

7.2.1 Overall implementation costs

Stakeholder views: Directions paper submissions

The AEC commissioned Russ Skelton & Associates to prepare a paper to "contribute to the discussion regarding the proposed rule change to introduce five 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."³⁰² These included:

- Costs to re-negotiate contracts longer than 3 years: \$8.3 million
- System change costs: \$150 million
- Ongoing costs (licencing fees, maintenance costs and storage costs): \$7 million/year (present value = \$50 million)
- AEMO system change cost: \$10 million.

Snowy Hydro noted that the benefits, advocated by supporters of the five minute settlement rule change, have 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.³⁰³

ECA noted that in general, cost estimating exercises usually make two errors. The first is to assume that the only benefit from the change is the triggering event. This ignores the possibility of other benefits. The second is to allocate the full cost rather than the marginal cost from bringing forward an investment that would still need to be made in the future.³⁰⁴

Stakeholder views: Draft determination submissions

Snowy Hydro expressed concerns that the Commission believes the estimated implementation costs are small when compared to the annual NEM transactions and

³⁰² AEC, consultant report by Russ Skelton & Associates, directions paper submission, pp. 22-23.

³⁰³ Snowy Hydro, directions paper second supplementary submission, 4 July 2017, p. 2.

³⁰⁴ Energy Consumers Australia, directions paper submission, p. 7.

investment costs required in the NEM.³⁰⁵ Aurora Energy added that it does not support the AEMC's justification of considering the additional costs of the rule change directly against the total revenue of the NEM.³⁰⁶

AusNet Services was of the view that even though the implementation of the approach in the draft determination will be at lower cost than the earlier approach outlined in the directions paper, it will still be very significant.³⁰⁷

ERM Power disagreed with the Commission's view that implementation costs are minor relative to the scale of investment required as part of the transition to a lower emissions energy market. In addition, ERM Power stated that the Commission has failed to consider or quantify the additional cost for replacement generation that will be required under a five minute settlement market design compared to the status quo.³⁰⁸

Energy Queensland appreciated that the AEMC recognises that the current proposed rule change would result in significant costs as it relates to the hedge market, metering and IT systems, including billing and data warehousing. However, in its view, this offers little comfort when these increased costs will be passed on to consumers with no quantifiable value.³⁰⁹

On the other hand, Uniting Communities noted that there will be some costs involved in the transition to five minute settlement. Nevertheless they are convinced that some of the cost projections being stated in the public forums considering this rule change were excessive.³¹⁰

Uniting Communities also added that it is satisfied that there will only be modest real additional costs for implementing five minute settlement, most of which will be one-off set up costs. Uniting Communities considered that any consumer detriment is likely to be minimal, and over time the net benefit to consumers from implementing the rule change should be more substantial.³¹¹

Analysis

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 present

³⁰⁵ Snowy Hydro, draft determination submission, p. 4.

³⁰⁶ Aurora Energy, draft determination submission, p. 5.

³⁰⁷ AusNet Services, draft determination submission, p. 2.

³⁰⁸ ERM Power, draft determination submission, p. 6.

³⁰⁹ Energy Queensland, draft determination submission, p. 2.

³¹⁰ Uniting Communities, draft determination submission, p. 6.

³¹¹ Uniting Communities, draft determination submission, p. 6.

value of the implementation costs would reach \$250 million³¹², 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.³¹³ 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 final rule. 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,³¹⁴ 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.³¹⁵ 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 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

312 AEC, consultant report by Russ Skelton & Associates, directions paper submission, pp. 22-23.

313 AEC, consultant report by Russ Skelton & Associates, directions paper submission, p. 22.

314 Energy Edge, *Effect of 5 Minute Settlement on the Financial Market*, March 2017, p. 86.

315 For further detail, see AEMC, *Five minute settlement directions paper*, April 2017, pp. 32-34.

high level:

- the value of electricity settlements within the NEM were around \$16 billion in 2016/17³¹⁶
- estimated replacement cost of NEM generation assets are in the order of \$130 billion³¹⁷
- estimated replacement cost of NEM network assets are in the order of \$120 billion.³¹⁸

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

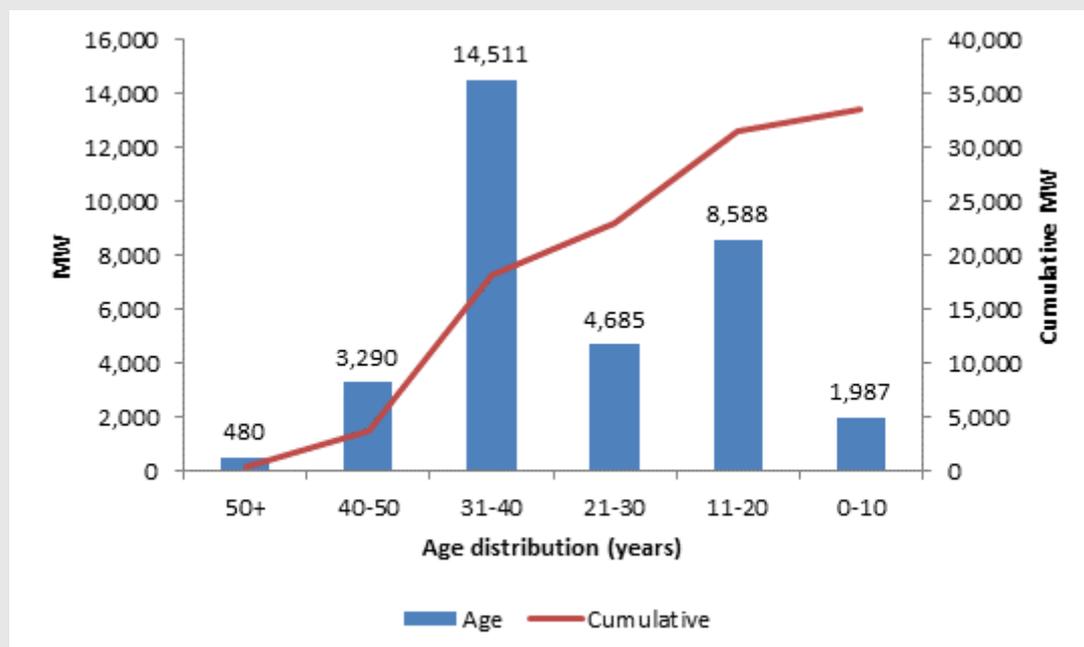


Figure 7.1 shows there is nearly 7,000 MW of thermal generation capacity that is over 40 years of age and more than 15,000 MW between 31 and 40 years old. The design life of thermal generation plants tends to be 30 to 40 years depending on the technology. While in practice thermal generation plants can last significantly

³¹⁶ AEMO, *Fact sheet: The National Electricity Market 2017*, p. 1.

³¹⁷ This estimate is based on 45 GW of capacity with an average replacement cost of \$2.9 million/MW.

³¹⁸ This estimate is based on the aggregate regulated depreciated asset values of around \$80 billion and an assumption of two thirds life expired.

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 are 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 the 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.³¹⁹

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 billion³²⁰ and 196.5 TWh of electricity traded in the NEM,³²¹ 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 is particularly the case given that 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 average wholesale costs, this would represent just under a \$100 million per year saving in energy costs that will be passed onto consumers.

³¹⁹ 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.

³²⁰ AEMO *Fact sheet: The National Electricity Market 2017*, p. 1.

³²¹ 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> .

7.2.2 Contract market requirements

One-off contract negotiation costs

Stakeholder views: Directions paper submissions

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 and would have a material financial impact for participants to such agreements.³²²

The RSA report, prepared for the AEC based on discussions with market participants, estimated the number of contracts that would need to be re-negotiated as a result of implementing five minute settlement. 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.³²³

Origin Energy and ERM Power supported the analysis undertaken on behalf of the AEC by RSA that suggests that contract renegotiations costs could be in the order of \$8.3 million.³²⁴

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.³²⁵

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.³²⁶

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 there are a significant number of contracts (such as power purchase agreements (PPAs) that have much longer maturities (out to 2030 in some

³²² Hydro Tasmania, directions paper submission, p. 2.

³²³ AEC, consultant report by Russ Skelton & Associates, directions paper submission, p. 22.

³²⁴ Directions paper submissions: Origin Energy, p. 13; ERM Power, p. 9.

³²⁵ Arrow Energy, directions paper submission, p. 11.

instances). AFMA concluded that the longer the transition period, the greater the mitigation of one-off contract negotiation costs.³²⁷

United Energy suggested that contract negotiation costs extend beyond the wholesale market type contracts. This could include things such 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.³²⁸

Stakeholder views: Draft determination submissions

Stakeholders did not provide any further information on the one-off costs related to contracts negotiation in their submissions to the draft determination.

Effect of a transition period on contracts

The directions paper published by the AEMC in April 2017 proposed a transition period in the order of three years,³²⁹ whereas the draft determination published in September 2017 set a transition timeframe of three years and seven months from the date the rule is made.³³⁰

Stakeholder views: Directions paper submissions

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. However, most members consulted by AFMA 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.³³¹

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.³³²

Arrow Energy and 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 a potential for disruption to bespoke

³²⁶ Aurora Energy, directions paper submission, p. 4.

³²⁷ AFMA, directions paper submission, pp. 6-7.

³²⁸ United Energy, directions paper submission, p. 3.

³²⁹ AEMC, *Five minute settlement*, directions paper, 11 April 2017.

³³⁰ AEMC, *Five minute settlement*, draft determination, 5 September 2017.

³³¹ AFMA, directions paper submission, p. 2.

³³² Major Energy Users, directions paper submission, p. 34.

contractual arrangements and long dated PPAs.³³³ Energy Queensland noted that, at present, their longest market based contracts are 10-year PPAs.³³⁴

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 ISDA³³⁵ 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 OTC forward trading and 13 years for PPAs ending in 2030 i.e. $(3+13)/2$.³³⁶

ERM Power and ENGIE 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 would potentially mean reopening these contracts to negotiation.³³⁷

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.³³⁸

Stakeholder views: Draft determination submissions

The AEC argued that in proposing a start date of 1 July 2021 the AEMC has focused on assessing metering and IT system implementation timeframes and on the settlement date of forward contracts. The AEMC has failed to consider the operational timeline that affects market participants, particularly retailers. For example, market participants must ensure they have available sufficient levels of customer data at a five minute level in order to make contracting decisions to manage forward market risk.³³⁹

Arrow Energy provided a similar observation, stating that more time is needed to enable legacy contracts to expire, rather than artificially disrupting the contract market.³⁴⁰

333 Directions paper submissions: Energy Queensland, p. 10; Arrow Energy, p. 9.

334 Energy Queensland, directions paper submission, p. 10.

335 International Swaps and Derivatives Association.

336 Snowy Hydro, directions paper submission, p. 19.

337 Directions paper submissions: ERM Power, p. 9; ENGIE, pp. 3-4.

338 AFMA, directions paper submission, p. 6.

339 AEC, draft determination submission, p. 3.

340 Arrow Energy, draft determination submission, p. 2.

ASX, on the other hand, considered that the proposed transition date will allow sufficient time to implement any changes required to their range of futures and options. It should have minimal impact on the derivatives market, as the transition date is beyond where market users are currently using ASX derivatives to hedge forward.³⁴¹

Analysis

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.

³⁴¹ ASX, draft determination submission, p. 1.

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 is adopted. There would however be a one-off cost incurred in renegotiating or terminating existing contracts that endured beyond this transition period.

The final rule also introduces an obligation on AEMO to publish a 30 minute price (calculated in the same way that the current spot price is calculated) for each regional reference node. The Commission understands that some of the potential disruption to clauses in contracts that refer to a 30 minute contract price could be mitigated by requiring AEMO to publish a 30 minute price.

7.2.3 Metering requirements

Stakeholder views on metering upgrades to accommodate a move to five minute settlement were canvassed in section 6.4. These views specifically relate to the physical capability of meters to record and provide 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 settlement.

Metering implementation costs

The directions paper set out the Commission's initial view that a staged transition period would be appropriate if five minute settlement was introduced. With respect to metering, this involved:

- upgrading type 1, type 2 and type 3 high voltage meters to record and provide five minute data within three years
- upgrading type 4 and remotely-read type 5 meters to record and five minute data within five years.³⁴²

In response to stakeholder submissions to the directions paper, the draft rule had the following key features for metering:

- Types 1, 2 and 3 meters to record and provide 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, to record and provide five minute data from the commencement date of the rule.
- The draft rule did 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 is to be profiled to five minute trading intervals by AEMO using net system load profiles.
- From 1 December 2018, all new and replacement metering installations to have five minute data capability.
- 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.³⁴³

Stakeholder views: Directions paper submissions

AusNet Services indicated that the cost implications of applying five minute settlement as proposed to existing Victorian 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.³⁴⁴

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

³⁴² AEMC, *Five minute settlement*, directions paper, p. 113.

³⁴³ AEMC, *Five minute settlement*, draft rule determination, p. v.

³⁴⁴ AusNet Services, directions paper submission, p. 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.³⁴⁵

Energy Queensland noted that their Ergon Energy arm had a fleet of around 313,000 electronic meters of which only around 2,500 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 \$1,500 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.³⁴⁶ 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. Consequently all will need to be replaced or reprogrammed if they are required to provide five minute data.³⁴⁷

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.³⁴⁸

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.³⁴⁹

SA Water indicated it would need to audit around 1,640 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.³⁵⁰

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

346 Energy Queensland, directions paper submission, p. 7.

347 Energy Queensland, directions paper submission, p. 8.

348 AusNet Services, directions paper submission, p. 9.

349 Aurora Energy, directions paper submission, p. 5.

350 SA Water, directions paper submission, p. 4.

EnergyAustralia 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.³⁵¹

Stakeholder views: Draft determination submissions

Even though AusNet Services has not offered a revised estimate of its metering implementation costs, it has identified the following cost areas in implementing the proposed rule:³⁵²

- upgrade or replace network billing system
- replace transmission/distribution interconnector meters
- change existing AMI metering data management systems, and
- increase data storage and changes to head and end systems (for example, SilverSprings UIQ system).

Uniting Communities added that some metering is already compatible with five-minute settlement and that other metering changes within the NEM are underway. This means that based on a business as usual scenario over nearly four years, any additional expenditure for market participants directly attributable to this rule change will be modest.³⁵³

EDMI indicated that all its meters installed since 2010 can deliver five-minute data, and where EDMl meters, communications and reading systems are used, no meter firmware updates are required (no meter cost impact). EDMl noted, however, that any downstream software or operational process costs for the conversion to five minute configurations is best estimated by MDPs.³⁵⁴

Energy Queensland and Energy Networks Australia both noted their concern that type 7 meters – which are calculated, not physically metered – would need to be calculated on a five minute basis. Energy Queensland suggested that this would be administratively onerous and costly, whilst providing little value to the wholesale market.³⁵⁵ Similarly, Energy Networks Australia noted that adding five minute granularity to on/off times would provide little benefit. They suggest the change would cost TasNetworks between \$3-5 million to upgrade their systems.³⁵⁶

351 EnergyAustralia, directions paper submission, p. 10.

352 AusNet Services, draft determination submission, p. 2.

353 Uniting Communities, draft determination submission, p. 6.

354 EDMl, draft determination submission, pp. 3-4.

355 Energy Queensland, draft determination submission, p. 3.

356 Energy Networks Australia, draft determination submission, p. 4.

Metering implementation timeframe

Stakeholder views: Directions paper submissions

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.³⁵⁷ 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.³⁵⁸

Several Victorian network service providers raised concerns that if existing Victorian AMI meters needed to be reconfigured or replaced, a three to five year transition time may not be adequate.³⁵⁹ In order to minimise cost associated with reconfiguring existing Victorian AMI meters, they 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.³⁶⁰

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.³⁶¹

Stakeholder views: Draft determination submissions

Landis+Gyr raised some potential risks to achieving firmware changes by the 1 December 2018 timeframe specified in the draft determination. They estimated the full system testing and incorporating of new firmware into the manufacturing supply chain is estimated to be more than six months.³⁶²

Analysis

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.

³⁵⁷ United Energy, directions paper submission, p. 2.

³⁵⁸ United Energy, directions paper submission, p. 4.

³⁵⁹ Directions paper submissions: United Energy, p. 5; AusNet Services, p. 6.

³⁶⁰ CitiPower and Powercor, directions paper submission, p. 3.

³⁶¹ Energy Queensland, directions paper submission, p. 8.

³⁶² Landis+Gyr, draft determination submission, p. 2.

Chapter 6 sets out the policy in the final rule on implementing five minute settlement in relation to metering. At the commencement date:

- all type 1, 2 and 3 meters and some type 4 meters³⁶³ would be required to be upgraded or replaced so that MDPs can provide AEMO with five minute resolution data from these meters for settlement
- AEMO would for the settlement processes, profile the 30 minute data it receives from MDPs from the remaining type 4 meters and most remotely read type 5 meters into five minute increments
- AEMO would continue profiling type 6 accumulation meter data. However, data would be profiled into five minute increments rather than the current 30 minute increments
- AEMO would update the type 7 consumption calculations to be in five minute increments instead of 30 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 NER³⁶⁴ 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

³⁶³ 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 and any new and replacement meters installed after 1 December 2018 are required to generate five minute data.

³⁶⁴ Tables s7.3.2 and s7.3.3

- delaying the requirement for new and replacement meters to provide five minute data, which allows a longer period for retailers and MDPs to invest in IT systems upgrades
- enabling AEMO to profile 30 minute interval data from type 4, 4A and 5 metering installations into five minute trading intervals (in accordance with the Metrology Procedure)
- 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.

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.³⁶⁵ Discussions with stakeholders indicate that few, if any, meters will require additional pattern testing to comply with the National Measurement Institute standards, which reduces costs and timeframes.

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.

The metering approach outlined above and in Chapter 6 is complementary to the 'competition in metering' rule changes allow for a market-led roll-out of interval meters at the lowest possible cost.³⁶⁶ 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.³⁶⁷ The Commission considers that this concern has been addressed by maintaining the 'grandfathering' approach to small customer meters, particularly given that most new meters are already five minute capable. The 'grandfathering' approach should also minimise the initial effect of having increased data going through the meter communication network and being stored by MDPs.

³⁶⁵ The metrological and technical requirements of electricity meters by the National Measurement institute is available at: <http://www.measurement.gov.au/>.

³⁶⁶ 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.

³⁶⁷ Energy Queensland, directions paper submission, p. 3.

As discussed in Chapter 6, some type 4A meters may currently not have enough storage capacity to accommodate the 200 days of five minute granularity data required by the NER. The Commission considers that it is therefore appropriate to allow additional time before new installations of these meters are required to store and record five minute data.

7.2.4 IT system requirements

This section sets out stakeholder views on general IT system requirements, followed by more detailed stakeholder views on:

- IT systems affected by the rule change
- IT systems implementation costs
- IT systems implementation timeframe.

Stakeholder views: Directions paper submissions

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.³⁶⁸

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.³⁶⁹

AGL Energy made similar observations, noting that analysis on the impact on settlement systems should be undertaken by AEMO before decisions on implementation timeframes and processes is taken.³⁷⁰

The AEC expressed concerns that there is a high risk of failure during implementation, because of the complexity of the system changes and the need for new systems to work effectively together immediately following the introduction of five minute settlement. The consequences of such a failure could be significant and affect the secure and reliable operation of the power system.³⁷¹

³⁶⁸ 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.

³⁶⁹ Stanwell, directions paper submission, p. 6.

³⁷⁰ AGL Energy, directions paper submission, p. 2.

³⁷¹ AEC, directions paper submission supplementary report, p. 5.

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.³⁷²

Stakeholder views: Draft determination submissions

Alinta Energy noted that as an active user of NEM trading systems, settlement systems, forecasting tools and wide array of other associated brokering products, its systems will be directly affected by the implementation of five minute settlement and will subsequently require substantial upgrading.³⁷³

IT systems affected by the rule change

Stakeholder views: Directions paper submissions

Stakeholders identified many of the various IT systems that would require upgrades due to the proposed rule change. They include, but are not limited to risk management, trading, meter data management, settlements, billing, reporting and data collection and storage.³⁷⁴ ENGIE noted that all these changes are on top of the system and process changes that AEMO would also need to implement.³⁷⁵

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.³⁷⁶

Energy Networks Australia, Jemena and AusNet Services 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' back end systems and processes of market participants and AEMO.³⁷⁷ Energy Networks Australia added that this could result in, at minimum,

³⁷² ERM Power, directions paper submission, p. 12.

³⁷³ Alinta Energy, draft determination submission, p. 1.

³⁷⁴ Directions paper submissions: Energy Queensland, p. 11; ENGIE, p. 3.

³⁷⁵ ENGIE, directions paper submission, p. 3.

³⁷⁶ EnerNOC, directions paper submission, pp. 4-5.

³⁷⁷ Directions paper submissions: Energy Networks Australia, p. 4; Jemena, p. 2; AusNet, pp. 2, 8.

the need to significantly modify, if not lead to the replacing of current network billing systems.³⁷⁸

United Energy and CitiPower/Powercor provided some specific guidance on the types of changes required in their systems for the five minute settlement rule change.³⁷⁹

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.³⁸⁰

Stakeholder views: Draft determination submissions

Stakeholders did not provide any further information on the IT systems that are likely to be affected by the rule change in their submissions to the draft determination.

IT systems implementation costs

Stakeholder views: Directions paper submissions

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.³⁸¹

Origin Energy estimated it could cost approximately \$33 to \$38 million to effect the necessary system changes to Origin Energy's systems alone.³⁸²

Arrow Energy expected that all participants would be exposed to a substantial IT system upgrade and this could run into the millions of dollars.³⁸³

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.³⁸⁴

378 Energy Networks Australia, directions paper submission, p. 4.

379 Directions paper submissions: United Energy, p. 2; CitiPower and Powercor, p. 2. See page 113 of the draft determination for more details.

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

381 Aurora Energy, directions paper submission, p. 4.

382 Origin Energy, directions paper submission, p. 2.

383 Arrow Energy, directions paper submission, p. 11.

384 Energy Queensland, directions paper submission, p. 11.

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 per cent would be approximately \$200 million.³⁸⁵

Stanwell agreed with the broad estimate of "tens of millions of dollars" in the Energy Edge report³⁸⁶, but added that at this stage it is unable to estimate how many tens of millions. Further, Stanwell noted that the estimate provided at the forum of industry wide IT costs exceeding a quarter of a billion dollars³⁸⁷ is likely to be realistic.³⁸⁸

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 AEC.³⁸⁹

Some NSPs provided their views on the implementation costs of the proposed rule change.

Based on a preliminary view, United Energy expected 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.³⁹⁰

AusNet Services 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 would be in excess of \$20 million.³⁹¹

385 AEC, consultant report by Russ Skelton & Associates, directions paper submission, p. 22.

386 Energy Edge, *Effect of 5 minute settlement on the financial market*, March 2017, p. 86.

387 Russ Skelton and Associates presentation 2, AEMC, Five minute settlement public forum, May 2017, slide 5.

388 Stanwell, directions paper submission, p. 3.

389 EnergyAustralia, directions paper submission, p. 10.

390 United Energy, directions paper submission, p. 3.

391 AusNet Services, directions paper submission, p. 9.

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 included 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.³⁹²

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 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.³⁹³

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.³⁹⁴

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.³⁹⁵

Stakeholder views: Draft determination submissions

AusNet Services noted that the draft determination shifts from the directions paper proposal, to an incremental approach where types 4 and 5 metering are deployed from 1 December 2018. Notwithstanding this change, AusNet indicated that the costs for making just the essential changes to be compliant with the draft rule would still be material to their business.³⁹⁶

Jemena made similar observations, noting the draft rule means the costs of IT systems, data storage and communication will increase for handling five minute data.³⁹⁷

Uniting Communities observed that many of the costs associated with the transition including IT and data costs would have been incurred over the next four years by market participants irrespective of the changed time period for market settlement.³⁹⁸

392 CitiPower and Powercor, direction paper supplementary submission, p. 1.

393 AEMO, directions paper submission, p. 4; AEMO, *Five minute settlement: High level design*, September 2017, p. 29.

394 AEMO, directions paper submission, p. 4.

395 AEC, consultant report by Russ Skelton & Associates, directions paper submission, p. 23.

396 AusNet Services, draft determination submission, p. 1.

397 Jemena, draft determination submission, p. 1.

398 Uniting Communities, draft determination submission, p. 6.

IT systems implementation timeframe

The directions paper published by the AEMC in April 2017 proposed a transition period in the order of three years,³⁹⁹ whereas the draft determination set a transition timeframe of three years and seven months from the date the rule is made.⁴⁰⁰

Stakeholder views: Directions paper submissions

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.⁴⁰¹ 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.⁴⁰²

Arrow Energy and Energy Queensland indicated that a transition period of at least five years would be appropriate and allow for necessary budgeting.⁴⁰³ 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.⁴⁰⁴

Origin Energy was of the view that at least six to seven years was required for a transitional period. It noted this would better align with the timeframe proposed for the completion of metering changes in support of five minute settlement.⁴⁰⁵

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.⁴⁰⁶

Stanwell cautioned against the three year transition period proposed in the directions paper, noting it would be insufficient for the redevelopment of IT systems.⁴⁰⁷

AusNet Services 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

³⁹⁹ AEMC, *Five minute settlement*, directions paper, 11 April 2017.

⁴⁰⁰ AEMC, *Five minute settlement*, draft determination, 5 September 2017.

⁴⁰¹ AEC, directions paper submission, p. 2.

⁴⁰² EnergyAustralia, directions paper submission, p. 10.

⁴⁰³ Directions paper submissions: Arrow Energy, p. 11; Energy Queensland, p. 11.

⁴⁰⁴ EnergyAustralia, directions paper submission, p. 12.

⁴⁰⁵ Origin Energy, directions paper submission, p. 3.

⁴⁰⁶ Infigen, directions paper submission, p. 8.

⁴⁰⁷ Stanwell, directions paper submission, p. 6.

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.⁴⁰⁸

EnerNOC supported the AEMC's preliminary view to implement five minute settlement following a three year transition period.⁴⁰⁹

A contrasting view was provided by Aurora Energy. It 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.⁴¹⁰

Stakeholder views: Draft determination submissions

Energy Networks Australia suggested that no specific software changes should need to be in place or mandated by 1 December 2018, only the relevant meter hardware. In addition, they proposed that no five minute data should need to be provided/required pre 1 July 2021 (or 6 months prior). This in effect means all participants systems need to be ready by 1 July 2021 to receive five minute data and provide such five minute data.⁴¹¹

Stanwell reiterated their view that system re-development cannot be meaningfully started by participants until the rules and AEMO interfaces are defined and published.⁴¹²

Origin Energy stated that significant IT and system changes are often subject to unexpected delays, particularly given the level of customisation that is required to accommodate NEM settings. Even if the required changes could feasibly be made within the specified timeframe, there is no allowance in the event of contingencies. Origin Energy also noted that the Power of Choice implementation indicates that changes of this magnitude are rarely implemented smoothly, particularly when internal systems are required to interface with numerous external parties (for example, AEMO and MDPs).⁴¹³

Alinta Energy added that the demand for energy systems upgrades will come not just from market participants who hold a physical position, but also many others, including the ASX, a wide array of brokers, AEMO, AER and banking institutions. Given the short time frame for implementation, this will potentially lead to scarcity pricing of systems upgrades arising, which will ultimately be passed on in the form of higher prices for implementation.⁴¹⁴

⁴⁰⁸ AusNet Services, directions paper submission, p. 8.

⁴⁰⁹ EnerNOC, directions paper submission, p. 1.

⁴¹⁰ Aurora Energy, directions paper submission, p. 5.

⁴¹¹ Energy Networks Australia, draft determination submission, p. 6.

⁴¹² Stanwell, draft determination submission, p. 3.

⁴¹³ Origin Energy, draft determination submission, pp. 2, 6.

⁴¹⁴ Alinta Energy, draft determination submission, p. 2.

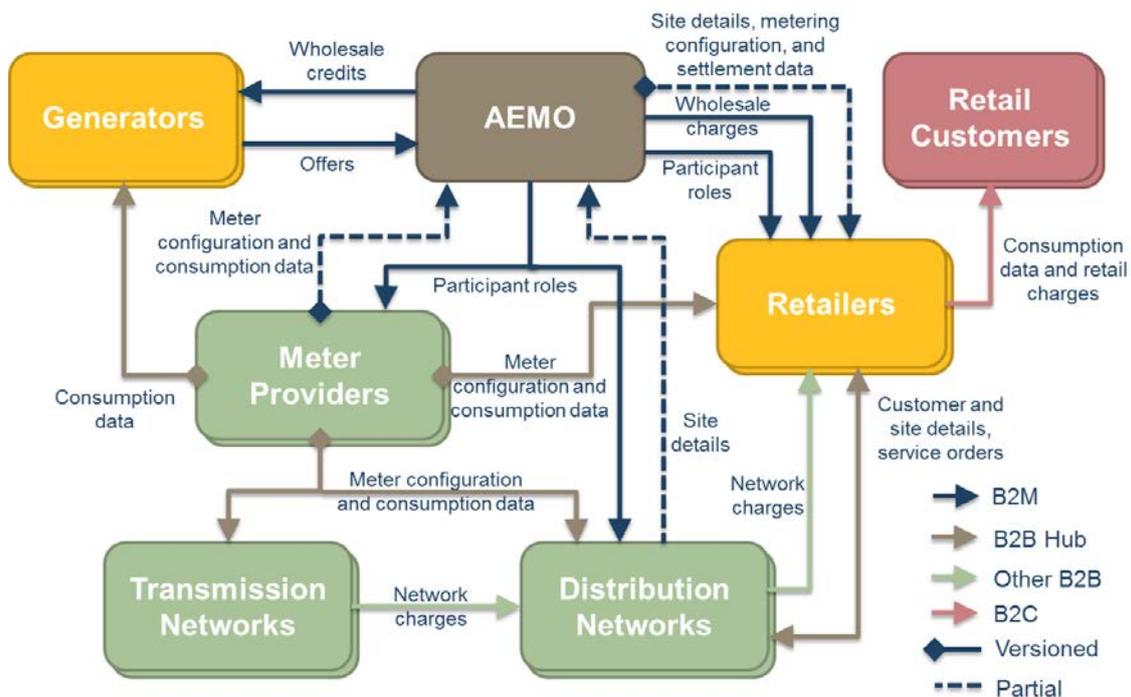
Alinta Energy went on to suggest that a longer transition period (additional 12 months) would go some way to mitigate price scarcity arising, and thus help ensure uneconomic outcomes are minimised. Additionally, a longer transition period would give participants an appropriate lead time to undertake the not-insignificant task of designing, building, testing and operationalising what is the biggest wholesale market IT systems upgrade the NEM has experienced in recent memory.⁴¹⁵

Analysis

Moving to a standard of five minute resolution data will require information system and process changes for most market participants.

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.⁴¹⁶ 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



⁴¹⁵ Alinta Energy, draft determination submission, p. 2.

⁴¹⁶ 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.

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. They have maintained though 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 would be higher than their current ongoing costs.⁴¹⁷

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 ⁴¹⁸ ; 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 IT system changes to be in place. In further consultation, AEMO indicated that it can

⁴¹⁷ AEMO, directions paper submission, p. 4.

⁴¹⁸ Only affected if the retailer chooses to bill on a 5 minute basis

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.

As discussed in Chapter 6, retailers often have two IT systems – one to deal with large commercial and industrial customers and another to handle small-scale residential and small business customers. The nature of these two systems may warrant separate treatment for transition timeframes.

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 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.⁴¹⁹

7.2.5 Transition

The directions paper published by the AEMC in April 2017 proposed a transition period in the order of three years,⁴²⁰ whereas the draft determination set a transition timeframe of three years and seven months from the date the rule is made.⁴²¹ Therefore submissions to the directions paper described below will be addressing the three year transition period, whereas the submissions to the draft determination refers to the three year and seven months proposed transition period.

General views

Stakeholder views: Directions paper submissions

Many stakeholders were of the view that a transitional period of adequate length may help reduce implementation costs.⁴²² 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.⁴²³

Energy Consumers Australia noted its disappointment with the fact that the AEC and many of its members have not acknowledged the need for change, or where they did, have not assisted the AEMC by identifying a transition strategy.⁴²⁴

⁴¹⁹ Stanwell, directions paper submission, p. 2.

⁴²⁰ AEMC, *Five minute settlement*, directions paper, 11 April 2017.

⁴²¹ AEMC, *Five minute settlement*, draft determination, 5 September 2017.

⁴²² Directions paper submissions: EnergyAustralia, p. 10; TasCOSS, p. 4; Mojo Power, p. 3; Clean Energy Council, p. 5.

⁴²³ PIAC, directions paper submission, p. 1.

⁴²⁴ Energy Consumers Australia, draft determination submission, p. 1.

TasCOSS was of the view that a rule change to align settlement and dispatch intervals has been reasonably foreseeable for some time. It noted that if "energy companies and their consultants and lawyers have not made appropriate and timely provisions, the costs of their inadequate planning should not be passed on to consumers who rely on energy as an essential service."⁴²⁵

Stakeholder views: Draft determination submissions

AEMO noted that the transition to five minute settlement is a critical component of the rule change. Participant experiences in respect of transitioning over to the new approach are likely to shape their initial views of the rule change. A smooth and effective transition is therefore essential in shaping the overall success of this rule in achieving its intent, and avoiding the risk of market disruption.⁴²⁶

Energy Consumers Australia added that the purpose of the transition period is not only to provide time for IT and system changes. It also provides a clear signal that the market arrangements will change and the time for parties to make those changes.⁴²⁷

Proposed timeframe is appropriate

Stakeholder views: Directions paper submissions

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.⁴²⁸ 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.⁴²⁹

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.⁴³⁰

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.⁴³¹

⁴²⁵ TasCOSS, directions paper submission, p. 4.

⁴²⁶ AEMO, draft determination submission, pp. 3-4.

⁴²⁷ Energy Consumers Australia, draft determination submission, p. 1.

⁴²⁸ Directions paper submission: EnerNOC, p. 1; Clean Energy Council, p. 5.

⁴²⁹ Clean Energy Council, directions paper submission, p. 5.

⁴³⁰ Wartsila, directions paper submission, p. 3.

⁴³¹ EDMI, directions paper submission, pp. 5-6.

Stakeholder views: Draft determination submissions

PIAC, ECA, AER, Tesla and United Communities were of the view that the proposed transition timeframe of three years and seven months is appropriate and sufficient to enable market participants to implement the changes required by the rule change.⁴³²

Reposit elaborated further by stating that the transition period would also serve as nursery for fast-responding generation and storage technology. Reposit is planning for at least 3.5 GW of residential and commercial electricity storage capacity to be available to the market at the end of the transition period.⁴³³

Energy Consumers Australia noted the analysis conducted by the AEMC on the significance of different implementation dates. The ECA considered that 1 July 2021 is free from holiday, other risks and usefully aligns with contract rollovers.⁴³⁴

EnergyAustralia, Snowy Hydro and Origin Energy, however, suggested that the proposed transition period of three years and seven months should be designated as the minimum required to effect the required change.⁴³⁵

Longer transition period

Stakeholder views: Directions paper submissions

Infigen noted that a longer transition period is clearly more desirable than a shorter one. It will enable contracts to unwind and importantly, competitively priced technology to be tested in the market and potentially deployed.⁴³⁶

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.⁴³⁷

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.⁴³⁸

EnergyAustralia considered that the proposed three year transition period may not align with the natural replacement of meters at the end of their life.⁴³⁹

⁴³² Draft determination submissions: PIAC, p. 1; ECA, p. 1; AER, p. 2; Tesla, p. 1; Uniting Communities, p. 6.

⁴³³ Reposit, draft determination submission, p. 1.

⁴³⁴ Energy Consumers Australia, draft determination submission, p. 2.

⁴³⁵ Draft determination submissions: EnergyAustralia, p. 7; Origin Energy, p. 2; Snowy Hydro, p. 4.

⁴³⁶ Infigen, directions paper submission, p. 6.

⁴³⁷ Energy Queensland, directions paper submission, p. 10.

⁴³⁸ Arrow Energy, directions paper submission, p. 9.

⁴³⁹ EnergyAustralia, directions paper submission, p. 10.

Stakeholder views: Draft determination submissions

Some stakeholders suggested that the AEMC should increase the transition period by 12 months, with the implementation to commence on 1 July 2022. The main reason given by participants was to give more time for participants to manage implementation risks and to allow any unforeseen issues to be addressed.⁴⁴⁰

Alinta Energy added that an additional 12 months of implementation will allow AEMO, market participants, brokers, regulators and market observers the necessary time to establish, test and monitor the shadow NEM wholesale market environment, in what is a critical piece of work underpinning the NEM wholesale market.⁴⁴¹

CitiPower, Powercor and United Energy recommended the AEMC include a transitional period post 1 July 2021 for meters to start providing five minute data rather than requiring the changeover to occur on a particular day. In their view, a 12 month transition beginning from 1 July 2021 would allow the industry time to troubleshoot and ensure the system that they have built or modified are capable of coping with the significantly higher data volumes.⁴⁴²

Certain stakeholders, however, were still of the view that the transition period should be much longer than the proposed one.⁴⁴³

ERM Power noted that the AEMC should delay implementation by a further two years to 1 July 2023. This would ensure that industry and AEMO have sufficient time to guarantee a smooth implementation, including adequate time for a market test environment for five-minute bidding and five-minute settlement. It also stated that a later start date would reduce the costs involved with re-opening some long-duration contracts such as PPAs.⁴⁴⁴

Arrow recommended the implementation timeframe to be extended to 2025. This would allow appropriate time for existing market participants to safely and effectively prepare for the rule change; legacy hedge contracts to expire; new fast start technologies to integrate and prove reliable in the market; and accurate analysis of the five minute settlement rule. Arrow added that providing more time for the transition would allow for more new technologies to join the NEM and prove their capabilities, as well as ensuring appropriate regulatory measures are in place to allow for effective coordination.⁴⁴⁵

440 Draft determination submissions: Origin Energy, p. 2; Aurora Energy, p. 5; Alinta Energy, p. 2; Snowy Hydro, p. 2.

441 Alinta Energy, draft determination submission, p. 2.

442 CitiPower, Powercor and United Energy, draft determination submission, pp. 1-2.

443 Draft determination submissions: AGL, p. 4; AFMA, p. 3; AEC, pp. 2-3, 5; ERM Power, p. 1; ENGIE, p. 2.

444 ERM Power, draft determination submission, p. 2.

445 Arrow Energy, draft determination submission, pp. 1, 3.

ENGIE and Energy Queensland suggested that the transition period needs to be at least five years. This would ensure that all forward contracts can be transitioned in an orderly manner, and that the new technologies that will be relied upon to provide risk management products in the future, are sufficiently established in the NEM.⁴⁴⁶

Shorter transition period

A contrasting view was provided by some stakeholders, which is summarised below.

Stakeholder views: Directions paper submissions

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.⁴⁴⁷

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.⁴⁴⁸

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.⁴⁴⁹

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.⁴⁵⁰

Stakeholder views: Draft determination submissions

The South Australian government remained of the view that the rule change should be introduced with as short a transition period as practicable. It also requested the AEMC to consider transition options, including staggering implementation, which would enable implementation of five minute settlement as soon as practicable.⁴⁵¹

⁴⁴⁶ Draft determination submissions: ENGIE, p. 2; Energy Queensland, pp.3-4.

⁴⁴⁷ South Australia Department of Premier and Cabinet - Energy and Technical Regulation Division, directions paper submission, p. 2.

⁴⁴⁸ Future Business Council, directions paper submission, p. 1.

⁴⁴⁹ Ipen Consulting, directions paper submission, p. 2.

⁴⁵⁰ Tesla, directions paper submission, p. 1.

⁴⁵¹ South Australia Department of Premier and Cabinet - Energy and Technical Regulation Division, directions paper submission, pp. 1-2.

The Clean Energy Council agreed that a reasonable timeframe is needed to transition to a five minute settlement regime. The Clean Energy Council were of the view that this should occur as fast as practicable so that investments in flexible technologies made today can see a clear pathway towards an appropriate market environment.⁴⁵²

The Australian Energy Storage Association (AESAs) noted that some of its members expressed a preference to reduce the proposed implementation period, so as to realise the benefits of the rule change earlier.⁴⁵³

Lyon Group was of the view that financial intermediaries and existing participants significantly overstated any negative effects of the rule change. Taking into consideration that the vast majority of ASX products, swaps and cap volume trades occur within a 12 month period, Lyon Group suggested that delaying the rule introduction until 1 July 2021 to insulate forward markets is unnecessary. Lyon Group also added that the AEMC needs to bring forward the start date to Monday, 1 July 2019.⁴⁵⁴

Two stage approach

Some stakeholders also provided feedback on the two stage transition approach proposed in the directions paper. Their views are summarised below.

Stakeholder views: Directions paper submissions

AusNet Services and Mojo Power considered the phased approach outlined by the AEMC offered a reasonably balanced, practical implementation timetable for the new five minute settlement regime.⁴⁵⁵

Energy Consumers Australia 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.⁴⁵⁶

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. In

⁴⁵² Clean Energy Council, draft determination submission, p. 2.

⁴⁵³ AESA, draft determination submission, p. 2.

⁴⁵⁴ Lyon Group, draft determination submission, p. 1.

⁴⁵⁵ Directions paper submissions: AusNet Services, p. 8; Mojo Power, p. 3.

⁴⁵⁶ Energy Consumers Australia, directions paper submission, p. 8.

addition, ERM Power considered that a single five year period would lower the costs of upgrading IT systems.⁴⁵⁷

Infigen was of the view that the proposed three year period was not sufficient, noting their preference for a transition period of more than four years.⁴⁵⁸

United Energy noted the proposed two stage transition appeared reasonable, but added the following qualifications:

- (a) amendments to NEM procedures should be finalised within 8 months of the rule change to allow the change of contracts and IT systems
- (b) the move to five minute data should only occur after participants are ready to process five minute data 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.⁴⁵⁹

Stakeholder views: Draft determination submissions

Vector suggested that the AEMC reconsider a staged implementation starting from generators and the large customer category. Five minute settlement can then be implemented in the small customer category at a later stage, potentially in conjunction with a percentage of the energy in this segment being on advanced meters.⁴⁶⁰

Vector elaborated further by suggesting that the AEMC specifically consider a staged approach in relation to new metering requirements for the following reasons:

- A staged approach allows scale to grow pragmatically from a technical perspective.
- Staged investments in metering platforms allow metering service providers to incrementally recover the costs of their investments from retailers and other (potential) customers. This is in line with the transition of consumers to advanced metering (that are capable of five minute settlement), rather than making a large upfront investment with a very long timeframe for cost recovery.⁴⁶¹

⁴⁵⁷ ERM Power, directions paper submission, p. 11.

⁴⁵⁸ Infigen, directions paper submission, p. 8.

⁴⁵⁹ United Energy, directions paper submission, pp. 4-5.

⁴⁶⁰ Vector, draft determination submission, pp. 3-4.

⁴⁶¹ Vector, draft determination submission, pp. 3-4.

ARENA noted that the AEMC's approach to transition is prudent in allowing a long lead time for market participants to develop new systems, install or reconfigure technology, and negotiate or re-negotiate contracts. However, the lead time does have an opportunity cost in failing to provide a more efficient operational incentive (and corresponding investment incentive) in the interim period.⁴⁶²

Analysis

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

⁴⁶² ARENA, draft determination submission, p. 5.

- 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 made it intends to provide a test environment for a period of three to six months prior to the commencement of five minute settlement.⁴⁶³

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.

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 final determination.

Transition length and start date

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.

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 five 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),

⁴⁶³ AEMO, *Five minute settlement: High level design*, September 2017, pp. 30-31.

noting that AEMO will likely be able to mobilise IT expertise and adapt all of its bespoke systems within a three year timeframe.

The Commission 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> still relatively close to proposed 3 year transition timeframe 1 day before Easter holiday weekend possible stable market (autumn)
Thursday, 1 July 2021 (Start date as set out in the final rule)	3 years and 7 months	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> moving further from proposed 3 year transition timeframe 1 day before holiday weekend for Qld, NSW, ACT and SA possible stable market (spring)

CSR have questioned the proposed start date of 1 July 2021 when the Liddell power station in NSW is scheduled to close the following year.⁴⁶⁴ The Commission notes that the start date, and therefore the benefits, of this rule change are not contingent on generator entry to or exit from the NEM. Further, AGL already indicated that it has a well-developed plan to replace Liddell's nominal 1,680 MW capacity. This involves a mix of wind, solar and gas generation capacity, batteries and demand response systems, which it said would be more than enough to cover for Liddell's closure.⁴⁶⁵

7.2.6 Market procedures

The draft rule introduced:

- an obligation on AEMO to amend and publish its relevant procedures to apply from the commencement date by 1 December 2020
- an obligation on AEMO to establish and publish the procedure required in respect of exemptions from data storage requirements by 1 December 2020
- an obligation on the AER to amend and publish its relevant procedures to apply from the commencement date by 1 December 2020
- an obligation on the information exchange committee to change the B2B Procedures to take into account the amending rule by 3 December 2018.

Stakeholder views: Draft determination submissions

Various stakeholders were of the view that the finalisation of AEMO procedures in December 2020 does not allow sufficient time for market participants to upgrade their systems and processes to accommodate five minute data. They recommended that AEMO should complete the development of the market procedures by 1 December 2019 to ensure readiness for 1 July 2021.⁴⁶⁶

EnergyAustralia added that if bringing forward the date is not possible, that AEMO considers progressive planning dates and information released allowing participant sufficient time to planning to proceed with the significant changes to processes and design, build and testing of systems.⁴⁶⁷

Energy Networks Australia and Jemena also recommended that the B2B and NEM procedures be finalised by 1 December 2019 allowing participants over a year and a

⁴⁶⁴ CSR, draft determination submission, p. 2.

⁴⁶⁵ AGL, 2017 AGM presentations, p. 21.

⁴⁶⁶ Draft determination submissions: AusNet Services, p. 3; Energy Queensland, p. 3; Jemena, p. 3; Ausgrid, p. 1; CitiPower, Powercor and United Energy, pp. 1-3; Energy Networks Australia, p. 5; Origin Energy, pp. 2, 6; Clean Energy Council, p. 2; AEC, p. 4; Energy Australia, p. 3; Aurora Energy, p. 2.

⁴⁶⁷ EnergyAustralia, draft determination submission, p. 1.

half to finalise system design, business requirements, change of Metering Coordinator contracts and tests.⁴⁶⁸

Analysis

In further consultation with AEMO, it agreed that procedure development could occur by 1 December 2019 to support the transition to five minute settlement. Further, procedures would be updated progressively so many would be completed prior to 1 December 2019 enabling participants to act sooner.

The B2B Procedures are maintained by the Information Exchange Committee (IEC). Recommended changes to the B2B Procedures need to be approved by AEMO. Once the procedures are agreed and updated, AEMO and participants then test and make changes to their systems. Therefore the B2B Procedures should be ready earlier than the other relevant procedures discussed above so that they can take effect by 1 December 2019.

The AER also has documents which require updating to support the move to five minute settlement. It has also agreed that these documents can be completed by 1 December 2019.

7.2.7 Test environment prior to five minute settlement commencement

Stakeholder views: Directions paper submissions

GreenSync (one of the members of the Australian Energy Storage Alliance) fully supported the move to five minute settlement, but also outlined that changes may affect market price certainty. To address this concern, it recommended the introduction of a shadow market for 12 months. This would offer stability to the market through the introduction of five minute settlement.⁴⁶⁹

The Clean Energy Council recommended the creation of a test environment or model. This would allow market participants to explore the characteristics of the new settlement regime and how they 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.⁴⁷⁰

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.⁴⁷¹

⁴⁶⁸ Draft determination submissions: Energy Networks Australia, p. 5; Jemena, p. 3.

⁴⁶⁹ Australian Energy Storage Alliance, directions paper submission, p. 5.

⁴⁷⁰ Clean Energy Council, directions paper submission, p. 5.

⁴⁷¹ AEC, supplementary consultant report by Russ Skelton & Associates, directions paper submission, 25 May 2017, p. 7.

Stakeholder views: Draft determination submissions

Some stakeholders commented on the importance of providing industry participants with a sufficient testing period during the transition.⁴⁷²

Stanwell noted that any implementation timeframe should include a measure of the duration between the finalisation of these interfaces and the provision of a testing environment. In their view, the proposal for AEMO to provide a pre-production environment for "three to six months prior to the rule change becoming effective" is far too short and thereby creates unnecessary risk. The systems to be tested in this environment are not just business critical, but market critical.⁴⁷³

Alinta suggested that any test environment established by AEMO should span six – twelve months at a minimum, and should run over an entire summer period. It suggested a long trial time is necessary to allow market participants to test effective operations, wholesale strategies, settlement compliance processes, prudential operations and to more broadly monitor the performance of the NEM as a whole.⁴⁷⁴

Origin Energy added that it would likely be required to run two systems simultaneously and begin collecting five minute data on both the supply and demand side ahead of the implementation deadline to inform operational and investment decisions and test systems, which will be challenging.⁴⁷⁵

Analysis

Some stakeholders recommended that a shadow market or test environment is provided to market participants for a pre-determined period before five minute settlement commences.

AEMO has signalled that it will provide a market test environment for five-minute bidding and five-minute settlement around three to six months in advance of the commencement date.⁴⁷⁶ In further discussions with AEMO, it has indicated a test environment is likely to be available to participants up to nine months ahead of the commencement date.

7.3 Commission's position

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

⁴⁷² Draft determination submissions: Clean Energy Council, p. 2; Vector, p. 4; Alinta Energy, p. 2; Energy Consumers Australia, p. 2.

⁴⁷³ Stanwell, draft determination submission, p. 3.

⁴⁷⁴ Alinta Energy, draft determination submission, p. 2.

⁴⁷⁵ Origin Energy, draft determination submission, p. 6.

⁴⁷⁶ AEMO, *Five minute settlement: high level design*, September 2017, p. 30.

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 contracts⁴⁷⁷
- 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 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, and promote the efficient operation and use and investment in electricity services for the long term interests of consumers.

⁴⁷⁷ The issues related to the impact of five minute settlement on the financial contracts market have been addressed in Chapter 4.

To address the concerns raised about the costs and risks of implementation, the final 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. During the transition AEMO will undertake market readiness planning and implementation activities.

During the transition period:

(a) NEM participants must:

- (i) have upgraded type 1, type 2 and type 3 high voltage meters to be capable of recording and providing five minute data and, if required, undergo additional pattern testing for this service from 1 July 2021
- (ii) have 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 recording and providing five minute data and, if required, have additional pattern testing for this service from 1 July 2021
- (iii) have applied to AEMO for an exemption from complying with the data storage requirements for the following meter types installed prior to 1 July 2021:
 - type 1, type 2 and type 3 meters
 - 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 where the meter will be able to otherwise meet the requirements of the NER
- (iv) have implemented IT system upgrades to be capable of handling five minute bidding and offering, and five minute settlement
- (v) ensure that from 1 December 2018, all new and replacement type 4 and type 5 meters are capable of recording and providing five minute data and have pattern approval for this service, and that these meters record and provide five minute data from 1 December 2022 at the latest. As discussed above, those 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 record and provide five minute data from 1 July 2021

- (vi) ensure that from 1 December 2019, all new and replacement type 4A meters are capable of recording and providing five minute data and have pattern approval for this service, and that these meters record and provide five minute data from 1 December 2022 at the latest
 - (vii) ensure that by 1 December 2022, IT systems are capable of processing and handling five minute granularity data from type 4, type 4A, and type 5 meters.
- (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 2019
- (c) the AER must have consulted and amended its documents by 1 December 2019
- (d) the *Information Exchange Committee* must have consulted and recommended to AEMO any changes to the B2B Procedures by 1 July 2019
- (e) 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.

The Commission has determined that the final rule will commence on Thursday, 1 July 2021. This is mainly because the commencement date will align with the financial year contract rollover period.

The Commission acknowledges the breadth and depth of implementation required and therefore recommends that market participants begin transitioning to five minute settlement without delay in consultation with AEMO.

Abbreviations

AEC	Australian Energy Council
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AMI	Advanced Metering Infrastructure
ARENA	Australian Renewable Energy Agency
ASX	Australian Stock Exchange
CBA	cost-benefit analysis
CCGT	combined cycle gas turbines
COAG	Council of Australian Governments
CRNP	cost reflective network pricing
ECA	Energy Consumers Australia
FCAS	frequency control ancillary service
IEC	Information Exchange Committee
IT	information technology
MCE	Ministerial Council on Energy
MLEC	modified load export charge
MNSP	market network service provider
NEG	National Energy Guarantee
NEL	National Energy Law
NEM	national electricity market
NEO	national electricity objective
NER	national electricity rules

NMI	National Metering Identifier
NSLP	net system load profile
NSP	Network Service Provider
OCGT	open cycle gas turbines
OTC	over-the-counter
PASA	projected assessment of system adequacy
PoE	probability of exceedance
PPA	power purchase agreement
PSH	pumped storage hydro
RERT	reliability and emergency reserve trader
RSA	Russ Skelton & Associates
RSSR	Reliability Standard and Settings Review
SCADA	supervisory control and data acquisition
SEQ	south east Queensland
SRA	settlement residue auction
SRMC	short run marginal cost
TNSP	Transmission Network Service Provider
VI	vertical integration

A Summary of other issues raised in submissions

A.1 Summary of other issues raised in submissions to the directions paper

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.

Table A.1

Stakeholder	Issue	AEMC response
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) are expected to 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 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	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
	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)	<p>The Commission is not, as suggested here, disregarding the interests of current consumers in making the final rule. The Commission is concerned about both the short and long term impacts on consumers in the market. In relation to the impact on the cap contract market, the analysis presented in Chapter 4 indicates that the impact 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.</p> <p>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.</p>
International experience		
Australian Energy Council (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. 3)	<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".</p> <p>The Commission notes that the international context provided in the directions paper was intended to only be informative. The 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.</p>
Australian Energy Council (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	

Stakeholder	Issue	AEMC response
	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)	
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	

Stakeholder	Issue	AEMC response
	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 final 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 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 FCAS would be
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 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	

Stakeholder	Issue	AEMC response
	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)	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.
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)	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 structure of existing FCAS markets is being reviewed through the Frequency Control Frameworks Review.
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, EDM I 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)	
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 than seek to correct this by layering on more complexity.
Australian Energy Council (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	The Commission has looked into this issue in the final rule determination in relation to the Non-scheduled generation and load rule change request. In relation to the accuracy of AEMO's demand and price forecast accuracy, the Commission found:

Stakeholder	Issue	AEMC response
	<p>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).</p> <p>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)</p>	<ul style="list-style-type: none"> • 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. <p>In relation to whether the forecast inaccuracy that does occur was caused by price responsive loads or non-scheduled generators, the Commission found:</p> <ul style="list-style-type: none"> • 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 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). <p>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</p>

Stakeholder	Issue	AEMC response
		it is available via the Market Management System, or MMS.
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.
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 be passed through to the contracting entities and ultimately result in cost increases to the consumer. (p. 5)	The analysis in Chapter 4 indicates that participants are likely to 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. 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 within the three year and seven month transition period.
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)	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 given the competitiveness of the market that individual businesses would only recover those costs that are consistent with

Stakeholder	Issue	AEMC response
		the efficient industry-wide system costs.
Stanwell	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)	<p>A "tidy up" of the NER is outside of the scope defined by the issues raised in the rule change request.</p> <p>Further, as discussed in section 6.7.3, the Commission cannot make a conditional rule.</p> <p>The Commission notes that the Finkel Review recommended a comprehensive review of the NER by the end of 2020, through which 'untidy' aspects of the existing rules may be able to be addressed.</p>
Investment		
Australian Energy Council (AEC)	<p>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.</p> <p>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)</p>	<p>Chapter 5 addresses system security and reliability impacts from five minute settlement, particularly in respect of concerns that the rule, if made, would:</p> <ul style="list-style-type: none"> • 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. <p>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.</p> <p>The rule does not attempt to foster any particular technology but to</p>

Stakeholder	Issue	AEMC response
		enable more efficient pricing and dispatch and allow any relevant technologies to be implemented.
Reliability		
Australian Energy Council (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)	<p>The Commission considered this issue during its assessment of the Non-schedule generation and load in central dispatch rule change request.</p> <p>In its final determination in relation to this request, the Commission recognised the technological change that is occurring is likely to result in increased amounts of small generation and more responsive loads. In order to maintain a transparent market with accurate information for participants, the requirements to participate in central dispatch may need to change. Any such change should take account of a broad range of factors and market design options, and be informed by the outcomes of the reviews and rule change requests that are relevant to the central dispatch process and are currently underway.</p>
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)	<p>The Commission notes that the NEM market design already features five minute dispatch. The Commission's analysis presented in Chapter 4 of the directions paper indicated there are ample resources currently in the NEM, and new investments that will occur irrespective of whether five minute settlement is implemented, that can physically respond to five minute prices.</p> <p>Chapter 3 of this final determination, noted that not every resource in the NEM must be highly flexible and capable of an instant response. Rather, there will be some optimal level of flexible technologies, given the physical needs of the power system. In an efficient market, the physical need for supply and the financial</p>

Stakeholder	Issue	AEMC response
		rewards of providing it are aligned through prices, which provide an incentive to invest in the technologies that are valued most highly.
Energy Networks Australia	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. (p. 4)	This concern is responded to in section A.2 – Transmission network pricing.
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)	<p>The final rule preserves the current transmission pricing settings in the NER, so that transmission pricing is still based on a half hour period (see section A.2 below – Transmission network pricing). However maintaining the current settings has required a definitional change. Stakeholders are encouraged to review their connection and access agreements with respect to this change.</p> <p>While it would be possible in the future to provide TNSPs the option of pricing on either a five minute or a 30 minute basis, enabling five minute transmission pricing requires a more thorough analysis and further consultation with stakeholders (such as through a separate rule change process) to make sure there were no unintended consequences of five minute transmission pricing arrangements.</p>
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)	A response to these issues is provided in Chapter 3 (pp. 41-42).
EnergyAustralia	It is not easy to assess whether five minute settlement will alter bidding behaviour and hedging strategies, or encourage	

Stakeholder	Issue	AEMC response
	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)	
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)	
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 already undergoing a significant transformative period. (p. 1)	
Metering		
Energy Networks Australia	<p>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)</p> <p>As raised in the response to question 7(b), changes to</p>	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

Stakeholder	Issue	AEMC response
	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)	<p>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.</p> <p>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).</p>
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)	The Commission considers that the existing framework for dealing with supply interruptions remains appropriate under the final rule. However, if participants have concerns about their performance and reporting requirements, they can use the three year and seven month transition period to consult with the relevant authority.
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 arrangements as part of this rule change. (p. 4)	Chapter 6 details the Commission preferred metering implementation. The final rule does <i>not</i> require type 4, 5 and 6 meters – other than those type 4 meters referred to in cl. 7.8.2(b1) – 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.
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)	From 1 December 2017, all new and replacement meters that are installed for small customers must meet a minimum services specification. At a minimum, metering installations must be capable of providing: supply status; voltage; current; power; frequency; average voltage and current; and events that have been recorded in the meter log, including information on alarms. The actual configuration of meters is determined by commercial arrangements between Metering Coordinators and parties seeking

Stakeholder	Issue	AEMC response
		access to services that are enabled by advanced meters.
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 final rule provides a 3 year and 7 month transition period within which most 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)	AEMO will be responsible for implementation and this would be expected to involve market readiness planning and implementation. This is reflected in section 8.5 of AEMO's High level design document which was published alongside the Commission's draft determination.
Other		
CS Energy / Intelligent Energy Systems	Report entitled: <i>A package of improvements for the NEM auction</i> Arrangements within the half hour trading fail to implement	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

Stakeholder	Issue	AEMC response
	<p>marginal pricing principles in many ways, including:</p> <ul style="list-style-type: none"> • 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 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. <p>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.</p>	<p>metering data for settlement purposes.</p> <p>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. The Commission considers that the drawbacks of the using SCADA are:</p> <ul style="list-style-type: none"> • 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. <p>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, which includes the Frequency Control Frameworks Review.</p>
EDMI	<p>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)</p>	<p>The Commission agrees that an increase in the availability of advanced meters, and the uptake of the energy products and services that they enable, can offer a wide range of benefits for all parties across the electricity supply chain.</p>
Major Energy Users	<p>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</p>	<p>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</p>

Stakeholder	Issue	AEMC response
	<p>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)</p>	<p>simply means there is enough competition that the market does not need to be subjected to regulation to control market power and price.</p> <p>As outlined in Chapter 3, the Commission's view is that 30 minute 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 consumers paying more than the otherwise would have, as there would be a relatively less efficient mix of technologies in the market.</p> <p>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.</p>
Major Energy Users	<p>The Directions paper 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)</p>	<p>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.</p>
Energy Queensland	<p>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.)</p>	<p>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.</p>

A.2 Summary of other issues raised in submissions to the draft determination

This appendix sets out the issues raised in the consultation on the Five Minute Settlement rule change draft determination 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.

Table A.2

Stakeholder	Issue	AEMC response
AEMO's high level design		
Energy Networks Australia	<ul style="list-style-type: none"> • New file formats, and the administration and management of the change from settlement-week data delivery to settlement-day data delivery or within day delivery. This is a significant change to core IT and metering systems. • A consolidated table outlining key dates for metering requirements would also help Transmission Network Service Provider (TNSP) members who are performing the Metering Coordinator Role to fulfil its required functions. • AEMO's high-level design is suggesting a new meter data file format, called NEM22, be introduced and that the Meter Data Provision Procedure be updated to provide an option to allow the proposed NEM22 to be supplied to customers. It is not clear what benefit will be achieved by the introduction of NEM22. As such, Energy Networks Australia reserves its opinion on the value or otherwise of this until more information regarding the purpose and benefits are provided to stakeholders. (p. 6) 	AEMO will develop a detailed design of the five minute settlement implementation with input from industry.

Stakeholder	Issue	AEMC response
AER reporting		
Australian Energy Council (AEC)	In relation to the Australian Energy Regulator's monitoring of variations between forecast and actual prices (Clause 3.13.7), paragraph (d)(1) should include consideration of changes in AEMO's forecasts of regional demand and changes in AEMO's forecasts of intermittent generation. (p. 5)	Changing the AER's reporting requirements are not within the scope of this rule change. The current settings in the NER are retained in the final rule.
ERM Power	<p>ERM Power believes that the draft clause is insufficient in scope. Rather, we propose that the AER's report must:</p> <p>"describe the significant factors that contributed to 30 minute price exceeding \$5,000/MWh, including changes in AEMO forecasts of regional demand, AEMO's forecast of unconstrained intermittent generation, the withdrawal of generation capacity and network availability..."</p> <p>Significant inaccuracies in AEMO's forecasts of demand or unconstrained intermittent generation may lead to high price events. Without requiring these aspects to also be included to any AER report, there is a risk of generators being blamed for high prices that were beyond their capabilities, potentially undermining confidence in the market. ERM Power considers that the rules should ensure that all possible impacts on high price events be considered rather than limiting this only to the withdrawal of generation capacity and network availability. (p. 8)</p>	
Alternatives to five minute settlement		
Major Energy Users	What is most concerning is that the AEMC has not considered there might be other solutions to the problem they have identified	In its consultation paper published in May 2016, the Commission consulted on alternative solutions, including options to align dispatch and settlement at different intervals, such as 15 or 30

Stakeholder	Issue	AEMC response
	<p>with 30 minute settlement. Such other options include:</p> <ul style="list-style-type: none"> • Earlier gate closure on rebidding, such as a one hour ahead as used in the UK and elsewhere in the EU • No rebidding within the 30 minute settlement period • Capacity markets like those used extensively in most electricity markets and implied for the NEM under the new National Energy Guarantee policy. Even the UK which pioneered energy only markets like the NEM has opted for a capacity market due to the difficulties inherent in energy only markets • Marginal pricing over 30 minute settlement periods (p. 10) 	<p>minutes (see pp. 22-24).</p> <p>The Commission considered the option of gate closure in 2015 during its assessment of the Bidding in good faith rule change request. In the final determination, the Commission concluded that the potential costs associated with restricting efficient rebids close to dispatch would outweigh the benefits of preventing generators submitting deliberately late rebids.</p> <p>The potential implementation of a 'capacity market' is outside the scope of the rule change request.</p>
Snowy Hydro	<p>In previous submissions Snowy Hydro articulated that the alignment of 15 minute settlement is likely to be more preferable to five minute settlement as it would have less adverse consequences due to the physical characteristics of the existing generation mix. In response the Commission has poorly assessed the 15 minute settlement proposal noting that the option would be an indirect form of risk management.</p> <p>The alignment of dispatch and settlement cycle has continued to be limited to 5 minute settlement dispatch and the Commission has not provided serious consideration to the net benefits that should be given to 15 minute dispatch and 15 minute settlement.</p> <p>The Draft Determination notes that the <i>"alignment at 15 minutes would also include more substantial changes to IT systems as it would require wholesale change to settlement, dispatch and the ancillary service markets"</i>. Snowy Hydro however supports that it would have less adverse consequences due to the physical</p>	<p>The Commission continues to be of the view that 15 minute settlement would be an indirect form of risk management. Thirty minute settlement was originally chosen due to limitations in metering and data processing in the 1990s, not because it would provide for more effective risk management. On the contrary, the Commission has demonstrated in Chapter 3 of this determination that 30 minute settlement creates the potential of risks and price volatility that are divorced from the supply and demand conditions of the market.</p> <p>It is axiomatic that modifying or replacing settlement, dispatch and ancillary service market IT systems to implement 15 minute settlement and dispatch would be more substantial than changing settlement systems only to align with the existing five minute dispatch (while also leaving ancillary service market systems unchanged).</p>

Stakeholder	Issue	AEMC response
	characteristics of the existing generation mix and is unclear how the Commission has assumed that there will be more substantial changes to IT systems when a proper analysis has not been undertaken. (p. 7)	
Tasmanian Government	There does not appear to have been due consideration given to alternative approaches to five minute settlement. (p. 3)	The Commission also considered aligning dispatch and settlement at different intervals, and changes to the price calculation.
Hydro Tasmania	Hydro Tasmania encourages the AEMC to consider lower cost and less complex (lower risk) alternatives to address spot market price volatility in preference to implementing the proposed rule. (p. 2)	Sun Metals' rule change request relates to the misalignment of the NEM dispatch and settlement interval and the incentives that this creates for bidding behaviour and investment decisions in peaking generation capacity and demand response. An investigation into alternatives to "address spot market price volatility" would have been outside the scope of the rule change request.
Compensation thresholds		
AEMO	AEMO notes that the draft rule includes a change of threshold from \$5,000 to \$1,000 in relation to intervention compensation in four specific rule clauses. AEMO considers that the change proposed may not be the most appropriate way of reflecting the change to five-minute trading intervals. (p. 6)	The Commission acknowledges AEMO's assessment that the current rule maybe ambiguous as to whether the compensation threshold relates to an event or a single trading interval. However, consideration of these clauses more broadly is not within the scope of this rule change.
ERM Power	The original threshold of \$5000 has been divided by 5, ostensible to retain a 'round' number threshold. In order to maintain consistency, ERM Power believes that the threshold for compensation should be set at \$830 unless the AEMC can clearly demonstrate the need to effectively increase this threshold by 20 per cent. (p. 7)	In order to not exacerbate the potential existing issue with interpreting the rules relating to the threshold for compensation for AEMO interventions, the current settings in the NER are retained in the final rule by: <ul style="list-style-type: none"> • maintaining the existing \$5,000 compensation threshold
Origin Energy	The threshold for Affected Participants and Market Customers entitlements to compensation in relation to AEMO intervention should be reduced from \$5,000 to \$1,000. (p. 7)	<ul style="list-style-type: none"> • amending the NER so that the compensation threshold refers to an intervention pricing 30-minute period rather than a five minute intervention pricing interval.

Stakeholder	Issue	AEMC response
Australian Energy Council (AEC)	In Clauses 3.12.2 and 3.15.7B, the proposed changes are to reduce the thresholds from \$5,000 to \$1,000. Given the proposed settlement period is one-sixth of its previous value, the Energy Council would argue that the thresholds should be one-sixth of \$5,000 as well. (p. 4)	
Stanwell	There are a number of "magic numbers" in the draft Rule, for example the change from \$5,000 per (30 minute) interval to \$1,000 per (five minute) interval in cl 3.12.2(b). Stanwell requests the AEMC to provide the rationale behind such changes. (p. 5)	
Costs		
Tasmanian Government	While benefits of five minute settlement are less likely to be realised in Tasmania, the costs are likely to be significant (and relatively higher on a per capita basis). Estimates of the costs of five minute settlement to Tasmanian energy businesses are in the order of tens of millions of dollars. (p. 2)	The Commission acknowledges there will be implementation costs, and has set a transition period that will help minimise such costs.
Distribution network billing		
CitiPower/ Powercor / United Energy (p. 4); AusNet (p. 9); Energy Networks Australia (p. 2)	In reference to 6.20.1 (a)(2)(i), there should be nothing in the NER that constrains the tariff structures to customers to require 5 minute data for demand billing.	Clause 6.20.1(a)(2)(i) does not constrain demand billing to 5 minute increments.
CitiPower/ Powercor / United Energy (p. 4); AusNet (p. 9); Energy Networks Australia (p. 2)	The AEMC should consider amending clause 6.20.1(e) (2) to clarify that type 4 billing can occur on metering data in accordance with the metrology procedure or settlement ready data. (type 4A is included in (e) (2) by the <i>National Electricity Amendment (Expanding competition in metering and related services) Rule 2015</i>). The use of metrology data, actual 30	Clause 6.20.1(e) requires DNSPs to base network charges on metered active power, reactive power and demand. This clause also requires charges to be calculated from: <ul style="list-style-type: none"> 'settlements ready data' for types 1-4 meters (active power data only)

Stakeholder	Issue	AEMC response
	<p>minute data, is preferred for network billing as opposed to settlement ready profiled 5 minute data. Five minute demand based on profiled settlement ready data or 5 minute metering data obtained from the meter is likely to be more volatile and may not be suitable for customers. It may be preferable to retain more flexibility in demand and network billing so that demand can be re-aggregated from MDP provided 5 minute metering data to 30 minute demand. Flexibility should be retained in the Rules to allow engagement with impacted stakeholders as part of the Tariff Structure Statement.</p>	<ul style="list-style-type: none"> metered data for types 5 and 6 meters. <p>The final rule enables DNSPs to use metered data in relation to type 4 meters.</p> <p>Any inconsistencies or lack of clarity in this clause would need to be addressed through a separate rule change.</p>
Governance		
Energy Consumers Australia	<p>Among other specific concerns, Energy Consumers Australia notes that despite a long lead time market participants may all decide to wait till the last moment to commence their IT and metering projects. A governance framework can monitor and report on participant preparation. (p. 2)</p>	<p>AEMO will be responsible for implementation and this would be expected to involve activities of market readiness planning and implementation.</p> <p>The transition period allows time for AEMO to work with industry and the AEMC to develop an implementation schedule for five minute settlement that meets the timelines set out in the final rule.</p> <p>The Commission acknowledges the breadth and depth of implementation required and therefore recommends that market participants begin transitioning to five minute settlement without delay in consultation with AEMO.</p>
Australian Energy Council (AEC)	<p>The AEC suggests that any final rule needs to include regular market readiness tests to ensure that the transition goes smoothly and all parties are adequately prepared. (p. 4)</p>	
Energy Networks Australia	<p>The AEMC may also wish to consider the early establishment of a cross stakeholder governance group to be deployed early in the program for the delivery of the reform and development of the more detailed procedures. (p. 5)</p>	
Uniting Communities	<p>Uniting Communities encourages the AEMC, in making its final rule decision, to consider a process for monitoring the transition to five-minute settlement with particular regard to identifying any detrimental impacts on consumers. Transparent processes and regular public reporting particular during periods of change, does</p>	

Stakeholder	Issue	AEMC response
	much to allay consumer wariness. (p. 7)	
EnergyAustralia	Governance of implementation is critical for success and should incorporate readiness reporting from all participants and coordination across the industry. (p. 1)	
EnergyAustralia	<p>Based on our experiences during the Power of Choice metering implementation we suggest the following aspects should be reviewed to avoid similar issues occurring during the five-minute settlement implementation:</p> <ul style="list-style-type: none"> • Incomplete governance over activities required to deliver industry changes. • AEMO is responsible for delivering a series of procedures and system changes across the industry, but is not required to work with industry to meet the objectives of the rule changes – i.e. to ensure that metering competition delivers a competitive market that will deliver benefits for customers. • No governance or rules over the establishment or renegotiation of bi-lateral arrangements between participants. • Little recourse for participants who are made non-compliant, operationally inefficient or must incur additional costs due to actions by other participants (often at short notice). • Lack of decision making forums for some aspects of the industry changes. • Most of the implementation (from procedure design through to testing) has been done under immense time pressure and this has driven up implementation and ongoing costs across the industry and will also lower quality of the solution delivered in 	

Stakeholder	Issue	AEMC response
	December 2017. (p. 5)	
Uniting Communities	<p>We note that the AER is currently considering their "Approach to electricity wholesale market performance monitoring" and has issued a discusison paper.</p> <p>It is our suggestion that monitoring the transition to five-minute settlement 'resides' appropriately with the AER and would almost certainly be compatible with their newly extended wholesale market performance monitoring responsibilities. (p. 7)</p>	This is a matter for the AER.
Hazelwood Power Station closure		
Aurora Energy	<p>The recent withdrawal of Hazelwood Power Station's capacity in Victoria highlights the high risk of increasing cap and swap contract prices, and in turn, hedging costs for retailers...A relevant example is the impact of the closure of Hazelwood Power Station on the Victorian cap and swap contract prices. On 30 June 2016, the Quarter 1 2018 Victorian cap contract price was \$9.50. Following the withdrawal of capacity associated with the Hazelwood Power Station on 26 September 2017, the Quarter 1 2018 Victorian cap contract price had increased to \$35.25. This represents a 262% increase in cap contract prices due to the closure of Hazelwood Power Station. In the same period, the Quarter 1 2018 Victorian swap contract price increased by 156%. This example of increased costs due to the withdrawal of capacity is much higher than the theoretically modelled increase in contract portfolio costs included in the Draft Determination. (p. 4)</p>	<p>The Commission acknowledges the impact of the closure of the Hazelwood Power Station on prices in the physical and contract markets. The impact was exacerbated by the relatively short period of time between the announcement of the closure and when it actually occurred.</p> <p>The Commission does not consider that five minute settlement will result in a similar impact to the closure of Hazelwood. Chapter 4 and 5 of this final determination set out the Commission's view that moving to five minute settlement will not in itself cause the widespread withdrawal of existing peaking generation capacity. To the extent that there is a reduction in contract volumes from existing peaking generators, there appears to be a range of alternatives risk management options available that could be developed within the implementation period specified in the final rule. This is a key point of difference: the closure of Hazelwood was formally announced five months before it occurred, whereas the implementation period for five minute settlement is three years and seven months.</p>
Australian Energy Council (AEC)	<p>The reduction in competition would lead to higher prices for consumers, particularly for residential and weather-sensitive small commercial and industrial customers, as the price of cap contracts would increase, and competition in both the cap market and more generally would be reduced. (As an example, from 30th</p>	

Stakeholder	Issue	AEMC response
	<p>June 2016 to 26th September 2017 the Victorian Q1 2018 cap price increased from \$9.50 to \$35.25, a 271% increase since Hazelwood Power Station's closure, and significantly greater than the corresponding flat swap price change over the same period, which increased 156%. This highlights the increasing influence cap prices have on swap prices and in turn, hedging costs for retailers – which are passed on to consumers.) (p. 3)</p>	
ERM Power	<p>There are already signs that contract liquidity is falling in part due to the closure of thermal generators such as Hazelwood and Northern... The closure of Hazelwood has had a marked impact on the price of cap contracts in Victoria. In July 2016, flat cap contracts for the 2017-18 financial year were \$4.40/MW. In July 2017, following the closure of Hazelwood, flat cap contracts for the 2017-18 financial year had increased to \$11.91/MW, a 170 per cent increase. For peak cap contracts, the increase is more than 200 per cent. This shows the impact of a tightening supply-demand balance in the market. We maintain there is a real risk that five-minute settlement will produce at least similar results and will have a detrimental impact on the cost of energy for customers. (p. 4)</p>	
Major Energy Users (MEU)	<p>The MEU points to the ACCC view that the loss in competition occasioned by the closure of Hazelwood power station was a prime cause in the doubling of the wholesale contract prices, even though the loss of supply was less than 3.5% of available generation in the NEM. This shows that any reduction in competition from current levels will result in higher prices to consumers. (p. 4)</p>	
International experience		
Major Energy Users	<p>The AEMC makes some reference to changes towards 5 minute settlement in overseas markets overseas. Despite this,</p>	<p>The Commission notes that the international context provided in the directions paper was intended to be informative rather than</p>

Stakeholder	Issue	AEMC response
	<p>examination of the detail of that overseas experience does not support the proposed change or that there will be net benefit for consumers. The overseas actions support a view that the AEMC approach is leading edge and essentially unproven in an energy only market such as the NEM. (p. 4)</p> <p>The AEMC has not examined the reasons why other electricity markets have not transitioned to 5 minute settlement. For example, in section 6, the MEU points out that the EU commissioned Frontier Economics to assess the benefits of normalising EU markets to 15 minute settlement yet the conclusion was that at best the change would be marginally positive and at worst strongly negative. Also, the UK examined in detail the 30 minute settlement process and elected not to even look at shorter settlement. (p. 10)</p>	forming the motivation for change.
Metering		
Ausgrid	<p>A large quantity of existing type 4 metering installations measure metering data in fifteen minute intervals. As the rule change allows for many of these to remain until replacement is necessary, Ausgrid contends the settlement process should also accept fifteen minute data. Currently, metering data providers aggregate fifteen minute data to thirty minute intervals for provisions to AEMO. It appears contrary to the rule change objective and not in the interest of accuracy for this process to continue. Ausgrid went further to suggest that meters that record 15 minute data, which is currently aggregated to 30 minutes before sending to AEMO, could be allowed to provide their 15 minute data to increase the accuracy of settlements. (p. 4)</p>	<p>The Commission notes the NER allows for sub-multiples of 30 minute intervals to be submitted to AEMO and this does not change under the final rule. The treatment on how specific data packages are profiled is a decision for AEMO in consultation with industry.</p>
Major Energy Users	<p>If the majority of end users are effectively marginalised through profiling, and this continues, the MEU points out that much of the benefit that the AEMC asserts will be achieved cannot be</p>	<p>The Commission considers that end users would not be marginalised through profiling as over 70 per cent of consumers currently have their meter data profiled to 30 minute intervals. The</p>

Stakeholder	Issue	AEMC response
	delivered under 5 minute settlement until the necessary metering is provided. So far, the AEMC assessment of the costs for converting the necessary metering does not include the conversion of all end users to smart metering.	Rule change does mandate 0.13 per cent of meters to be reconfigured or replaced by the commencement date, however this small proportion of consumers use around 400TWh of energy annually. To minimise cost and ease the transition for the remainder of meters, the Commission has adopted a grandfathering approach for other end users. This approach will maximise the net benefit for all end users.
Vector	We further suggest that the review of the AEMO's procedures relating to metering for the purposes of the proposed rule change include, among others, an assessment of memory and local download performance requirements. It should also include identifying exemptions that may be required as a result of reallocating some of the market's existing metering capabilities for five minute settlement.	The final rule places an obligation on AEMO to review and amend its relevant procedures by 1 December 2019. See section 7.2.6 (Market procedures) and 7.3 (Commission's position) for further details.
Non-scheduled generation and load rule change		
ERM Power	<p>Demand response currently does not bid into the market and instead responds to the price set by AEMO as part of its dispatch process. Demand response currently does not participate in the price setting calculation. As such, any additional demand response does not result in lower price events because the high price has already eventuated. Following a price spike in a five minute market, if demand response does occur, the National Energy Market Dispatch Engine (NEMDE) may then, having seen demand fall, set a lower price for the next trading interval leading to the demand response switching off. The NEMDE, seeing a rebound in demand, may lead to another price spike for the following five minute trading period, resulting in a demand response and the cycle continuing. This scenario would result in increased volatility in the wholesale market.</p> <p>Prices would be more efficient if price responsive load were</p>	These issues were considered by the Commission in its assessment of the Non-scheduled generation and load in central dispatch rule change request.

Stakeholder	Issue	AEMC response
	<p>required to signal these intentions to AEMO as part of the bidding process. Yet, the AEMC rejected this very option in the Non-scheduled generation and load in central dispatch rule change. In our view it is contradictory for the AEMC to propose to move to five minute settlement on the grounds of unquantified efficiency gains while simultaneously rejecting a rule change that would also have improved market efficiency with fewer risks and significantly lower costs to the wider market. To be clear, we are not advocating for all load to provide bids for consumption, only those loads which choose to operate in a price sensitive mode. Nor do we believe that a strict compliance regime would be necessary. (p. 5)</p>	
Pre-dispatch schedule		
ERM Power	<p>Given the importance that the accuracy that the pre-dispatch schedule will have for the ongoing operations of the market, ERM Power also believes that clause 3.8.20 should contain formal obligations for AEMO to monitor and report weekly on the accuracy of their demand and intermittent generation forecasts prepared. The weekly report should detail the level of accuracy of the pre-dispatch schedule in the immediate 60 minutes prior to dispatch and contain details and cause of errors for significant deviations. (p. 7)</p>	<p>Changing AEMO's reporting requirements are not within the scope of this rule change. The current settings in the NER are preserved in the final rule.</p>
Australian Energy Council (AEC)	<p>Given the importance that the accuracy of the pre-dispatch schedule will have for the ongoing operations of the market, the Energy Council recommends that there be an additional Clause 3.8.20(l), which places formal obligations on AEMO to monitor and report weekly on the accuracy of the demand and intermittent generation forecasts. (p. 4)</p>	
Stanwell	<p>Intervention trading price interval is still referenced in cl 3.12.2; 3.12.3(c); 3.15.7B(a4); 3.15.8(b), however it appears these</p>	<p>Noted and adopted in the final rule.</p>

Stakeholder	Issue	AEMC response
	references should be to intervention pricing interval. (p. 5)	
Stanwell	3.13.7(d)(3) references comparisons of dispatch bids and dispatch offers with those in preceding (five minute) trading intervals, in the context of an AER report into outcomes in a 30 minute period. (p. 5)	The final rule maintains the current setting whereby the AER reports on high price events over 30 minute periods.
Stanwell	3.8.4(c) (d)(e), 3.8.6(a)(2) and (g), 3.8.6A(b), 3.8.7(c), 3.8.7A(b), all change "48 trading intervals in the trading day;" to "288 trading intervals in the trading day;" for no apparent reason. Simply removing the reference to "48" appears sufficient. (p. 5)	The final rule maintains the reference to the number of trading intervals in a day for clarity.
Stanwell	CI 3.13.4(l) and (m) appear to now require publication of the same information. (p. 5)	<p>Clause 3.13.4(l) relates to AEMO publishing 30-minute prices.</p> <p>Clause 3.13.4(m) relates to AEMO publishing spot prices (which will be 5 minute prices from the commencement date).</p>
Stanwell	CI 3.8.20(b) contains a reference which no longer appears to make sense "...and no analysis will be made of operations within the trading interval, other than to ensure that contingency capacity reserves are adequate as set out in Chapter 4". Stanwell seeks clarification of whether this reference should be to "...operations within a 30 minute period..." or something else. (p. 5)	The current wording is retained. A separate consultation process is required to establish whether the wording of this clause needs refining.
Stanwell	CI 3.8.20(f) requires that "The pre-dispatch schedule must include the details set out in clause 3.13.4(f)". Under the current rules, 30 minute pre-dispatch requires this detail to be published but five minute pre-dispatch does not. Stanwell seeks clarification of whether this will require additional reporting from AEMO. (p. 5)	Clause 3.13.4(f) requires that the information published in relation to the 30 minute resolution pre-dispatch is also published in relation to the five minute resolution pre-dispatch.
Stanwell	Pre-dispatch resolution and coverage with respect to AEMO's proposal to use bid/offer data from the last five-minute interval for each 30 minute period as inputs into the 30 minute pre-dispatch	AEMO will develop a detailed design of the five minute settlement implementation with input from industry.

Stakeholder	Issue	AEMC response
	process. (p. 5)	
Stanwell	The draft rule will mean that there are two official pre-dispatch forecasts for the same trading interval where that trading interval is the last interval in a 30 minute period and within one hour of dispatch. Stanwell seeks clarification of how this circumstance would be considered in relation to cl 3.8.20(g) if the two pre-dispatch schedules produce inconsistent targets. Similarly for clause 3.8.22A(a1). (p. 4)	No change is required to the clause. Under cl 3.8.20 as amended by the five minute settlement rule change, there is still only one pre-dispatch schedule prepared and published by AEMO although it includes two resolutions (five minute and 30 minute). The pre-dispatch schedule covers each trading interval commencing from the next trading interval up to and including the final trading day for which all valid dispatch bids and offers have been received. Participants will still be required to ensure that they are able to dispatch the relevant plant as indicated in the pre dispatch schedule – i.e. under both relevant resolutions.
Settlement by difference		
AEMO	AEMO considers that the current settlement-by-differencing framework established in Chapter 3 of the NER, whilst effective in enabling the commencement of retail competition, is no longer suitable for use in a market where customer switching is well established. AEMO consider that a global settlement framework should be considered for implementation alongside a change to five-minute settlements. (p. 2.)	The Commission anticipates that AEMO will consider in consultation with stakeholders how a global settlement framework would be implemented and, if necessary, submit a rule change request.
Soft cutover		
AEMO	<p>Transition management in respect of this rule change will incorporate several streams including systems, metering and hardware, contracts, market and contracts. In this respect it is not only the overall timeline and period for implementation that is relevant but also the specific approach to shifting and 'cutting over' to new systems and rules.</p> <p>AEMO considers that a staged 'soft cutover' approach may allow for better management of readiness activities. In AEMO's view a</p>	<p>The Commission agrees that a soft cutover for metering data and bidding data is likely to be desirable to reduce the risk of market disruption at 'go-live'. A soft cutover could involve:</p> <ul style="list-style-type: none"> • making changes to AEMO's IT system interfaces so that it can receive five minute granularity, and • enabling participants to progressively migrate to the live

Stakeholder	Issue	AEMC response
	soft cutover approach will mitigate against some of the risks of transition and allow for better and more effective response to any issues that may arise during the changeover period. (p. 4)	system ahead of the commencement date (1 July 2021). A soft cutover would be in addition to the test environment discussed in chapter 7.
AEMO	<p>AEMO proposes a transition approach based on a soft cutover of metering and bidding systems. This could involve:</p> <ul style="list-style-type: none"> • Metering cutover: for a specified period prior to 'go-live', metering data providers being able to provide 5-minute metering data to AEMO with AEMO aggregating this into 30-minute data. • Bidding system cutover: during a specified period (of around 3-6 months), participants being able to bid either 5-minute or 30-minute granularity, and AEMO providing the necessary translation – this could be allowed for a period of time prior to or following go-live. (p. 4) 	The Commission anticipates that AEMO will run industry consultation to establish how a soft cutover for metering data and bidding data could be implemented and, if necessary, submit a rule change request. During consultation, it will be important to understand whether there would be any advantage or disadvantage to those participants submitting five minute bids/offers in relation to those who continued to provide 30 minute bids/offers and whether there is the potential for market outcomes to be affected.
Timeframes and implementation		
Vector	We urge the AEMC to be mindful that the shift to five minute settlement would not undermine the benefits that the Power of Choice reforms are expected to deliver. This includes refraining from imposing new metering requirements that could be unduly onerous (i.e. costly to implement at this stage of market development without overriding net consumer benefits) and result in unintended consequences. (p. 4)	Chapters 6 and 7 explain how the metering requirements in the final rule are complementary to the "competition in metering" reforms.
CitiPower/ Powercor / United Energy	We strongly recommend that an independent post implementation review of this Power of Choice reform be undertaken and the learnings considered in the implementation of this 5 minute rule change. (p. 1)	AEMO will work with industry and the AEMC to develop an implementation schedule for five minute settlement that meets the timelines set out in the final rule. For example, the final rule requires AEMO to amend and publish its relevant procedures by 1

Stakeholder	Issue	AEMC response
Aurora Energy	The implementation of Power of Choice has been undertaken concurrently with AEMO procedure development. This has considerably increased the risk of the implementation for all parties, resulting in higher costs and lack of readiness for market participants. (p. 2)	<p>December 2019, eighteen months ahead of the five minute settlement commencement date.</p> <p>The AEMC understands that the term 'Power of Choice' relates to the 'competition in metering' reforms. Any review of the competition in metering implementation is a matter for market participants and AEMO.</p>
Energy Networks Australia	A Post Implementation Review of Power of Choice is necessary to examine the governance and the late release of final procedures. Learning from recent implementation issues would minimise risks on customers and stakeholders of the (at the very earliest) 1 July 2021 date. (p. 5)	
Origin Energy	If the rule is made, AEMO could be charged with developing a detailed implementation plan in consultation with industry that can be used to more accurately inform the scope of required system changes and therefore the appropriate length of the transitional period. (p. 2.)	
EnergyAustralia	<p>We consider that if the Commission is proceeding to set a fixed commencement date as per the draft determination, then there should be an assessment of what key decision gates can be built into the final rule to provide a more certain trajectory to implementation. (p. 4)</p> <p>A further consultation period of six months focussed on the proposed design of the five minute settlement market would assist in developing a least-cost transition. This period would give sufficient opportunity to hold a series of workshops with industry participants to identify specific risks, understand the times to develop and implement key aspects of the rule change and plan the coordinated approach necessary to transition smoothly to five-minute settlement. (p. 6)</p>	<p>The transition period allows time for AEMO to work with industry and the AEMC to develop an implementation schedule for five minute settlement that meets the timelines set out in the final rule.</p> <p>The Commission has undertaken extensive consultation on this rule change: workshops, bilateral meetings, a public forum, and the publication of three additional papers in addition to the statutory documents required for a rule change process.</p>

Stakeholder	Issue	AEMC response
	<p>We strongly support mechanisms to provide additional opportunity to review and assess the actual implementation of this rule change, if the Commission decides to make the overall change to five-minute settlement. We note the process used in the Commission’s Review of the Victorian Declared Wholesale Gas Market, and the release of a draft final report. If a similar workshop based process were to be utilised in under this process, it would allow the Commission to confirm its decision in relation to the headline aspects of the rule change proposal, while providing an opportunity to ensure the drafting of the final rule has industry support and that the implementation will meet the objectives. A further consultation period of six months focussed on the proposed design of the five minute settlement market would assist in developing a least-cost transition. (p. 6.)</p> <p>The draft determination has added material new elements to the rule change. Prior to finalising the specific drafting of the final rule, we propose that industry workshops are held to ensure that sub-optimal design is not enshrined in the rules. (p. 6.)</p>	
CitiPower/ Powercor / United Energy	<p>We remain concerned that the final policy could vary again from the current position and would welcome an industry workshop to review the final draft rule in light of the AEMC final policy intent. It is important that industry participants understand their obligations and that practical transition arrangements are built into the process. A managed approach is important so that wholesale settlements and billing is not impacted. (p. 2.)</p>	
EnergyAustralia	<p>As has been seen in other processes with commencement dates locked into the rules, is that there is a lack of flexibility in managing significant issues identified close to that date. Risk mitigation may be reliant on a rule change process to adjust time frames if the AEMO consultation processes, or industry testing</p>	<p>The Commission is providing for a transition period of 3 years and 7 months. This is sufficient time for participants to identify and mitigate implementation risks and for rule change requests to be made and processed if need be.</p>

Stakeholder	Issue	AEMC response
	identifies material barriers to meeting the legislated date. (p. 4)	The Commission acknowledges the breadth and depth of implementation required and therefore recommends that market participants begin transitioning to five minute settlement without delay in consultation with AEMO.
Transmission network pricing		
AusNet Services	<p>The draft rule appears requires both distribution and transmission demand pricing to change to 5-minutes where the metering is recording 5 minute interval energy data.</p> <p>Moving to 5-minute demand pricing is unnecessary and would potentially trigger demand exceedances that should not drive augmentation requirements. AusNet Services recommends that changes 6.20.1(e) to allow 30-minute demand pricing and removing the proposed change to clause 6.20.1(a)(2)(i). (p. 3)</p>	<p>The final rule retains the current settings in the NER, so that the MLEC CRNP definition is with reference to a half hour period (an 'intervention pricing 30-minute period').</p> <p>While it would be possible in the future to provide TNSPs the option of pricing on either a five minute or a 30 minute basis, enabling five minute transmission pricing requires a more thorough analysis and further consultation with stakeholders (such as through a separate rule change process) to make sure there were no unintended consequences of five minute transmission pricing arrangements.</p>
Energy Networks Australia	<p>Energy Networks Australia considers there are a number of reasons to leave transmission pricing arrangements as they are, including:</p> <ul style="list-style-type: none"> • 5-minute measure of demand will drive up apparent system demand at connection points. This is likely to drive up non coincident system demand as it is the sum of individual connection point demands • 5-minute demand is inherently more volatile and would potentially trigger demand exceedances that should not drive augmentation requirements • direct connect customers do not typically have the benefit of diversity in the underlying load that a Distributor has, so will more than likely be disproportionately impacted 	

Stakeholder	Issue	AEMC response
	<ul style="list-style-type: none"> 5-minute MLEC may or may not drive price volatility but a 30-minute period provides a reasonable proxy given the broader 15 minute and half hour ratings used for operating interconnector assets. (p. 8) 	
Other		
Arrow Energy	<p>Consideration should be given to the investment costs required in new technology by manufacturing, residential and other commercial customers to manage their electricity exposure. The AEMC should also consider the impacts of creating a two tiered system - where those who cannot afford batteries will be disadvantaged the most. (p. 1)</p>	<p>The Commission notes that most consumers, especially residential and commercial consumers, are not directly exposed to spot prices. They are therefore not required to actively manage this risk themselves as this role of performed by a retailer. Those consumers that are exposed to spot prices are generally sophisticated consumers that have actively decided to manage risk in this way.</p>
Major Energy Users	<p>Since the AEMC provided its draft decision, the ACCC has released its preliminary report on its Retail Electricity Pricing Enquiry which, amongst other aspects, has identified that the levels of competition in the NEM are currently very low and that the wholesale electricity market is considered to be highly concentrated. The AEMC draft decision does not address the issue of the very low levels of competition in the NEM that the ACCC has identified or whether the proposed change will further reduce levels of competition. (p. 3)</p>	<p>The Commission expects that five minute settlement will promote more efficient operation of and investment decisions in the wholesale market, and, in particular, more efficient competition in the supply of peak energy requirements. Chapter 4 and 5 set out the Commission's view that moving to five minute settlement will not in itself cause the widespread withdrawal of existing peaking generation capacity.</p>
Major Energy Users	<p>There is a view widely held that responsiveness from consumers of electricity has to be an essential feature of the electricity market. While economists discuss efficiency measures in the electricity market as being a driver for efficient outcomes, the MEU points out that electricity supply is not an end in itself. Electricity is needed by all sectors of society and this imposes a responsibility that the price of electricity is no higher than the cost that consumers can carry. For example, if the price for electricity</p>	<p>The Commission notes that there is no requirement under the NER for consumers to engage in demand management activities. However, some consumers may find that it is in their commercial interests to manage their electricity price exposure in this way.</p> <p>The Commission also notes that productivity is a measurement of the efficiency with which inputs are converted into outputs. Hence, if a manufacturer was to curtail production when electricity prices</p>

Stakeholder	Issue	AEMC response
	<p>is too high and this causes a user to cease operations (eg a regional manufacturer) the effect of the high electricity prices will result in unemployment and severe disadvantage to that region's economy. So seeking high economic efficiency in the electricity market might lead to a significant loss of efficiency in other sectors and impact the national productivity.</p> <p>It is a major concern of the MEU and its members that there is an attitude that the efficiency of the electricity market is paramount, even if this reduces the productivity of electricity users. The MEU points out that the small gains in productivity seen in the electricity market as a result of demand side activity might well result in a larger loss of productivity when measured nationally. (pp. 23-24)</p>	<p>are highest, there would in most cases be some reduction in output volume, but also a reduction in the average cost of electricity for the remaining units produced. In this way, demand management activities can potentially result in both higher productivity levels for individual consumers and greater efficiency in the electricity market.</p>

B Legal requirements under the NEL

This appendix sets out the relevant legal requirements under the NEL for the AEMC to make this final rule determination.

B.1 Final rule determination

In accordance with ss. 102 and 103 of the NEL the Commission has made this final rule determination in relation to the rule proposed by Sun Metals.

The Commission's reasons for making this final rule determination are set out in sections 2.2 to 2.4 of this final rule determination.

A copy of the more preferable final rule is attached to and published with this final 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 final rule falls within the subject matter about which the Commission may make rules. The more preferable final 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 final 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, second and third rounds of 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.⁴⁷⁸

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 Australian Energy Market Operator (AEMO)'s declared network functions.⁴⁷⁹ The more preferable final 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.⁴⁸⁰ Under those Regulations, only certain parts of the NER have been adopted in the Northern Territory.⁴⁸¹

The final 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.

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.

⁴⁷⁸ 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.

⁴⁷⁹ Section 91(8) of the NEL.

⁴⁸⁰ National Electricity (Northern Territory) (National Uniform Legislation) (Modifications) Regulations.

⁴⁸¹ 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-\(Northern-Territory\)](http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/National-Electricity-Rules-(Northern-Territory)).

B.5 Civil penalties

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's final 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 is proposing to recommend, subject to consultation with the AER, to the COAG Energy Council that the above clauses should continue to be classified as a civil penalty provisions. 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 final 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 is proposing to recommend, subject to consultation with the AER, 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.

B.6 Conduct provisions

The final rule amends does not amend any 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.⁴⁸² When generators are online and running, responsiveness can be observed via ramp rates, and maximum and minimum output levels.

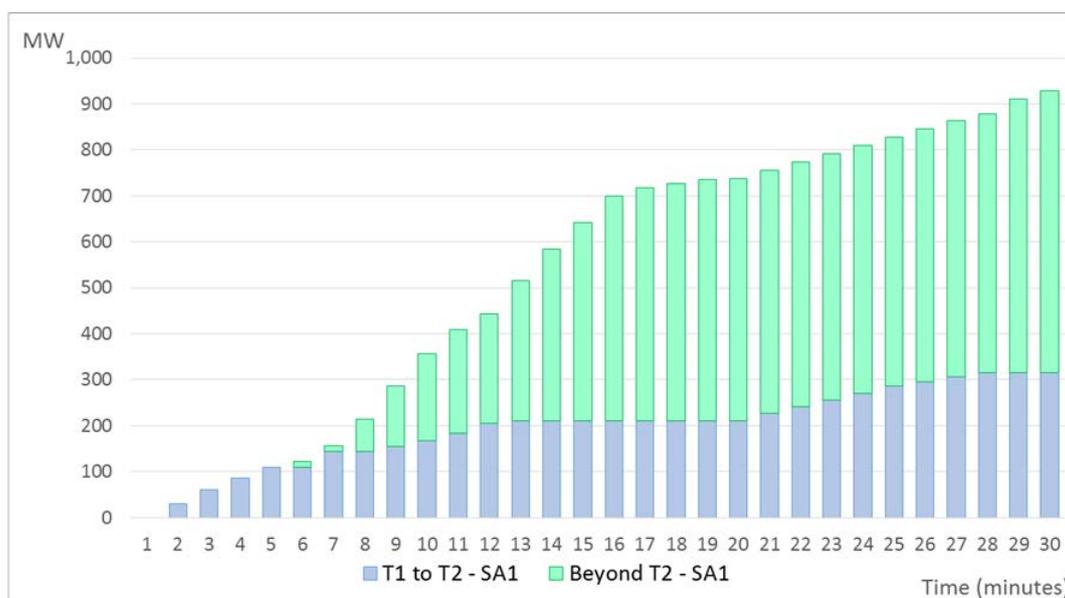
An indicative illustration of the potential response from rest can be observed by extracting the fast start profiles for all scheduled, fast start generators for a single day.

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, then 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.

⁴⁸² 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.⁴⁸³ This analysis is based on fast start profiles from a single day and ramp rates have been assumed at nameplate ratings.⁴⁸⁴

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 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.⁴⁸⁵ The results

⁴⁸³ AEMC, *Five Minute Settlement Working Group: Working Paper No.1*, 12 October 2016, pp. 39-40.

⁴⁸⁴ 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.

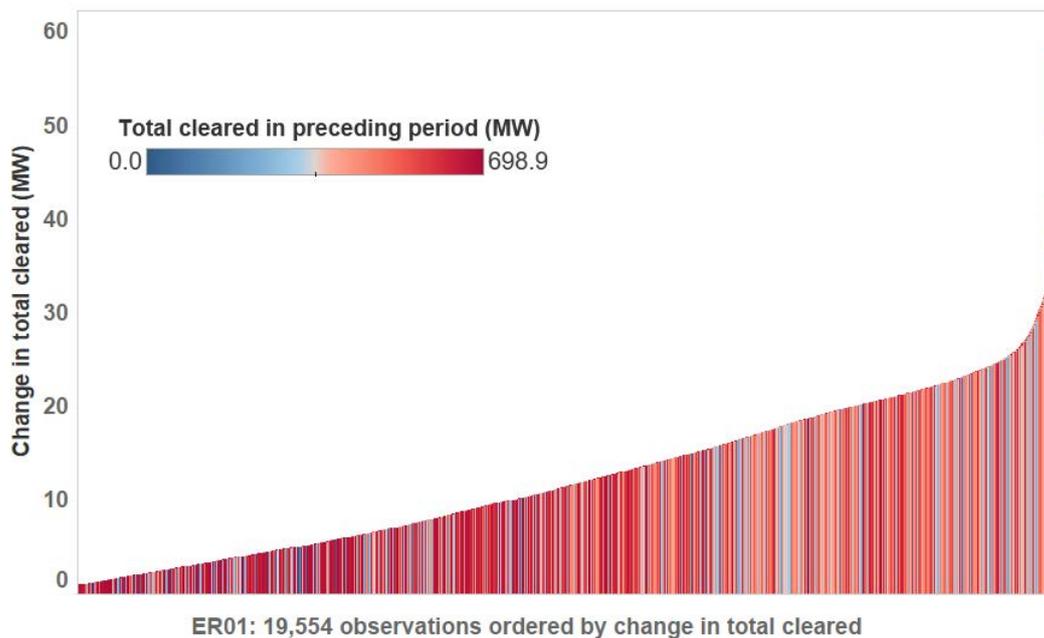
⁴⁸⁵ Differences in Total Cleared MW.

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)

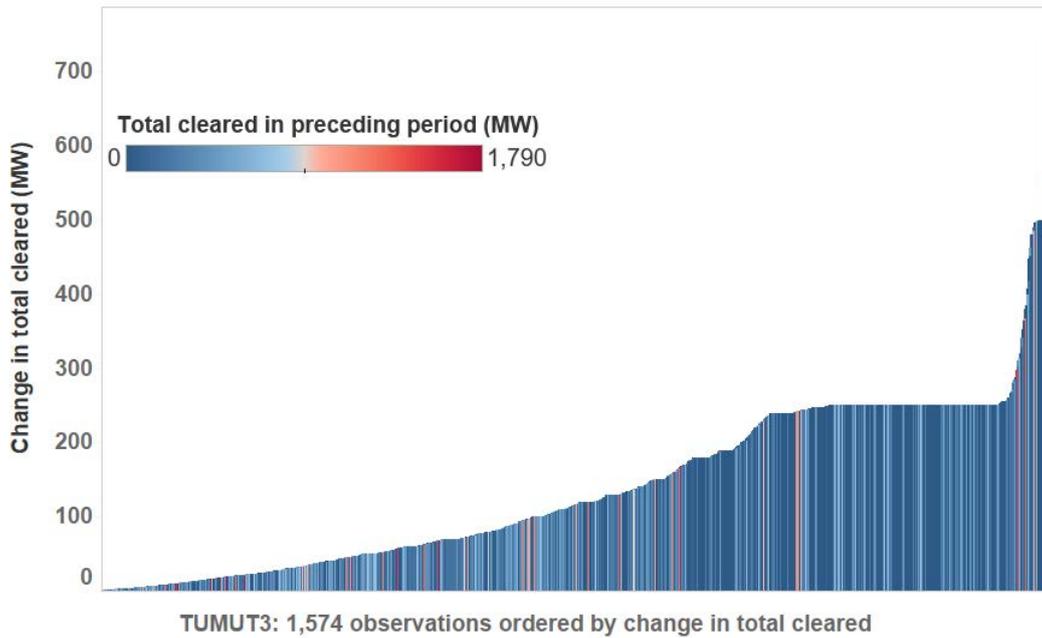
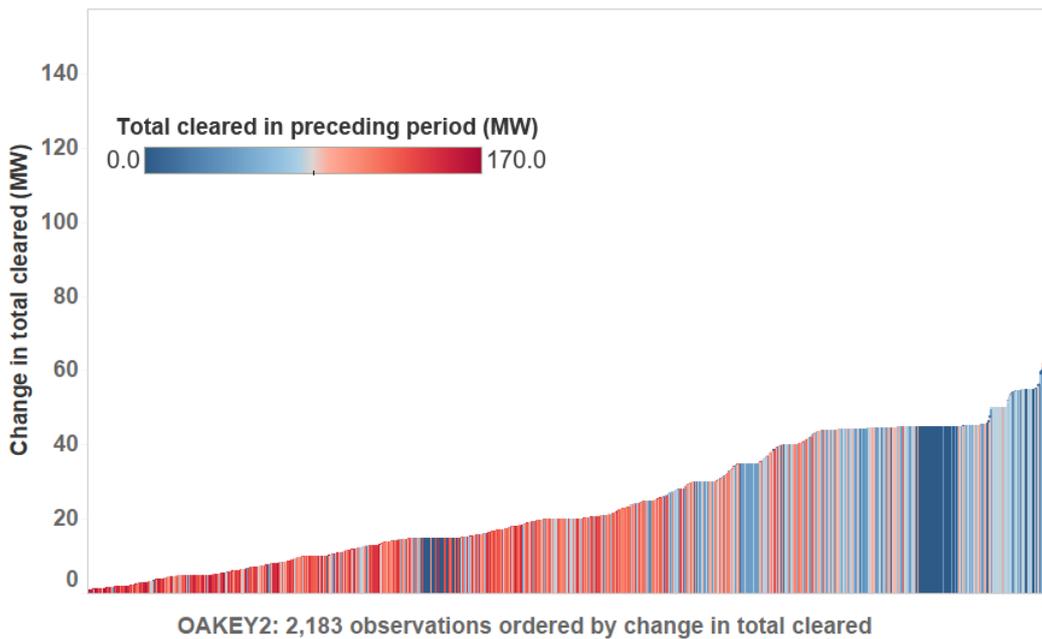


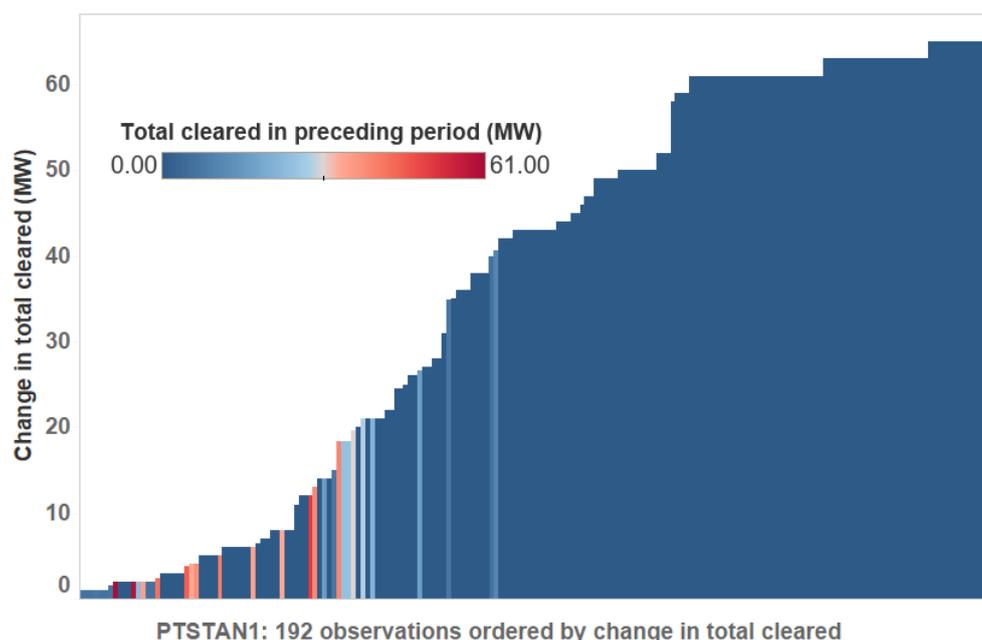
Figure C.4 Historical five minute ramping of Oakey unit 2 (2016)



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.⁴⁸⁶ 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.⁴⁸⁷

⁴⁸⁶ 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 $(5/60)/2 \times 100 \text{ MW} = 4.17 \text{ MWh}$ 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.

⁴⁸⁷ 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.