FIVE-MINUTE SETTLEMENT: HIGH LEVEL DESIGN

HIGH-LEVEL DESIGN TO SUPPORT AEMC DRAFT DETERMINATION

September 2017

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

AEMO has prepared this document at the request of the AEMC, to provide information about the potential design of AEMO processes and systems to support the proposed introduction of five-minute settlement, as at the date of publication. The design has been prepared on the basis of assumptions provided by the AEMC, which are set out in Section 1.2. AEMO also intends on making a submission to the draft determination to provide input on broader policy considerations, which if appropriate, may improve the implementation and operation of the rule change.

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EXECUTIVE SUMMARY

Introduction

As part of the draft determination process the AEMC has requested AEMO to provide guidance on design and implementation of the proposed rule change[1] (proposed Rule). This High Level Design (HLD) report will accompany the draft determination and provide guidance for industry on implementation and transition considerations. Stakeholders will be able to review this HLD as part of the consultation process in respect of the draft determination and provide feedback as part of the submission process for the draft determination.

The specific objectives of the report are to:

- Enable market participants and other affected stakeholders to evaluate the system and process changes they would need to make, and quantify the associated one-off and ongoing costs, and to provide feedback as part of their submissions to the draft determination
- Inform the AEMC's choice of transition period length and other aspects of the rule change.
- Provide guidance to the AEMC in respect of the draft and final determination and rules.

The HLD prepared for this report has been determined given a set of base assumptions provided by the AEMC, as outlined in the Section 1 of the report. AEMO will also seek to make submissions on the draft determination as part of the consultation process, on areas where we believe that policy opportunities exist to align the implementation of 5-minute settlement with other potential initiatives.

Metering arrangements

The proposed Rule requires the collection, storage and delivery of revenue metering data based on five-minute intervals for use in energy settlement, network and retail billing.

Subject to confirmation from the National Measurement Institute, metering devices designed to record metering data in five-minute intervals will require their own pattern approval and metering manufacturers will need to obtain pattern approval from an Approving Authority, including newly manufactured metering devices, those held in stock and those currently in service.

Based on preliminary discussions with the National Measurement Institute, the use of five-minute data to dynamically profile 30-minute metering data to support a five-minute settlement model would not affect the pattern approval requirements of existing 30-minute metering devices.

The current minimum requirements for the storage of interval energy data in metering installations have been put in place to support the integrity of the settlement process, and AEMO has not identified any factors that requires these arrangements to be changed. However should metering installation storage be identified as a material issue, an exemption process could be established to minimise the need for legacy metering installations to be replaced.

Additional matters in AEMO procedures that will require review include:

- Frequency of metering data delivery
- Sample metering for the Controlled Load Profiles
- Accreditation and Participant Registration.

Settlement arrangements

To support the introduction of five-minute settlement, the profiling arrangements will need to be amended. The profiling of 30-minute metering data is based on a "dynamic" profile, rather than simply apportioning the energy in six equal amounts for each five-minute period. The dynamic profile is

[1] Information on the rule change is located at: http://www.aemc.gov.au/Rule-Changes/Five-Minute-Settlement

calculated as the shape of all energy which is not metered on a five-minute basis, so as metering arrangements progressively transition the profile will best reflect the remaining non-five-minute meters. To support the implementation of the proposed arrangements, AEMO will amend the associated procedures through consultation.

To support five-minute settlement, energy transactions will be calculated with the following characteristics:

- Transactions will be calculated for every five-minute period.
- The current process of calculating Marginal Loss Factors will retained.
- The process of settlement estimation for prudential purposes and in the event of metering data or system failure will also calculate energy transactions for every five-minute period

Industry data flows

AEMO considers that existing data formats, known as the MDFF NEM12 and MDM, will need to be amended to enable the delivery of five-minute metering data to participants and to AEMO for settlement. Whilst the MDFF NEM12 currently allows for delivery of five-minute metering data, AEMO considers that there is value in establishing a new format, proposed to be identified as MDFF NEM22, specifically for the delivery of data to participants.

A review of metering data formats should include the potential for the removal of the need to generate the separate MDM file created for AEMO, in favour of AEMO adopting the revised MDFF NEM12 and NEM22 formats for use in settlement.

Dispatch and market information

AEMO's design will involve changes to accept five-minute offers and bids, but retain a number of existing 30-minute market information processes in order to minimise implementation costs and risks for the industry.

AEMO will create new data structures to receive, store and use five-minute bids and offers. Bids will be validated using existing processes, modified to allow for five-minute data. Dispatch processes will be modified to load bid data from the five-minute rather than 30-minute data. Systems used by AEMO to manage the market will require changes to accommodate five-minute offers and bids. AEMO will also create new processes to publish five-minute offer and bid data.

Implementation

There are a number of processes that will be impacted by five-minute settlement which involves time periods that will span the commencement date. AEMO has identified transition approaches for each based on the process being impacted. In terms of settlement cutover, AEMO intends to make changes to systems and processes to implement five-minute settlement on a commencement date that is within a billing week.

The implementation of five-minute settlement will involve AEMO making changes to a number of procedures and other documentation, and AEMO has performed an initial assessment of impact.

AEMO is currently assessing the merits and drawbacks of technology implementation options including externally licenced MDM and Settlement modules, and modification and re-architecture of existing systems. Given the extent of the changes to AEMO and participant systems, it is proposed that the changes are made available for industry-wide testing for a period of 3-6 months prior to go-live. The initial assessment is that this could be facilitated through AEMO's existing pre-production systems, which provide an integrated non-production environment for retail, metering, B2B, dispatch, settlement and prudential functions.

AEMO will work with industry and the AEMC to develop an implementation schedule and consultation process for five-minute settlements that meets the timelines set out in the draft determination.

CONTENTS

1. INTRODUCTION

1.1 Background

In December 2015, Sun Metals Corporation submitted a rule change request that proposes to align dispatch and settlement in the NEM through a modification of the settlement interval to five minutes. The rule change proposal involves compulsory five-minute settlement for generators, scheduled loads and market interconnectors. Retailers and large consumers could choose to be settled on either a five-minute or 30-minute basis.

On 19 May 2016, the AEMC initiated its assessment of the proposed rule with the publication of a consultation paper for stakeholder comment.

On 22 August 2016, the AEMC extended the period of time to make the draft determination on the rule change proposal to 30 March 2017, under section 107 of the National Electricity Law.

Following requests from stakeholders, on 2 February 2017 the AEMC extended the period of time to make the draft determination on the rule change proposal to 6 July 2017, under section 107 of the National Electricity Law.

On 11 April 2017 the AEMC published a directions paper to facilitate public consultation and assist stakeholders to make submissions on the rule change request. The directions paper provides details of how five-minute settlement could be implemented subject to stakeholder feedback on detailed costs and benefits. The AEMC held a public forum on the discussion paper in Sydney on 4 May 2017.

On 4 July 2017, the AEMC extended the period of time to make the draft determination on the rule change proposal to 5 September 2017, under section 107 of the National Electricity Law.

As part of the draft determination process the AEMC has requested AEMO to provide guidance on design and implementation of the rule change. This High Level Design report will accompany the draft determination and provide guidance for industry on implementation and transition considerations. Stakeholders will be able to review this High Level Design as part of the consultation process in respect of the draft determination and provide feedback as part of the submission process for the draft determination.

1.2 Purpose

The purpose of this report is to provide a high level operational design for the implementation of the five-minute settlement rule change to support the draft determination. The specific objectives of the report are to:

- Enable market participants and other affected stakeholders to evaluate the system and process changes they would need to make, and quantify the associated one-off and ongoing costs, and to provide feedback as part of their submissions to the draft determination
- Inform the AEMC's choice of transition period length and other aspects of the rule change.
- Provide guidance to the AEMC in respect of the draft and final determination and rules.

The High Level Design ("HLD") prepared for this report has been determined given a set of base assumptions provided by the AEMC, as outlined in the table below. The design prepared for this report is thus specific to these Base Assumptions and any changes to these assumptions would require a reconsideration of the design.

Base Assumptions

Design element	Assumption
Rule	AEMC makes a positive rule implementing five-minute settlement

Spot Price	The 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.
Data source for settlement	Revenue metering. No SCADA.
Scope of implementation and extent of application across market participants	• Types 1, 2 and 3 meters will need to record and store five-minute data from the commencement date of the rule. • Type 4 meters at a transmission network connection point or distribution network connection point where the relevant financially responsible Market Participant is a Market Generator or Small Generation Aggregator will need to record and store five-minute data from the commencement date of the rule. • All other types 4, 5 and 6 meters that are already installed do not need to provide five-minute data at the commencement date. The data from these meters will be profiled to five-minute trading intervals by AEMO using net system load profiles • From 1 December 2018, all new and replacement type 4 metering installations will need to record and store five-minute data. • 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.
Residues and imbalances	Allow to merge with existing *intra*-regional settlement residues.
Five-minute bidding	Five-minute bidding to be implemented
Settlement-by-difference	• Settlement-by-difference would be maintained, but would operate at a five-minute resolution (i.e. types 4, 5 and 6 would be profiled to five-minute resolution using five-minute data from TNIs) • AEMO would develop five-minute NSLPs
Publishing 30-minute prices	AEMO to publish 30-minute regional prices calculated in the same way that it is now for a number of years after rule commencement through a transitional rule.
Commencement of rule	July 2021

1.3 Workstreams and Document Structure

The high-level design was structured into a set of nine workstreams as outlined below. Internal workshops were held in respect of each key workstream with guidance and expertise provided from key subject matter experts within AEMO. The workstreams identified were:

- Metering
- Energy calculation
- Residue treatment
- Settlement framework
- Industry data flows
- Dispatch and market information
- Transition arrangements
- Implementation factors
- Other matters

This HLD report is structured as follows:

- Section 1 provides an introduction to the HLD and outlines the purpose and scope of the work undertaken by AEMO and the structure of the document;
- Section 2 focuses on the metering and metrology aspects and procedures;
- Section 3 covers settlement calculations including profiling, transactions (both energy and non-energy) and residue treatment;
- Section 4 focuses on industry data flows including B2B, meter data and reconciliation reporting;
- Section 5 relates to changes required to dispatch and market information, incorporating the impact of the change to five-minute bidding;
- Section 6 covers key issues relating to transition and cutover for settlement and process;
- Section 7 covers other issues such as settlement frameworks, prudentials and reallocations; and
- Section 8 deals with implementation including impact on procedures, technology implementation considerations, industry timeframes and market readiness.

2. METERING

2.1 Metrology

The proposed Rule requires the collection, storage and delivery of revenue metering data based on five-minute intervals for use in energy settlement, network and retail billing. AEMO understands that this is a specific metrological requirement that is substantially different from current interval metering arrangements where metering devices have been designed to collect, store and deliver metering data based on 30-minute intervals. As a result of this change, and subject to confirmation from the National Measurement Institute, metering devices designed to record metering data in five-minute intervals will require their own pattern approval.

Pattern approval determines whether an instrument is capable of retaining its calibration over a range of environmental and operating conditions and ensures that the instrument is not capable of facilitating fraud. It is a means of determining the quality of the instrument.

In the case of electricity meters, the pattern approval process is conducted by an approving authority appointed by the National Measurement Institute, and typically includes exposing devices to a range of conditions under which they are reasonably expected to perform (e.g. extremes of heat and cold).

Pattern approval can be provided for metering devices that have been originally designed and installed for the purpose of recording revenue metering data on a 30-minute basis, providing that an application for the five-minute design of that meter was made and subsequently approved by an approving authority.

Based on preliminary discussions with the National Measurement Institute, the use of five-minute data to profile 30-minute metering data (under the method proposed in this paper – section 3.2.2) would not require existing 30-minute metering devices to undergo a new pattern approval as the total sum of energy for the 30-minute period would still be based on the 30-minute interval design that the metering has pattern approval for.

Information on the National Measurement Institute and the pattern approval process is available on the NMI website.[2]

2.2 Metering device storage capacity and accuracy

A number of in-service 30-minute metering devices may be capable of conversion to five-minute intervals. Where this is possible, and in particular where the conversion can be performed remotely, it is likely that it would be a more efficient process to make a connection point capable of five-minute interval recording than physically replacing the metering equipment.

When such a conversion is contemplated, the relevant Metering Coordinator will need to determine whether the metering installation remains compliant with the Rules with regard to the storage capacity of the metering device (NER 7.8.2(a) (9) and (10)), and metering installation accuracy requirements (NER S7.4.3) prior to undertaking the conversion.

Class accuracy

AEMO does not expect modern interval meters, which typically demonstrate a far higher degree of accuracy that is required by their classification, to be materially affected upon a change from 30-minute to five-minute interval design, however it remains a possibility.

In the case where a metering device designed to record 30-minute intervals to an accuracy standard of, say 0.5% maximum error, can only demonstrate an accuracy standard of a maximum 1% error when converted to a five-minute interval design, and where the meter has been installed at a metering

[2] http://www.measurement.gov.au/Industry/services/Pages/Pattern-Approval.aspx

installation that requires an accuracy or 0.5%, the meter would no longer be fit for purpose and would require replacement.

Clock error

AEMO has not identified any changes to the Rule requirements for metering installation clock error are necessary to support a change from 30-minute to five-minute settlements.

Storage capacity

Current minimum requirements for the storage of interval energy data are set at 35 days for metering installations with remote acquisition and 200 days for those that are manually read. These arrangements have been put in place to support the efficacy of the settlement process. AEMO has not identified any factors associated with the change from 30-minute to five-minute settlements that requires these minimum storage requirements to be reviewed.

There is a possibility that some older in-service metering devices at metering installations with remote acquisition, may be able to meet all other design and accuracy criteria but are unable to maintain compliance with the necessary storage requirements due to the increase in the number of intervals being recorded. AEMO has insufficient information to determine the materiality of this issue, but expects that Metering Coordinators, Metering Providers and metering manufacturers will provide more information through the AEMC's Rule change process in order that quantification of this matter can be properly assessed. In the case that there is materiality, options to reduce the need for inefficient replacement of existing devices could include:

- Metering Coordinators seeking confirmation of no enforcement action from the Australian Energy Regulator until such time that the device is replaced; and
- The Rule requesting AEMO establish an exemption process for metering installations that are in-service upon the commencement of the Rule. The exemption process could consider processes proposed by the Metering Coordinator to mitigate the risks of data loss, including collection frequency and proactive identification of metering installation malfunctions.

For the avoidance of doubt, AEMO does not consider that any such arrangement need apply to new metering devices installed following the commencement of the Rule. AEMO's understanding of new metering devices (including type 4 metering installations installed at small customer connection points since the publication of the AEMC's final determination on the Competition in Metering and Related Services Rule in November 2015) is that they are capable of recording energy to intervals smaller than five minutes (subject to pattern approval) and have sufficient memory capacity to meet the storage requirements in the Rules.

2.3 Type 7 metering data calculation

The annual load attributed to Type 7 metering installations is in the region of 1000 GWh. Whilst the type 7 load profile is flat, the intervals in which load commences and ceases changes daily. AEMO proposes that the granularity of the calculated type 7 load be changed from 30-minute to five-minute due to the potential impact on the trading intervals at the commencement and cessation of the type 7 load periods.

To illustrate the matter further, a simplified example is provided:

- Take for arithmetic simplicity a street lighting load of 60kW. This load will consume 60kWh every hour, 30kWh for each 30-minute trading interval and 5kWh for every five-minute trading interval.
- Apart from the solstice or equinox events (where sunset and sunrise times are constant for 2-3 days), sunrise and sunset times generally shift by 1 minute each day and these time shifts are factored into the type 7 Metering Data Provider's energy calculation for the trading intervals in which sunset or sunrise occur each day. In essence, on/off table values change every day.

- For 30-minute trading intervals (current situation) the energy volumes, as we approach summer, would resemble the following:
    a, Sunset five minutes into a trading interval – i.e. lights off for first five minutes of the trading interval, then lights on for 25 minutes of the trading interval.

        Energy (lights on) = 25/30 x 30kWh = 25kWh (4.166kWh per five-minute sliced trading interval)

    b, Lights off for first 10 minutes of trading interval

        Energy (lights on) = 20/30 x 30kWh = 20kWh (3.33kWh per five-minute sliced trading interval)

        Lights off for first 15 minutes of trading interval

        Energy (lights on) = 15/30 x 30kWh = 15kWh (2.5kWh per five-minute sliced trading interval)

    c, Lights off for first 20 minutes of trading interval

        Energy (lights on) = 10/30 x 30kWh = 10kWh (1.66kWh per five-minute sliced trading interval)

    d, Lights off for first 25 minutes of trading interval

        Energy (lights on) = 5/30 x 30kWh = 5kWh (0.83kWh per five-minute sliced trading interval)

    For the same 30-minute period where five-minute trading intervals apply, the five scenarios would look like this (each number is the consumption per five-minute trading interval);

    1. Energy = 0 + 5 + 5 + 5 + 5 + 5 =25kWh
    2. Energy = 0 + 0 + 5 + 5 + 5 + 5 =20kWh
    3. Energy = 0 + 0 + 0 + 5 + 5 + 5 =15kWh
    4. Energy = 0 + 0 + 0 + 0 + 5 + 5 =10kWh
    5. Energy = 0 + 0 + 0 + 0 + 0 + 5 =5kWh

    While the total energy consumed over the same 30-minute period is the same, the settled energy for each “sliced” five-minute trading interval (shown in red above) is very different when compared with “actual” five-minute trading interval consumption energy. A similar outcome will occur during the 30-minute period that contains sunrise time.

2.4 Metering in embedded networks

AEMO has not identified any requirements that necessitate alternative arrangements to be established for metering within embedded networks. Whilst it may appear preferable for the granularity of energy being recorded at the parent and on-market child connection points within embedded networks to be matched, AEMO’s settlement systems can adequately handle different granularity of metering data between the parent and child connection points.

AEMO is noticing a growing number of generators being registered within embedded networks, but points out that all market generation will require five-minute metering as a consequence of the wholesale settlement process.

2.5 AEMO metering and metrology procedures

There are a number of matters determined in AEMO procedures that are likely to require review prior to the commencement of the proposed Rule, including:

Frequency of Metering Data delivery – AEMO procedures specify the delivery requirements for metering data for settlements. This is facilitated by AEMO's Data Delivery Calendar, which currently sets a minimum requirement for metering data to be delivered in weekly batches. Whilst it is commonplace for Metering Data Providers to deliver metering data more frequently than specified in the Data Delivery Calendar, it may be prudent for AEMO to review whether the minimum requirement should be reduced as a result of the increased volume of data in each file for five-minute interval metering data.

Sample metering for the Controlled Load Profiles – AEMO's Metrology Procedures contain the requirements for the delivery of metering data to support the creation of the Controlled Load Profile (CLP) for New South Wales, Queensland and South Australia. AEMO considers that a move from 30-minute to five-minute settlement would necessitate a change in the current provision of 30-minute interval metering data for the sample metering which supports the CLP calculation. Subject to the requirements of the proposed Rule and where necessary the agreement of the participating jurisdiction, AEMO is keen to explore innovative and efficient ways to facilitate a change in metering arrangements to support a five-minute interval CLP.

Accreditation - Metering Data Providers and Metering Providers intent on providing five-minute metering services will need to amend their process and systems to meet the requirements of the Rules and procedures and this will require application for accreditation, or extension to an existing accreditation.

Participant Registration - AEMO has identified no specific changes that would require a participant's registration to be reviewed, or for the registration of any new party as a result of this design.

3. SETTLEMENT CALCULATION

3.1 Overview

The calculation of settlement amounts is fundamentally based on energy volumes which are derived from metering data for each connection point in the NEM. The current metering arrangements involve a mixture of different types of metering data, which are combined using agreed algorithms to determine the required energy volumes for settlement.

The proposed policy for five-minute settlement will involve changes to the types of metering data that will be provided as part of settlement. The type of metering data can be broadly summarised into the categories in the table below.

Table 1 Categories of metering data

Category	Connection points involved	Type of metering data
Wholesale boundary	• Market generating units (connected to a transmission, distribution or exempt network[3]) • Small generating units (classified by a Small Generation Aggregator) • Wholesale customers (i.e. transmission connected customer) • Boundary between the transmission and distribution networks • Regulated interconnectors • Market network service providers (currently only Basslink)	Interval metering data with five-minute resolution
Distribution network customers	• Retail customers • Non-market and exempt generating units • Unmetered loads	Either: • Interval metering data with five-minute resolution • Interval metering data with 30-minute resolution • Accumulation metering data
Exempt network customers	• Retail customers • Non-market and exempt generating units • Small generating units • Unmetered loads	Same as for distribution network customers, however parent and child market connection points not permitted to have a different type of metering data

The settlement arrangements for each of these categories involves a different calculation methodology, as set out in the following table.

[3] Note that AEMO's settlement systems treat market generators that are connected to a distribution system or within an exempt network as being part of the wholesale boundary. An adjustment is made to debit the local retailer of the distribution network for any sent-out generation.

Table 2 Settlement calculation methodologies

Category	Methodology	Settlement approach
Wholesale boundary	All participants calculated directly using metered energy	Direct calculation – no algorithms required
Distribution network customers	• Local retailer calculated indirectly using settlement by difference algorithm • Other participants calculated directly using metered energy	Profiling algorithms required to derive five-minute energy data from accumulation and 30-minute metering data
Exempt network customers	• Embedded network host retailer calculated indirectly using subtractive calculation • Market participants associated with embedded network child customers calculated directly using metered energy	Profiling algorithms required to derive five-minute energy data from accumulation and 30-minute metering data

The following sections will outline the algorithms and associated processes necessary to derive energy values for all connection points.

3.2 Profiling

The process of profiling is a calculation to estimate energy volumes suitable for settlement where the metering data does not support the required granularity. It involves determining a shape (referred to as profile preparation) based on other metering with suitable resolution, and then applying that shape to the energy volume of each connection point required.

3.2.1 Current arrangements

The current profiling arrangements involve two profiling algorithms, which are defined in the Metrology Procedures[4]:

- Net system load profile (NSLP) – this is used to determine energy volumes for accumulation metering (other than those associated with controlled loads in applicable jurisdictions) on the basis of the shape of energy in an area which is not interval metered.
- Controlled load profile (CLP) – this is used to determine energy volumes for accumulation metering which is associated with a controlled load in applicable jurisdictions[5] on the basis of a shape determined by a set of sample meters.

The process for calculating the net system load profile is implemented as a series of steps in AEMO's meter data management system[6], as follows:

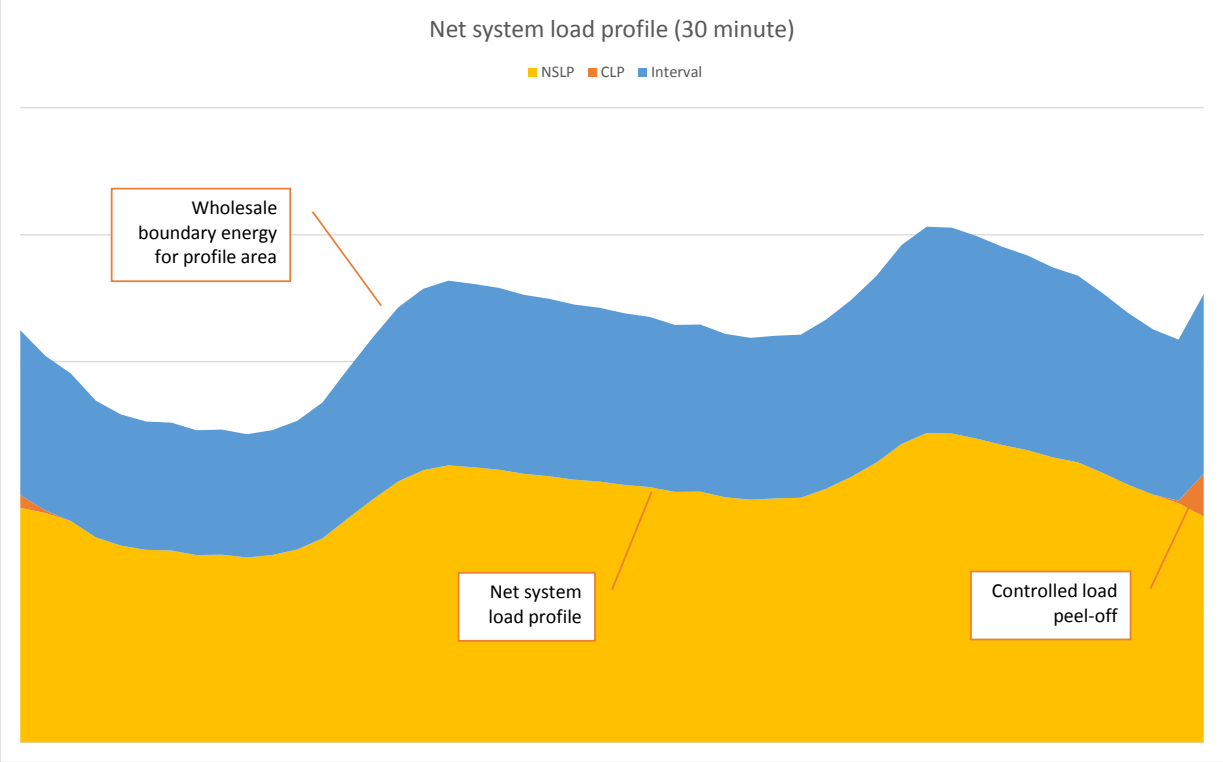
1. For each profile area, the energy for the wholesale boundary (each TNI) is determined based on 30-minute metering data.
2. The energy associated with all meters that have 30-minute metering data is summated, both for first-tier and second-tier connection points. This includes metering data associated with contestable unmetered loads treated as Type 7 metering installations.

[4] The Metrology Procedures are located at: http://www.aemo.com.au/-/media/Files/PDF/Metrology-Procedure-Part-B-v530.pdf
[5] Currently NSW, Qld and SA
[6] Further information is provided in the MDM Procedures located at: http://www.aemo.com.au/-/media/Files/PDF/0640-0023-pdf.pdf

3. The NSLP is determined by subtracting the sum of all 30-minute metering data from the profile area energy volume. If a CLP has been calculated for the jurisdiction, then the CLP is also "peeled off" the NSLP.

The following diagram represents the calculation of the NSLP for a settlement day.

Figure 1 Current profiling approach



The process of calculating the controlled load profile is performed using the following steps:

1. For each type of controlled load, 30-minute meter data is obtained from sample meters that have been installed at representative connection points.
2. The CLP shape is determined by averaging the energy volumes of the associated sample meters.
3. The CLP is scaled by the total energy volume derived from accumulation meters to be profiled by the CLP

Having prepared both the NSLP and CLP, these profiles are then applied to the energy volumes of all accumulation meters based on the profile type of each data stream.

3.2.2 Proposed arrangements

To support the introduction of five-minute settlement, the profiling arrangements will need to be amended to provide for the following:

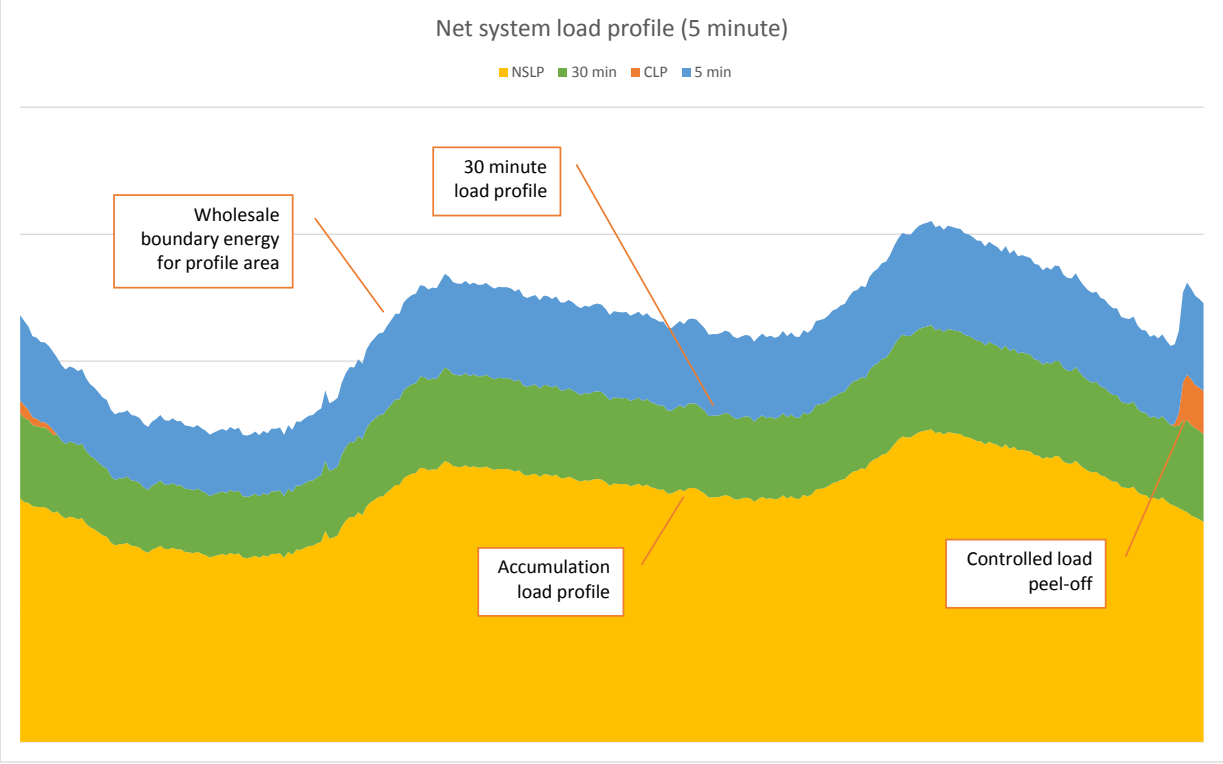
- Preparation of a load profile with five-minute granularity for the profiling of non-controlled load accumulation meters
- Preparation of a load profile with five-minute granularity for profiling of controlled load accumulation meters
- Preparation of a load profile with five-minute granularity for profiling of 30-minute meters.

The process of calculating these profiles is proposed to be done using the following steps:

1. For each profile area, the energy for the wholesale boundary (each TNI) is determined based on five-minute metering data.
2. The energy associated with all meters that have five-minute metering data is summated, both for first-tier and second-tier connection points. This includes metering data associated with contestable unmetered loads with Type 7 metering.
3. The 30-minute load profile is determined by subtracting the sum of all five-minute metering data from the profile area energy volume. If a CLP has been calculated for the jurisdiction, then the CLP is also "peeled off" the 30-minute load profile.
4. The energy associated with all meters that have 30-minute metering data is summated, both for first-tier and second-tier connection points.
5. The total 30-minute energy is profiled using the 30-minute load profile, which provides a five-minute representation of 30-minute metering data.
6. The five-minute representation of 30-minute metering data is subtracted off the 30-minute load profile, to derive an accumulation load profile.

The following diagram represents the calculation of load profiles to support five-minute settlement.

Figure 2 Proposed profiling approach



The proposed arrangements have a number of characteristics that are intended to align with the proposed policy for five-minute settlement:

- The profiling of 30-minute metering data is based on a "dynamic" profile, rather than simply apportioning the energy in six equal amounts for each five-minute period. The dynamic profile is calculated as the shape of all energy which is not metered on a five-minute basis, so as metering arrangements progressively transition the profile will best reflect the remaining non-five-minute meters.

- The controlled load profile will be determined with five-minute granularity – this will require a change to the existing sample meters, but will improve the accuracy of the controlled load profile shape.
- Controlled load 30-minute meters will be profiled using the CLP shape within each 30-minute period
- Non-controlled load accumulation meters will be profiled using a shape that reflects the net system with a five-minute granularity, excluding all meters with either five-minute or 30-minute metering.
- To support the introduction of five-minute data streams, it is proposed that a new data stream type be created.

To support the implementation of the proposed arrangements, AEMO will amend the Metrology Procedures and MDM procedures through consultation in accordance with the requirements of the NER.

3.3 Energy transactions

Energy transactions are calculated in AEMO's settlement system using energy volumes determined directly from metering data or by the application of profiling or estimation. To support five-minute settlement, energy transactions will be calculated with the following characteristics:

- Transactions will be calculated for every five-minute period. This involves using the energy volume for each market connection point with five-minute granularity, the five-minute price, and the MLF applicable to the period.
- The current process of calculating MLFs will be retained, with a single MLF calculated for each transmission connection point[7] for each financial year. AEMO proposes that MLFs will continue to be calculated on the basis of 30-minute energy volumes, as initially there is unlikely to be any material impact by using five-minute energy volumes.
- The process of settlement estimation which provides energy volumes for prudential purposes and in the event of metering data or system failure will also calculate energy transactions for every five-minute period. This process does involve using SCADA data for estimating scheduled generation output and for scaling like-day energy, and this will require aggregation to a five-minute level.

3.4 Residue treatment

Within the NEM settlement process a number of residues and imbalances can arise as a result of loss factors and inherent limitations in measurement. The following table outlines the impact and approach on each category of residue as a consequence of five-minute settlement.

Table 3 Residue treatment impact

Residue category	Methodology	Impact and approach
Inter-regional settlement residue	Proportion of settlement residue associated with inter-regional losses and price difference	Regulated interconnector flows will be metered with five-minute granularity, allowing the residue to be calculated on a five-minute basis. The residue will be allocated on a five-minute basis such that: • Positive residues are allocated through the SRA process.

[7] Except in cases where a dual MLF is calculated that applies to imports and exports individually. The determination of which MLF to apply will be based on the net flow in each five-minute period.

		• Negative residues are allocated to the appropriate TNSP. The calculation on a five-minute basis is expected to improve the firmness of SRA, as the potential for changes in flow direction during the period is reduced. Auction units are currently allocated up to 3 years in advance, which aligns with the proposed timing for introducing five-minute settlement. The calculation of interconnector losses is currently performed during the dispatch process using SCADA data, however is not recalculated during settlement – the use of five-minute metering data will permit losses to be recalculated during settlement, improving the accuracy of the loss estimation and allocation.
Intra-regional settlement residue	Proportion of settlement residue associated with intra-regional loss factors (MLFs)	As all wholesale boundary connection points will be metered with five-minute granularity, the intra-regional settlement residue can be accurately calculated on a five-minute basis.
Distribution network imbalances	Imbalances arise as a result of profiling, distribution loss factors, and the use of estimated metering data. These imbalances are currently not explicitly accounted for in the settlement-by-difference methodology.	Existing imbalances will remain under five-minute settlement, however an additional type of imbalance will arise due to the process of profiling 30-minute metering data to five. Initial analysis indicates the magnitude of this imbalance will be very small compared to existing imbalances (such as the profiling of accumulation meters), and so AEMO proposes to not separately account for the new imbalance.
Embedded network imbalances	Imbalances arise as a result of profiling, distribution loss factors, and the use of estimated metering data. These imbalances are currently not explicitly accounted for in the subtractive metering arrangements	Embedded network imbalances will be impacted in a similar way to distribution network imbalances; equivalent metering on parent and market child connection points is likely to reduce the impact.

3.5 Non-energy transactions

In addition to the settlement of energy transactions, the NEM also involves a number of other transactions, such as ancillary services, intervention compensation and participant fees. These transactions are much lower in volume, usually less than 5% of energy transactions, and the majority of these transactions are calculated on the basis of energy proportion.

The introduction of five-minute energy settlement has the potential to improve the granularity of the non-energy cost allocation, and the table below outlines AEMO's proposed approach.

Table 4 Non-energy transaction approach

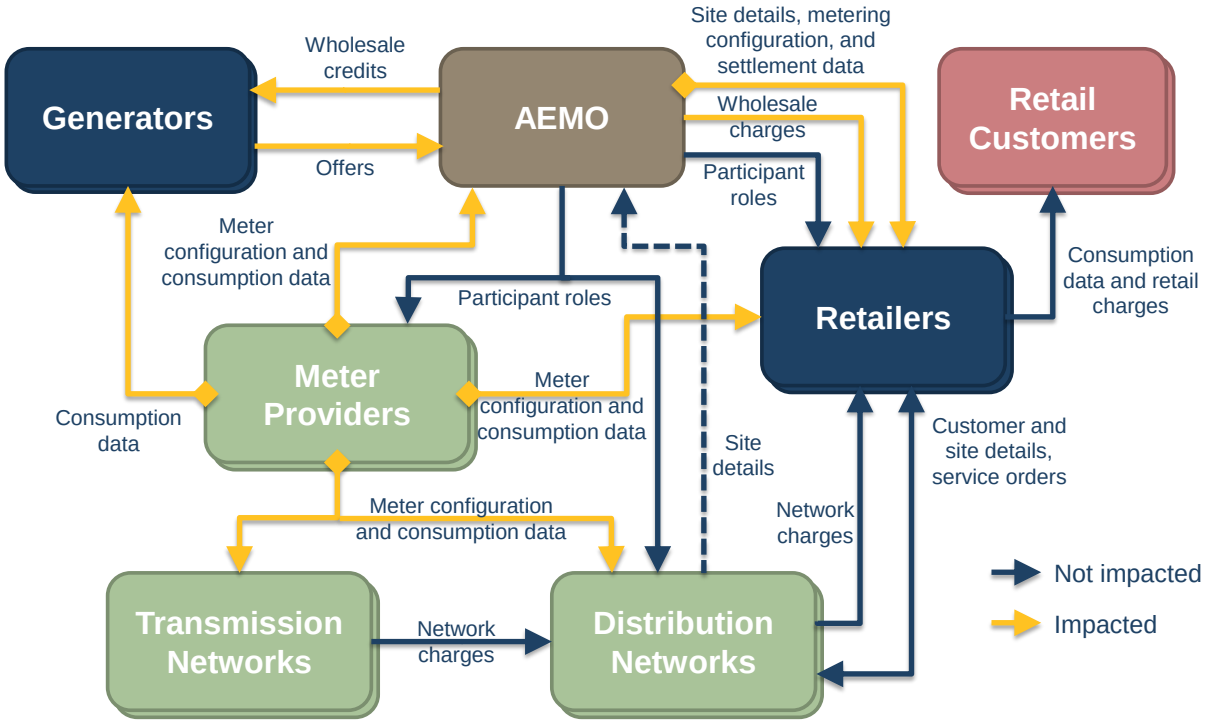
Transaction	Allocation	Proposed approach
Market ancillary services (i.e. FCAS)	Contingency services are allocated to market customers (lower) and market generators (raise) on the basis of energy proportion. Regulation services are allocated to market participants through the causer pays process, which includes a residual component being allocated to market customers on the basis of energy proportion.	The allocation for both contingency and regulation will be amended to use five-minute energy volumes – this will improve the granularity of the allocation, and ensure that price signals for the ancillary services market are not diminished.
Non-market ancillary services	Services are recovered from market customer and/or market generators on the basis of energy proportion.	The allocation will continue to be done on the basis of 30-minute energy volumes.
Direction compensation recovery	Compensation costs are recovered from market customer and/or market generators on the basis of energy proportion.	The allocation will be amended to use five-minute energy volumes over the period of the direction.
Mandatory restriction recovery	Costs are recovered from market customers on the basis of energy proportion.	The allocation will continue to be done on the basis of 30-minute energy volumes.
Administered price compensation recovery	Costs are recovered from market customers on the basis of energy proportion.	The allocation will be amended to use five-minute energy volumes over the administered price period.
RERT recovery	Costs are recovered from market customers on the basis of energy proportion.	The allocation will continue to be done on the basis of 30-minute energy volumes.[8]
Participant fees	Costs are recovered on the basis of the structure of fees determined and published by AEMO.[9]	The allocation on the basis of energy (which applies to market customers) will continue to be done on the basis of 30-minute energy volumes.

[8] RERT is currently recovered on the basis of net energy volumes over a billing week during the hours of 8am to 8pm on business days – consequently 30-minute and five-minute energy volumes will derive the same result.
[9] AEMO's current structure of participant fees is located at: https://www.aemo.com.au/Stakeholder-Consultation/Consultations/Electricity-Markets---Structure-of-Participant-Fees

4. INDUSTRY DATA FLOWS

In addition to the direct impact to AEMO and participant systems, five-minute settlement will also involve changes to a number of data flows within the industry. The diagram below represents the high-level electricity data flows, with those being impacted by five-minute settlement being highlighted in yellow.

Figure 3 Impacted data flows



The following sections will outline the specific areas of impact.

4.1 B2B arrangements

The business-to-business (B2B) e-hub is a technology platform which supports a set of standardised interfaces between participants and service providers, and enables the delivery of metering data. The delivery of metering data is facilitated using the Meter Data File Format (MDFF), and in particular interval meter data uses the NEM12 MDFF. Although this file format is technically capable of supporting different interval periods (including five-minute), AEMO considers that it would be beneficial to create an additional variant specifically for five-minute metering data.[10] This differentiation would simplify the logic for gateways and backend systems to process the existing 30-minute and proposed five-minute metering data.

The other important consideration for B2B arrangements with the introduction of five-minute settlement will be the volume of meter data being exchanged. The existing 30-minute data already involves a significant volume of data being transmitted across communications infrastructure, and so participants will need to consider the implications of the increased data volumes.

[10] This format could be identified as NEM22 for instance.

4.2 Meter data for settlement

AEMO requires Metering Data Providers (MDPs) to submit metering data for settlement according to AEMO's Data Delivery Calendar[11], which specifies the data delivery timetable. This data is provided to AEMO's Meter Data Management system, in accordance with the MDM Procedures[12]. The existing file format for data submission involves a file format that is specifically intended for 30-minute metering data, and would require modification to support five-minute metering data.

AEMO considers that it would be preferable to not create an additional meter data file format, but rather to enhance the MDM system to process MDFF data (including the proposed five-minute NEM22 file). AEMO would continue to support the existing file format for 30-minute interval and accumulation metering data.

4.3 Reconciliation reporting

AEMO produces a range of reporting data associated with settlement statements that facilitates reconciliation by participants. This data is produced in two primary ways:

- Energy data, produced by AEMO's MDM system (these reports are referred to as RM reports)
- Settlement data, produced by AEMO's wholesale settlement system (these reports are delivered through Data Interchange[13])

To support reconciliation at a five-minute level, AEMO proposes to make the following changes to reporting:

- Develop MDM reports to deliver five-minute energy data
- Where settlement outcomes are calculated at a five-minute level, provide reconciliation data on a five-minute basis.

AEMO is intending to continue to support existing 30-minute reports where appropriate.

4.4 Other data flows

AEMO has also identified the following data flows that will be impacted by five-minute settlement

- AEMO publishes a format for customer access to meter data, under the Meter Data Provision Procedures (MDPP)[14]. It will be necessary to amend these procedures to facilitate access to five-minute meter data by customers. At present the file format involves are variant of the NEM12 file, and a potential option would be to permit the proposed NEM22 to be supplied to customers.
- AEMO provides data to MDPs to facilitate validation of metering data for check metering that is based on SCADA data. This data is produced in NEM12 format, and will be amended to provide data in the proposed NEM22 format.
- AEMO performs the billing of Transmission Use of System (TUoS) charges in Victoria, and receives meter data from MDPs for Victorian transmission customers. AEMO expects to amend this process to receive the proposed NEM22 format as required.

[11] The data delivery calendar is located at: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Retail-and-metering/Metering-procedures-guidelines-and-processes
[12] The MDM Procedures are located at: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Retail-and-metering/Market-Settlement-and-Transfer-Solutions
[13] Information on data interchange is located at: https://www.aemo.com.au/Gas/IT-systems-and-change
[14] The Meter Data Provision Procedures are located at: https://www.aemo.com.au/Stakeholder-Consultation/Consultations/Metering-Data-Provision-Procedures

5. DISPATCH AND MARKET INFORMATION

This section describes changes to the central dispatch process and market information, including offer and bids, price determination, pre-dispatch, spot market operations timetable, and projected assessment of system adequacy (PASA).

5.1 Overview

AEMO's design will involve changes to accept five-minute offers and bids, but retain a number of existing 30-minute market information processes in order to minimise implementation costs and risks for the industry.

5.2 Offers and bids

The draft rule changes the resolution of bids and offers in the NEM from 30-minute to five-minute, which means the number of bidding intervals in a day will increase from 48 to 288. The rule does not change the underlying structure of bid information provided for each interval. In the NEM, offers are provided by generators and bids are provided by customers but are otherwise essentially identical.

Changes identified cover receipt and validation of five-minute bids and offers, creation of 30-minute bids for use in 30-minute processes, and management of default bids.

5.2.1 Five-minute offers and bids

AEMO will create new data structures to receive, store and use five-minute bids and offers. Bids will be validated using existing processes, modified to allow for five-minute data.

Dispatch processes will be modified to load bid data from the five-minute rather than 30-minute data.

5.2.2 30-minute offer and bid data

Processes such as 30-minute pre-dispatch and PASA that use bid information will require 30-minute offer and bid data. The existing 30-minute offer and bid data will continue in their current form. AEMO will populate this data with data from the last five-minute interval for each 30-minute period. For example, the 30-minute period ending 04:30 the bid will use information from trading interval[15] ending 04:30.

Any rebidding that changes a trading interval ending on the hour or half hour will trigger a revision of the derived 30-minute rebid.

5.2.3 Default offers and bids

Clause 3.8.9 of the Rules describes processes for default offers and bids. Under this procedure, AEMO substitutes the most recent valid offer or bid for the default offer or bid as an input to PASA, pre-dispatch and central dispatch (as per clause 3.8.9I of the Rules). This process will continue under five-minute settlement, with the additional requirement that a 30-minute prior offer or bid will be used until a five-minute prior offer or bid becomes available.

5.3 Central Dispatch Process

The central dispatch process is already a five-minute process and will not require any changes to the solver (NEM dispatch engine or NEMDE) or reports that come out of the solution. The systems that load offers and bids will be modified to use the new five-minute offers and bids, and any modified processes for default offers and bids.

[15] Under the proposed rule, the defined term trading interval will be altered and dispatch interval will be removed.

5.4 Pre-dispatch

AEMO has not identified any initial changes to the existing implementation of pre-dispatch. That is:

- The 30-minute pre-dispatch[16] will continue in its current form, covering the period from the next 30-minute period after the current 30-minute period up to an including the final 30-minute period of the trading day.
- The current five-minute pre-dispatch will continue in its current form, covering the period from the next five-minute trading interval for a period of 60 minutes. However, the five-minute pre-dispatch will load data from the five-minute offer and bid data, rather than from 30-minute offer and bid data.

5.5 Market information

AEMO will create new processes to publish five-minute offer and bid data. Otherwise, AEMO has not identified any material changes to market information being published, including information that is not required under the rules, such as pre-dispatch PASA.

Existing 30-minute price data will continue to be calculated and published in its current form.

The spot market operations timetable may require some consequential amendments before the rule commences.

5.6 AEMO Operational Systems

Systems used by AEMO to manage the market will require changes to accommodate five-minute offers and bids.

[16] The rules require pre-dispatch to be published at least every two hours

6. TRANSITION AND CUTOVER

6.1 Settlement cutover

The NEM settlement process is based on a billing week period, which is a 7 day period from the first trading interval on Sunday (currently the trading interval ending 00:30 EST) until the last trading interval the following Saturday. The majority of calculations are performed on a settlement day basis (from midnight to midnight), and then aggregated to a billing week. There a small number of calculations which can only be performed on a billing week basis, however none of these calculations are fundamentally impacted by five-minute settlement. AEMO's process of aggregating data for settlement that is performed within the meter data management system will however be limited to operating on either a 30-minute basis or a five-minute basis.

Consequently, AEMO will be required to make changes to settlement systems and processes to implement five-minute settlement on a commencement date that is within a billing week. These changes are expected to be minor compared to the overall work program, and so should not be a significant factor when considering the timing of commencement.

6.2 Processes spanning commencement

There are a number of processes that will be impacted by five-minute settlement which involves time periods that will span the commencement date. This requires specific considerations of how to handle old and new arrangements within the same operation. The table below outlines the initial assessment of these impacted processes spanning commencement:

Table 5 Impacted processes

Process	Impact	Transition approach
Bidding	Bids/offers are submitted on a trading day basis (4am to 4am), which will involve a trading day that spans the commencement date.	Specific functionality will be required to handle this, depending on the policy requirement for when five-minute bidding comes into effect.
Cumulative price threshold	The calculation of rolling sum over the previous 7 days will involve a mixture of 30-minute and five-minute prices.	Specific functionality will be required to perform this calculation.
Default pricing schedule	The calculation of default prices will involve a mixture of 30-minute and five-minute prices.	AEMO's procedure for estimated prices will need to address the transition, and corresponding functionality will be implemented.
Basic meter profile preparation	The window for preparing and applying the net system load profile will involve a mixture of 30-minute and five-minute metering data.	The process of weighting the profile across periods that span the commencement date will specifically factor in the different granularity of metering data.
Initial meter run	Initial metering data for prudential purposes covers a period of approximately five days, and will span the commencement date for a short period.	AEMO's functionality for processing metering data will allow five-minute or 30-minute logic based on whether the settlement day is before or after the commencement date.

Settlement statements and revised statements	Settlement statements (including revised statements) are issued up to 30 weeks after the billing period, and so statements issued after commencement may relate to previous arrangements.	AEMO's settlement processes will operate based on the applicable arrangements on each particular settlement day. Changes will be required to systems and processes to handle settlement statements which span the commencement date.
Settlement reports and data	Settlement reports and associated data are issued with settlement statements, hence relate to previous arrangements	During the transition it is expected that different data structures will be required to support 30-minute and five-minute settlement data. AEMO will publish data into the corresponding structure for each settlement day, and participants will need to be able to handle data in both structures.
Maximum credit limits (MCLs)	MCLs are determined approximately 3 months in advance, and at least one routine review will involve periods after commencement	AEMO estimates price and energy for next period based on historical data. The transition from 30-minute to five-minute will be considered in the Credit Limits Procedure and associated systems.

7. OTHER CONSIDERATIONS

7.1 Power system security

AEMO has not identified any material risks to power system security from the implementation of five-minute settlement that are not already being addressed through AEMO's existing Future Power System Security program.

In particular, very fast responding facilities such as batteries will be subject to AEMO's interim arrangements for utility scale battery technology[17].

7.2 Settlement framework

AEMO is in the process of considering the suitability of a 'global settlement and reconciliation process' against the current 'settlement-by-differencing' settlements framework. This is due to a number of factors, including the extent to which local retailer customer numbers have fallen due to high levels of customer switching in many areas of the NEM, and recent rule changes that affect the retail market, such as competition in metering.

Whilst AEMO considers that there is no dependency between a potential change to a global settlement framework and a move toward five-minute settlements, it is likely that synergies could be found for the design and build of technology platforms and information technology systems within the NEM should they be progressed in tandem. Accordingly, AEMO will work with the AEMC on the progress of the proposed Rule and AEMO's ongoing consideration of settlement frameworks.

7.3 Prudentials

The NEM prudential arrangements are intended to manage the risk of participant default, by requiring participants to collateralise their actual and contingent liabilities. The process of settling on a five-minute basis is expected to have some impact to participant liabilities, and so it is proposed that prudential arrangements be amended as follows:

- Settlement estimation – AEMO performs an estimation of settlement amounts on a daily basis, for the purposes of assessing prudentials, and as a fall-back in the event of a metering data or system failure. This process involves SCADA data where applicable for generation, and like-day estimation for customer energy. The use of five-minute metering will allow this calculation to be refined, in order to better reflect settlement amounts during periods of high price volatility.
- Initial metering data – AEMO also uses any metering data provided prior to the preliminary statement (five business days after the end of a billing week) in order to better assess liabilities for prudential purposes. This process occurs each business day, and involves any actual or estimated metering data that is available at the time. The availability of five-minute metering data will be included in this process.
- Outstandings – the calculation of outstandings is part of AEMO's daily prudential assessment against the participant's trading limit. The amount of outstandings is the sum of all invoiced but unpaid amounts, plus an estimate of amounts that have not yet been invoiced. By virtue of the settlement and estimation calculation being amended to use five-minute metering data, the calculation of outstandings will also reflect five-minute metering.
- Prudential forecast – AEMO performs a forecast of prudential outstandings for each market participant, on a similar basis to that used for settlement estimation. This process uses price

[17] https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwip3KbB1-zVAhUTOrwKHSiKDy8QFggoMAA&url=https%3A%2F%2Fwww.aemo.com.au%2FElectricity%2FNational-Electricity-Market-NEM%2FParticipant-information%2FNew-participants%2FInterim-arrangements-Utility-Scale-Battery-Technology&usg=AFQjCNHEFWyL-gBOt7eyCJ4mL2OQexGItw

information that is available from either the five-minute pre-dispatch (for the next hour) or 30-minute pre-dispatch (the remainder of the trading day). On the basis that the majority of the period will remain as a 30-minute price, AEMO proposes to not amend the prudential forecast process.

- Credit limits – AEMO determines an MCL for each market participant on a routine basis (typically each season), which must be met with bank guarantees. The availability of five-minute resolution trading price and energy volumes could be used to support a more granular calculation of load and price volatility, however this would involve a moderate level of system changes. AEMO proposes to further consider if changes to the Credit Limits Procedure and associated systems are warranted.

7.4 Reallocations

Reallocations provide the option for two market participants or reallocators[18] to make a matching credit and debit transaction which is reflected in their settlement statement, for the purposes of offsetting spot market transactions with financial market contractual arrangements. At the moment AEMO provides reallocation procedures and systems that permit transactions to occur on a half-hourly (existing trading interval) basis, calculated as either:

- A fixed dollar amount per half-hour;
- A fixed energy amount per half-hour, which uses the half-hourly spot price to determine the transaction value; or
- An energy amount and strike price per half-hour, which uses a swap, cap or floor methodology to determine the transaction value.

AEMO proposes to continue to support 30-minute reallocations, by using a 30-minute spot price which is consistent with the current NER methodology[19]. Some minor changes to existing reallocation procedures will be required in order to reflect changes to terminology, and to ensure appropriate basis for determining a 30-minute price.

AEMO also proposes to consult with market participants and reallocators on the practicality of developing five-minute reallocations, which would involve new reallocation procedures which use the five-minute price along with a daily profile consisting of 288 values. It is expected that five-minute reallocations would support the introduction and growth in five-minute contractual arrangements.

[18] A reallocator is category of registration that allows a registered participant to perform reallocations without having a physical involvement in the NEM.
[19] The existing spot price is calculated in accordance with 3.9.2(h) as the time-weighted average of dispatch prices within the trading interval

8. IMPLEMENTATION

8.1 Procedures

The implementation of five-minute settlement will involve AEMO making changes to a number of procedures and other documentation. A detailed analysis of the impact will be undertaken as part of implementation planning, however the following table summarises AEMO's initial assessment of impact.

Table 6 Impacted procedures

Procedure (and document location)	Consultation requirement	Impact
Spot market operations timetable http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Dispatch-information	Rules consultation	Minor changes to terminology
Reallocation procedures http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Settlements-and-payments/Prudentials-and-payments/Procedures-and-guides	Rules consultation	Requires amendments to permit reallocations on a 30-minute basis to continue to operate
Settlement estimates policy http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Settlements-and-payments/Settlements/Procedures-and-guides	Rules consultation	Requires amendments to perform settlement estimation on a five-minute basis
Causer pays procedure http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Ancillary-services-causer-pays-contribution-factors	Rules consultation	Minor changes to terminology
Credit limits procedure http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Settlements-and-payments/Prudentials-and-payments/Maximum-Credit-Limit	Rules consultation	Minor changes to terminology – AEMO to give further consideration on changing to five-minute resolution pricing and energy profiles
Estimated price methodology https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Market-Management-System-MMS/Market-Suspension-Pricing-Schedule	Rules consultation	Requires amendment to calculate on a five-minute basis
Metering data provision procedures https://www.aemo.com.au/Stakeholder-Consultation/Consultations/Metering-Data-Provision-Procedures	Rules consultation	Requires amendment to permit five-minute resolution metering data

MDM procedures https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Retail-and-metering/Market-Settlement-and-Transfer-Solutions	Rules consultation	Requires amendment to define process for new profiling methodologies
Metrology procedures (Subject to consultation at time of writing)	Rules consultation	Requires amendment to define algorithms for new profiling
Service Level Procedures: Metering Data Provider Services (Subject to consultation at time of writing)	Rules consultation	Consider requirements for delivery of five-minute metering data and frequency of data delivery to market.
Service Level Procedures: Metering Data Provider Services (**MDFF Specification)** (Subject to consultation at time of writing)	Rules consultation	Requires amendment to permit five-minute resolution metering data

8.2 Technology

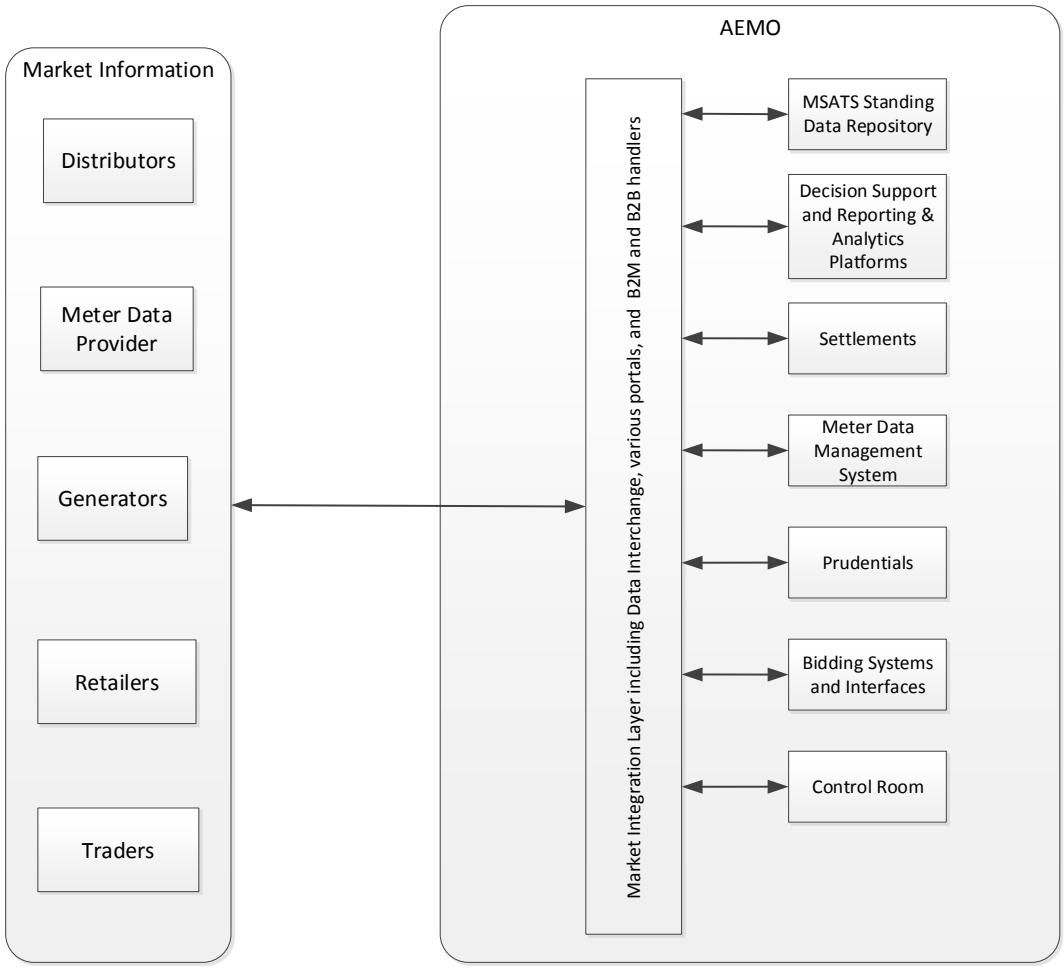
A high level system architecture is provided below. Preliminary review of the implementation of five-minute settlements from a technology and IT systems perspective has suggested two alternatives: i) replacement of existing systems with new Meter Data Management ("MDM") and Settlement modules, or ii) modification and re-architecture of existing systems. AEMO is currently assessing the merits and drawbacks of each approach. Some of the considerations involved include:

- an external 'off the shelf' solution to perform the metering data management and settlements functions has some industry benefits in allowing the ongoing hosting licensing and other platform components to be managed externally, allowing AEMO to focus on application business functions;
- external solutions would also incur an ongoing cost component that needs to be assessed and weighed against one-off costs;
- the need to build a system that is able to scale effectively with the increased data flows and storage requirements; and
- the ability to be able to have re-usable components and modules for other market initiatives.

The current settlements approach requires Metering Data Providers and Retailers to have additional interfaces to send /receive settlement meter data in an aggregated (NET format), as well as the ability to send a retail format more commonly known as a NEM12 which provides more granular level information. In its technology implementation AEMO will consider the costs of standardisation to the retail format as against the benefits that may include remove of multiple standards and complexity allowing AEMO to aggregate the retail meter data for settlement purposes.

Downstream systems will also be impacted as updates will be required to regression tests, web portals, and data interchange reports. Many of the decision support systems and reports for bidding will also need to be updated. The solution would also need to make use of existing components where appropriate.

Figure 4 High Level System Architecture

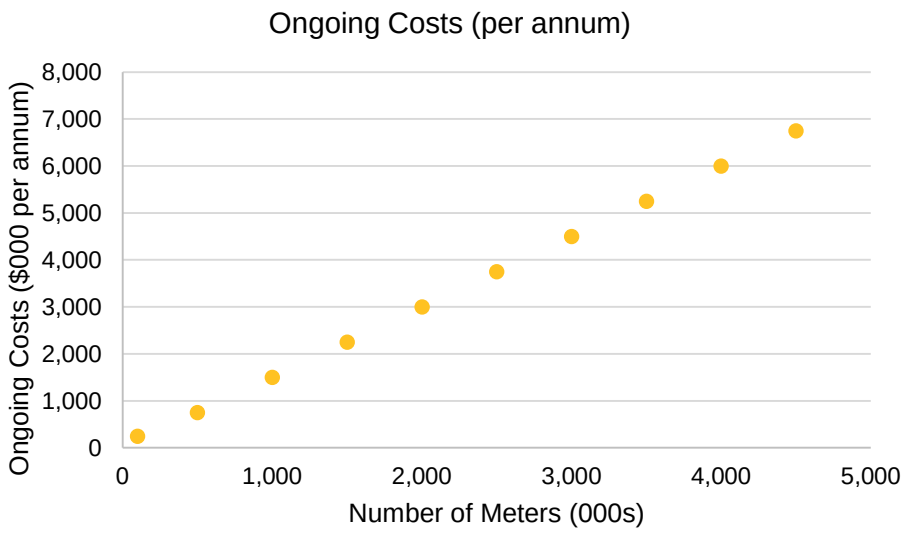


8.3 Costs

In its submission to the AEMC Directions Paper, AEMO provided a cost estimate of $10-15 million for an implementation of five-minute settlement within AEMO's systems and operations. The estimate incorporates costs for 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. Ongoing costs were estimated at around $2-7 million and incorporate costs relating to licensing, databases, application software, hardware and storage, and modules.

AEMO has reviewed its costings for the implementation and continues to consider that its original costing estimate of $10-15 million for upfront costs remains appropriate. Relative to the Directions Paper that has proposed a design involving mandatory rollout across all meter types, the AEMC Draft Determination does not impose five-minute settlements on a mandatory basis for all Type 4-6 meters. Consequently AEMO considers it likely that there would be a more measured rollout of five-minute metering for small customers based on retailer and network capital expenditure and operational plans. Ongoing costs, where the solution was based on an externally licensed solution would likely be based on and scale proportionately with the meter rollout. As an example we provide a scenario for ongoing costs based on an initial transition of 100,000 meters on commencement and an ongoing rollout of around 500,000 meters per year.

Figure 5 Ongoing operating costs (based on number of interval meters)



It is important to note that this costing was based on externally licensed meter data management and settlement modules. To the extent that an internal solution is preferred the proportional breakdown between upfront and ongoing costs would change.

8.4 Timeframes

AEMO will work with industry and the AEMC to develop an implementation schedule and consultation process for five-minute settlements that meets the timelines set out in the draft determination. Key timelines in respect of the process:

- AEMO will amend and publish its relevant procedures that apply from the commencement date by 1 December 2020.
- AEMO will publish a procedure setting out the requirements for applying for an exemption from complying with the data storage requirements for types 1, 2, 3, and 4 metering installations installed prior to 1 July 2021 by 1 December 2020.
- AEMO 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.

8.5 Market readiness

Given the extent of the changes to AEMO and participant systems, it is proposed that the changes are made available for industry-wide testing for a period of three to six months prior to go-live. The initial assessment is that this could be facilitated through AEMO's existing pre-production systems, which provide an integrated non-production environment for retail, metering, B2B, dispatch, settlement and prudential functions.

During the period of industry-wide testing, end-to-end testing would be facilitated through:

- Bidding and dispatch – accepting bids/offers in the new format, and have these included in the pre-dispatch and dispatch processes
- Market information – distribution of dispatch-related market information (except public data normally published to the AEMO website)
- Metering data – receipt and processing of existing and five-minute metering data to AEMO's meter data management system

- B2B – participant delivery of existing and five-minute metering data via the B2B e-hub
- Settlement – coordinating settlement calculations and delivery of settlement statements and associated data
- Prudentials – performing prudential calculations, including settlement estimation

Industry-wide testing may need to involve some scripted test cases, particularly for settlement and prudential functions, and for some unusual market circumstances like administered pricing, intervention, market suspension etc. However it is expected that the majority of testing could be done without AEMO coordination – this would enable participants to develop their own test cases and timing within the testing window.

AEMO considers that there may be some merit in developing a coordinated readiness assessment process, which could be facilitated by AEMO. This assessment would be particularly appropriate if the new market arrangements come into effect without any period of system transition. An example would be if all scheduled participants are required to submit bids/offers with five-minute granularity from and on the commencement date.

GLOSSARY

This document uses many terms that have meanings defined in the National Electricity Rules (NER). The NER meanings are adopted unless otherwise specified.

Term	Definition
AEMO	Australian Energy Market Operator
AEMC	Australian Energy Market Commission
B2B	Business-to-business
Billing week	A period of 7 days starting the trading interval ending 00:30 on Sunday
CLP	Controlled load profile
DLF	Distribution loss factor
FCAS	Frequency Control Ancillary Services
First-tier	A distribution connection point for which the local retailer is financially responsible
HLD	High Level Design
IEC	Information Exchange Committee
MCL	Maximum credit limit
MDFF	Meter data file format
MDM	Meter data management
MLF	Marginal loss factor
Metering Coordinator	A person who is registered by AEMO as a Metering Coordinator under Chapter 2 of the National Electricity Rules
NMI	National metering identifier National Measurement Institute
NER	National Electricity Rules
NEM	National Electricity Market
NEMDE	National Electricity Market Dispatch Engine
NSLP	Net system load profile
PASA	Projected Assessment of System Adequacy
Profiling	The process by which energy volumes are estimated where metering data does not support the required granularity
Reallocations	A mechanism that supports matching credit and debit transactions between two market participants or reallocators
SCADA	Supervisory control and data acquisition
Second-tier	A distribution connection point for which a retailer other than the local retailer is financially responsible
Settlement residue	A surplus (or deficit) of funds for energy transactions between what AEMO receives from market customers and pays to market generators
SRA	Settlement residue auction
TNI	Transmission node identifier
TNSP	Transmission network service provider
Trading day	A period of 24 hours from 4am to 4am
TUOS	Transmission Use-of-System