Settlement Estimation for Prudential Assessments – Guide

Prepared by:	AEMO Settlements and Prudentials
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Current version release details

Version	Effective date	Summary of changes
2.0	3 June 2024	• New AEMO template. • Updated text in multiple places to reflect the five-minute settlement rule. • Amendments to the methodology for determining settlement estimates for previous day energy at a TNI level when no meter data is available. • Edited document for clarity, minor drafting improvements.

Note: There is a full version history at the end of this document.

1. Introduction

1.1. Purpose and scope

This document is a guide (**Guide**) to help *market participants* understand the Settlement Estimation process that the Australian Energy Market Operator (**AEMO**) performs for the purposes of doing prudential assessments for National Electricity Market (**NEM**) *market participants*.

This Guide accompanies the NEM Settlement Estimates Policy (**Policy**), which is made under clause 3.15.12(c) of the National Electricity Rules (**NER**).

1.2. Definitions and interpretation

1.2.1. Glossary

Terms defined in the National Electricity Law and the NER have the same meanings in this Guide unless otherwise specified in this clause.

Terms defined in the NER are intended to be identified in this Guide by italicising them, but failure to italicise a defined term does not affect its meaning.

In addition, the words, phrases and abbreviations in the table below have the meanings set out opposite them when used in this Guide.

Term or acronym	Definition
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
Aggregated reads	Consumed Energy and Sent Out Energy aggregated to a TNI level
BESS	Battery Energy Storage System
Consumed Energy	For a *market connection point* for a *trading interval* is calculated as follows: ME- × DLF
DAILY estimate	A settlement estimate run for the previous day. Referred to in EMMS as a DAILY billing run.
DLF	The *distribution loss factor* applicable at the *market connection point*
DRSP	Demand Response Service Provider
EMMS	Electricity Market Management System
EMS	Energy Management System
Individual reads	Consumed Energy and Sent Out Energy at a *NMI* level
INITIAL meter data	Meter data sourced from the *MSATS* system prior to the preliminary run.
Interim estimate	A settlement estimate run for days for which INITIAL meter data was loaded into EMMS overnight. Referred to in EMMS as an INTRIM billing run.
MDP	Meter Data Provider
ME-	For a *market connection point* for a *trading interval*, the amount of electrical energy estimated in accordance with paragraph 3.2.1 of the Policy, expressed as a negative value in MWh, flowing at the *connection point* in the *trading interval*, where the flow is away from the *transmission network connection point* to which the *connection point* is assigned.

Term or acronym	Definition
ME+	For a market connection point for a trading interval, the amount of electrical energy estimated in accordance with paragraph 3.2.1 of the Policy, expressed as a positive value in MWh, flowing at the *connection point* in the *trading interval*, where the flow is towards the *transmission network connection point* to which the *connection point* is assigned.
Meter Entity	National Metering Identifier (NMI) or Transmission Node Identifier (TNI).
MSATS	Market Settlement and Transfer Solution
MSRP	Market SAPS Resource Provider
NEM	National Electricity Market
NER	National Electricity Rules
NMI	National Metering Identifier
PD	Prudential day
Policy	NEM Settlement Estimates Policy
SAPS	Stand-alone power system
SCADA	Supervisory Control and Data Acquisition
Sent Out Energy	For a market connection point for a trading interval is calculated as follows: ME+ × DLF
TNI	Transmission Node Indentifier
UFE	Unaccounted for energy

1.2.2. Interpretation

This Guide is subject to the principles of interpretation set out in Schedule 2 of the National Electricity Law.

1.3. Related documents

Title	Description and location
NEM Settlement Estimates Policy	Describes AEMO's procedures for the use of estimated values in the calculation of settlement results. https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/market-operations/settlements-and-payments/settlements/procedures-and-guides

2. Background

AEMO monitors the daily prudential position of each *market participant* in the *NEM*. This ensures that AEMO holds enough *credit support* to cover the liabilities of *market participants* and minimise credit risk to the *NEM* as a whole.

The prudential position of *market participants* is monitored through their total *outstandings*. Total *outstandings* is made up of all billable amounts yet to be settled up to, and including, the previous *day*. Where settlement data is not available for calculations of these amounts, the data is estimated.

This guide **ONLY** describes the settlement estimation process for prudential assessment purposes only. It **DOES NOT** describe settlement estimation for settlement purposes.

3. Settlement estimation for prudentials

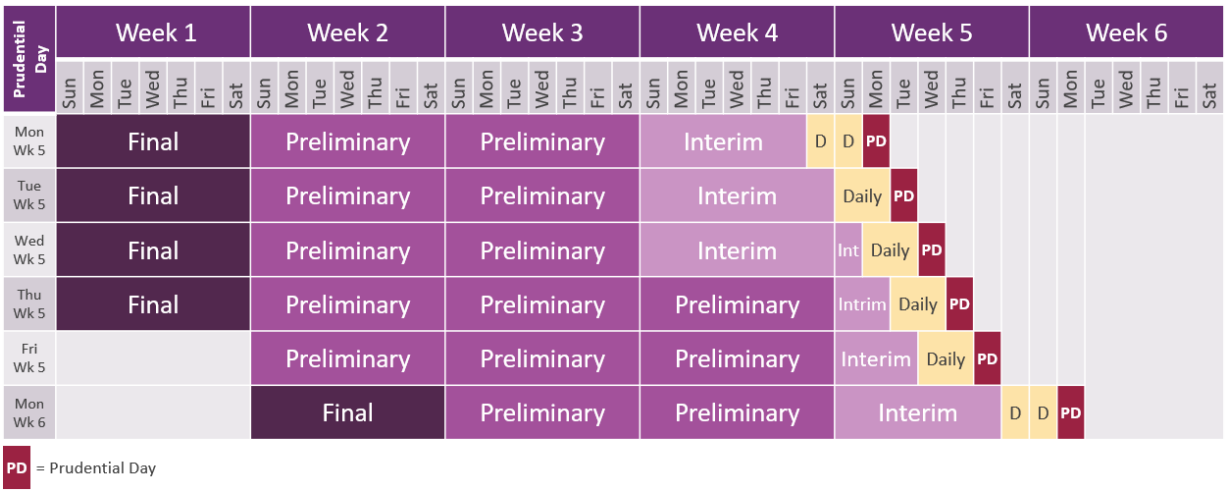
The prudential assessment for a *market participant* covers the *outstandings* period (an average of 30 *days*), which includes any whole *days* for which *energy* has been consumed or sent out but not yet paid. This includes *days* for which:

- A *Final* billing run has been performed, but billing amounts have not yet been paid.
  - Actual settlement data available - no estimates required.
- A *Preliminary* billing run has been performed.
  - Actual settlement data available - no estimates required.
- Other whole *days* (i.e. up to the end of the *day* before the prudential date).
  - Settlement data not available - estimation required (interim and daily estimate).

Figure 1 below shows how the total *outstandings* on a given *day* (a prudential day or PD) is comprised of *final* and *preliminary* settlement data with interim and daily estimates.

Note: If the prudential day is a payment date, the week for which payment is due to be made is excluded from the prudential assessment on that date.

Figure 1 Days included in a prudential estimate



3.1. Settlement estimation process

For *days* where *final* or *preliminary* settlement data is not available, estimation is required. Two types of estimations are performed for prudential purposes:

1. **Interim estimates (INTRIM)** – settlement estimates based on INITIAL meter data, sourced from the Market Settlement and Transfer Solution (MSATS) system and loaded daily into the Electricity Market Management System (EMMS). This data is typically available for D-3 to D-7 (i.e. 3 to 7 *days* in the past). The interim estimate replaces the previous daily estimates and is used to calculate the new *outstandings* amount (see Section 4.1). Typically, the interim estimate is used for 2-8 *days* out of the average 30-*day outstandings* period. The interim estimates are eventually replaced by *preliminary* settlement data once processed.
2. **Daily estimates** – the settlement estimate for the previous *day* (D-1), based on either SCADA data or estimated using a multiple linear regression model (see Section 4.2). Typically, the daily estimate is used for 2 *days* out of the average 30-*day outstandings period*, and after 2 *days*, it is replaced by interim estimates.

The high-level process for generating the interim and daily settlement estimate in EMMS is as follows:

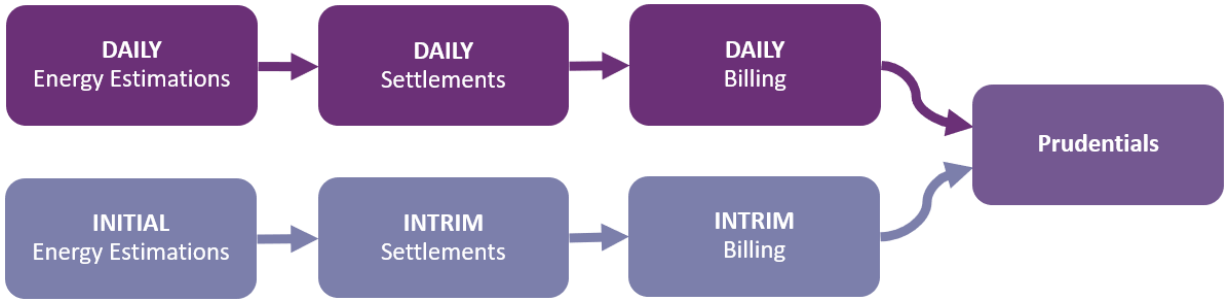
(i) Energy Estimation Run - calculates *trading interval energy* estimates.

(ii) Settlement Run – calculates *trading interval* settlement amounts (including the value of *energy*, *ancillary services* payments and recovery, and fees) based on the *energy* estimates.

(iii) Billing Run – calculates the corresponding weekly billing amounts (settlement amounts aggregated up to a weekly basis).

Each morning EMMS follows this process to generate the interim estimates for *days* in which INITIAL meter data has been loaded into EMMS, and the daily estimate. Once both the interim and daily estimates have been generated, EMMS performs the prudential calculation. Figure 2 below represents this process.

Figure 2 Settlement estimations process



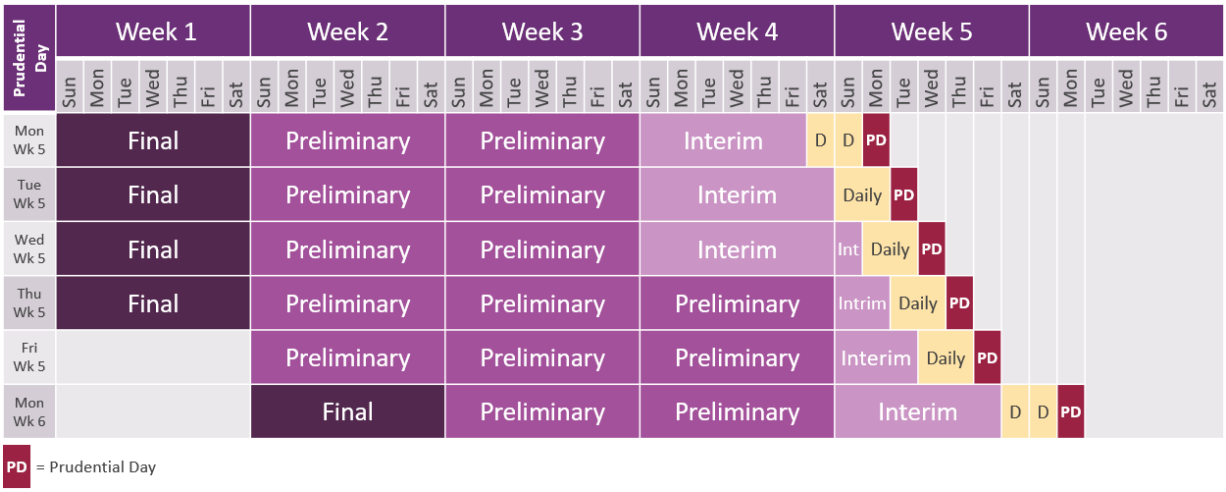
3.2. Days included in the prudential estimate

Figure 3 below shows the *days* and types of data (actual or estimate) used in calculating the total *outstandings*, for a range of prudential days (**PD**):

- Actual settlement data, shown as preliminary and final boxes, is used as available.
- INITIAL meter data is provided for D-3 to D-7 which means that the INTRIM *energy* estimation and settlements run occurs for D-3 to D-7 as shown by the 'Interim' boxes. However, when the INTRIM billing run is calculated it will be done for whole weeks - one or two depending on how many weeks the INITIAL meter data set spans. Each INTRIM billing run will include all *days* in the week for which INITIAL meter data is, or has been, available.
- Daily runs (*energy* estimation, settlements and billing) cover D-1 to D-2 as shown by the 'Daily' boxes. Once the daily estimate is complete, a settlement run converts the *trading interval energy* estimates in EMMS for each *market participant* into settlement amounts.

Once a billing run is completed, including INTRIM or daily, AEMO aggregates all the billing runs over the outstanding period and the daily prudential position is produced for each *market participant*.

Figure 3 Days included in a prudential estimate



3.3. Treatment of unaccounted for energy

Since 1 July 2021, AEMO has published unaccounted for energy (**UFE**) data under the Global Settlements framework. From 6 February 2022, all retailers are billed for a proportion of the UFE in a local area, based on the electricity consumed by their customers within that area. Since this date:

- Where initial metering data and/or preliminary and final settlement data is available, the UFE component is included in the settlement estimation for prudential purposes.
- Where there is no meter data available, and data is estimated based on either SCADA data or multiple linear regression model, then the UFE component on these *days* is assumed to be zero.

4. Estimations hierarchy – Interim and daily estimates

Settlement estimates are calculated based on a hierarchy of available data as outlined in Table 1 below. This hierarchy is considered on a per *trading interval*, per Meter Entity (National Metering Identifier (NMI) or Transmission Node Identifier (TNI)) basis.

The estimation process calculates:

- 'individual reads' *energy* for Consumed Energy and Sent Out Energy at a NMI level; and
- 'aggregated reads' *energy* for Consumed Energy and Sent Out Energy at a TNI level.

In general, the principles of Prudential estimation are as follows:

- meter data is preferred over SCADA data;
- if meter data is incomplete, the estimation process seeks to replace the missing data with SCADA data for individual reads;
- SCADA data is preferred over the regression model; the regression model is only applied for aggregated reads.

Table 1 Data hierarchy

Priority	Description
1.	INITIAL meter data regardless of quality; if available, otherwise
2.	SCADA data (for individual reads, and for aggregated reads if there is a single Financially Responsible Market Participant (FRMP) at the TNI and a SCADA to TNI map*); if available, otherwise
3.	If the absent meter data is expected at the TNI level, then data is estimated based on a multiple linear regression model; if available, otherwise
4.	Estimate of zero (for estimating *wholesale demand response settlement quantity* for DRSPs and Consumed Energy and Sent Out Energy for MSRPs).

* Note: a SCADA to TNI map needs to be established in AEMO's systems.

The following table summarises the estimation method applied by level of Meter Entity aggregation.

Table 2 Estimation method by level of Meter Entity aggregation

Estimation Method	Individual reads (NMI)	Aggregated reads (TNI)
1. INITIAL meter data of any quality	Y	Y
2.a. SCADA data	Y	Y
2.b. Dispatch targets	Y	Y
3. Multiple linear regression model		Y[1]
4. Zero estimate	Y	

(Y = If available and configured)
(1 = for DAILY estimate only)

4.1. Interim estimates

The data available and the type of *market participant* will determine how interim estimates are calculated. The process for calculating interim estimates using the following categories of data (as described above), is summarised below:

(i) INITIAL meter data of any quality

(ii) SCADA data

Multiple linear regression model data is used to calculate *energy* for a DAILY run where meter data is absent and expected to be provided at the TNI level (see Section 4.2).

4.1.1. INITIAL meter data of any quality

INITIAL meter data for (D-3) to (D-7) is sourced from MSATS and loaded into EMMS daily. At the time of settlement estimation, actual data may only be available for sites with remotely read interval meters. There may also be data substituted by Meter Data Providers (**MDPs**). EMMS will base its estimates for *market participant energy* on INITIAL meter data regardless of the quality.

4.1.2. SCADA data

Supervisory Control and Data Acquisition (**SCADA**) data is used as the second priority for estimating *market participant energy* if it is available.

SCADA data in this document encompasses two forms of data (in priority order):

1. SCADA data from AEMO's energy management system (**EMS**), this includes real-time data from remote terminal units.
2. Dispatch targets data, which are targets given by AEMO to providers of *energy*.

For both sets of data:

- If the SCADA or dispatch data value is negative, then it is used as a Consumed Energy estimate.
- SCADA is used as an estimate when the INITIAL meter data is not available.

It's important to note that if revenue meter data is available for a given FRMP at a TNI, all SCADA data that is associated to the TNI is ignored.

SCADA data will be used as the basis of estimates for aggregated reads if there is only one FRMP at the TNI, and there is a SCADA to TNI map in AEMO's systems.

Note: Where there is no TNI to SCADA map in AEMO's systems, multiple regression model *energy* is typically used to calculate DAILY estimates, see Section 4.2

The following notes apply:

- SCADA data is used as an estimate when the INITIAL meter data is not available, in a similar fashion to individual reads estimates.
- SCADA data is loaded for all currently registered participants with SCADA to TNIs maps in AEMO's systems at the date for which the estimate is being performed.

Note: Email prudentials@aemo.com.au and provide a TNI to check if you qualify.

4.2. Daily estimates

As part of the DAILY estimate, SCADA data is used, if available, as the basis of the estimate for all types of *Generators,* other than *Non-Market generators*.

4.2.1. Multiple linear regression model

If no other data is available, as is typically the case for the last two *days* prior to the prudential day (i.e. D-1 and D-2), the settlement estimate for that *day* for *energy* aggregated at the TNI level will be calculated using a multiple linear regression model.

The general form of the multiple regression model is as follows[1]:

$$y_t = \beta_0 + \beta_1 x_{1,t} + \beta_2 x_{2,t} + \cdots + \beta_k x_{k,t} + \varepsilon_t$$

Where:

- y_t is the dependant variable to be estimated by the model which is calculated for Consumed Energy and Sent Out Energy, where t = 8064 observations from 288 periods over 28 *days*.
- $x_{k,t}$ are explanatory variables where k = 291, and these variables are:
  - Region demand.
  - Business day vs non-business day, as single numerical variable with a value of 1 or 0.
  - Date being predicted as an ordinal number in the time series sequence.
  - Period ID as 287 categorical variables for each *trading interval* in a *day*, 1 less than 288 periods to avoid over-fitting.
  - $x_{0,t} = 1$ constant for the intercept.
- β_0 is the coefficient for constant term.
- β_k are the slope coefficients for each of the 291 explanatory variables.
- ε_t represents the random error.

The general form equation can also be expressed as a collection of linear equations:

$$\begin{array}{c} y_1 = \beta_0 + \beta_1 x_{11} + \beta_2 x_{12} + \cdots + \beta_k x_{1T} \\ y_2 = \beta_0 + \beta_1 x_{21} + \beta_2 x_{22} + \cdots + \beta_k x_{2T} \\ \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \\ y_T = \beta_0 + \beta_1 x_{k1} + \beta_2 x_{k2} + \cdots + \beta_k x_{kT} \end{array}$$

This can be expressed in matrix form where all the values of the forecast variable are given in a single equation:

$$\mathbf{X} = \begin{bmatrix} 1 & x_{1,1} & x_{2,1} & \cdots & x_{k,1} \\ 1 & x_{1,2} & x_{2,2} & \cdots & x_{k,2} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & x_{1,T} & x_{2,T} & \cdots & x_{k,T} \end{bmatrix}, \mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_T \end{bmatrix}, \boldsymbol{\beta} = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_k \end{bmatrix}$$

[1] Hyndman, R.J., & Athanasopoulos, G. (2018) Forecasting: principles and practice, 2nd edition, OTexts: Melbourne, Australia. OTexts.com/fpp2. Accessed on 17 October 2023.

Such that:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta}$$

To evaluate the regression model, the least squares estimation can be performed by minimising the error which can be shown when $\boldsymbol{\beta}$ takes the following value:

$$\hat{\boldsymbol{\beta}} = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{y}$$

$\hat{\boldsymbol{\beta}}$ can then be used to calculate the estimated data as follows:

$$\hat{\mathbf{y}} = \mathbf{x}\hat{\boldsymbol{\beta}}$$

Where:

- $\mathbf{X}$ is the matrix of data for the 28 *days* of region demand, business day indicator, date being predicted, and period IDs.
- $\mathbf{y}$ contains 28 *days* of historic meter data for a given TNI, FRMP, LR, NMIClass, and MeterTCD. A $\mathbf{y}$ matrix is produced for both Consumed Energy and Sent Out Energy.
- $\mathbf{x}$ is the matrix of data for the previous *day* of region demand, business day indicator, date being predicted, and period IDs.
- $\hat{\boldsymbol{y}}$ is the predicted estimated values for the previous *day* for a given TNI, LR, NMIClass, and MeterTCD. A $\hat{\boldsymbol{y}}$ matrix is calculated for both Consumed Energy and Sent Out Energy.
- $\mathbf{X}'$ denotes the transpose of $\mathbf{X}$.
- $\mathbf{M}^{-1}$ denotes the inverse of a matrix.

Once the estimates values are calculated, any negative values for both Consumed Energy and Sent Out Energy are zeroed out. A worked example of the regression model has been included alongside this guide on AEMO's website.

It's important to note the following underlying assumptions with the model:

- ε has mean zero, is not autocorrelated and is unrelated to the predictor values of $\mathbf{X}$.

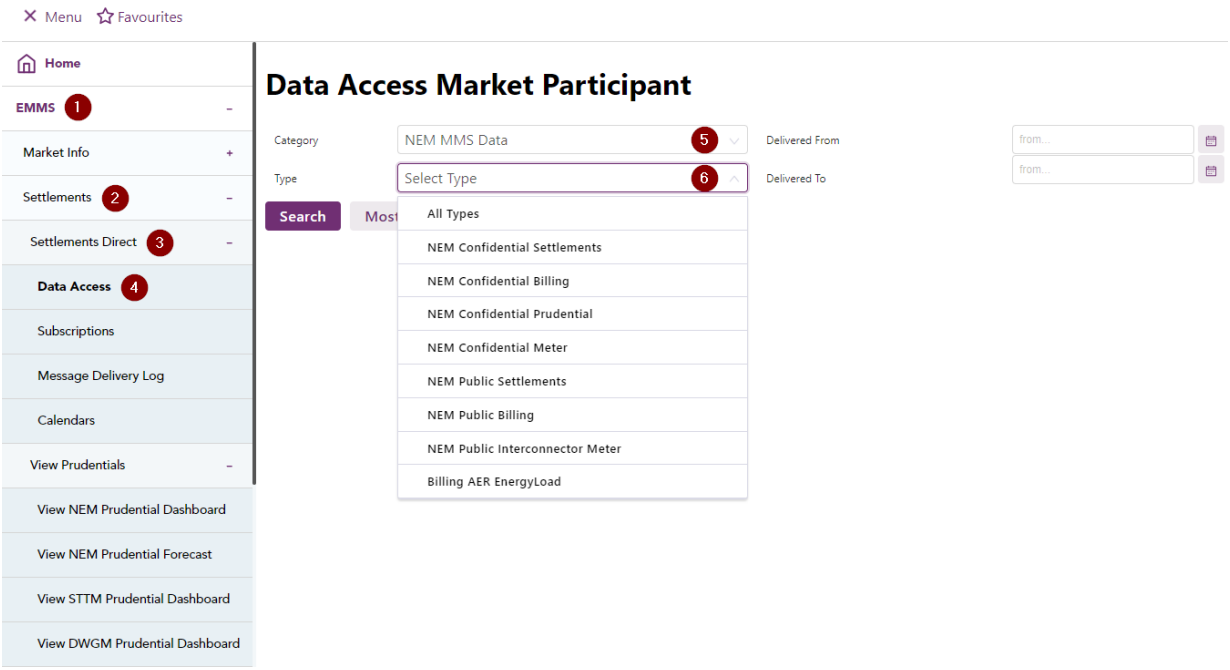
4.3. Settlement estimation triggers

The settlement estimations process runs automatically every *day* at 1:00am AEST and every time INITIAL meter data is loaded into EMMS from MSATS. However, if a *market participant* believes their prudential requirements have been materially impacted due to the regression model estimation not accurately reflecting their actual *energy* use for a given *day*, they can ask AEMO to review their settlement estimate. In such a case, AEMO may re-evaluate the settlement estimate based on additional data available in the MSATS system.

5. Settlements direct

Market participants are able to access their reports relating to settlement estimation via Settlements Direct as shown in Figure 4 below.

Figure 4 Settlement estimation via Settlements Direct



Not all settlement estimations data is published, as shown in Table 3 below.

Table 3 Published data summarised by run type

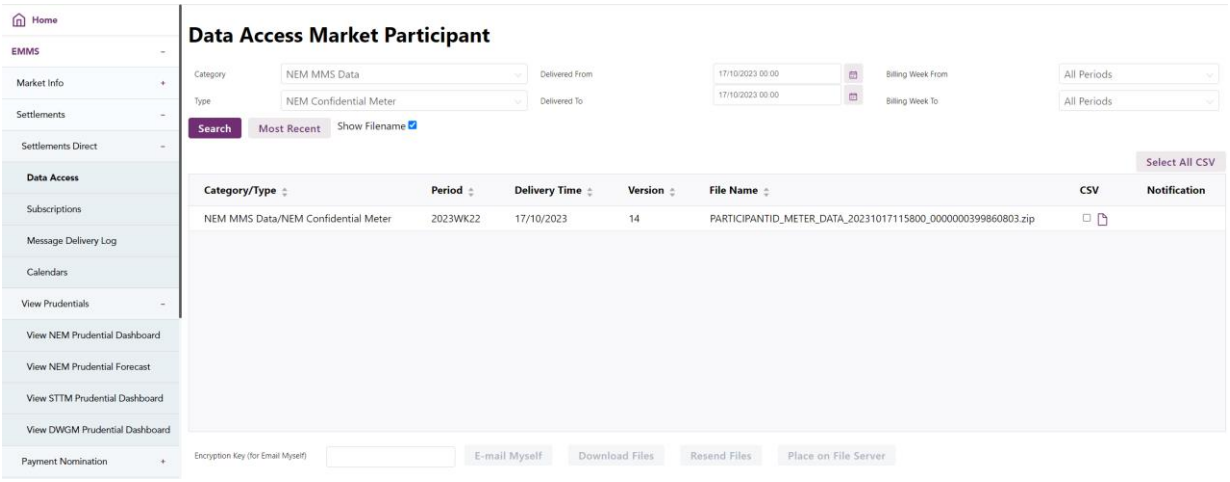
Run type	NEM confidential meter data	NEM confidential settlements data	NEM confidential billing data	NEM confidential prudential data
Daily	Not published	Published	Published	Published daily. Prudentials is an aggregate of all of this information.
Interim	Not published	Not published	Not published	
Preliminary	Published	Published	Published	
Final	Published	Published	Published	
Revision 1	Published	Published	Published	
Revision 2	Published	Published	Published	

5.1. NEM confidential meter data

Confidential NEM meter data for each *market participant* is posted for whole settlement weeks in Settlements Direct for each posted Preliminary, Final and Revision run. Separate files are provided for individual reads and aggregated reads. These files contain meter data for all of a *Market Participant's* connection points for each *trading interval* in the settlement week. *Market participants* only have access to their own confidential meter data.

No confidential meter data is provided for daily or interim runs.

Figure 5 NEM confidential meter data



5.2. NEM confidential settlements data

Confidential NEM settlements data for each *market participant* is posted for whole settlement weeks in Settlements Direct for each posted Preliminary, Final and Revision run. Daily settlement estimates are also published at D+1, with version numbers 990 (Sunday) to 996 (Saturday). *Market participants* only have access to their own confidential settlements data.

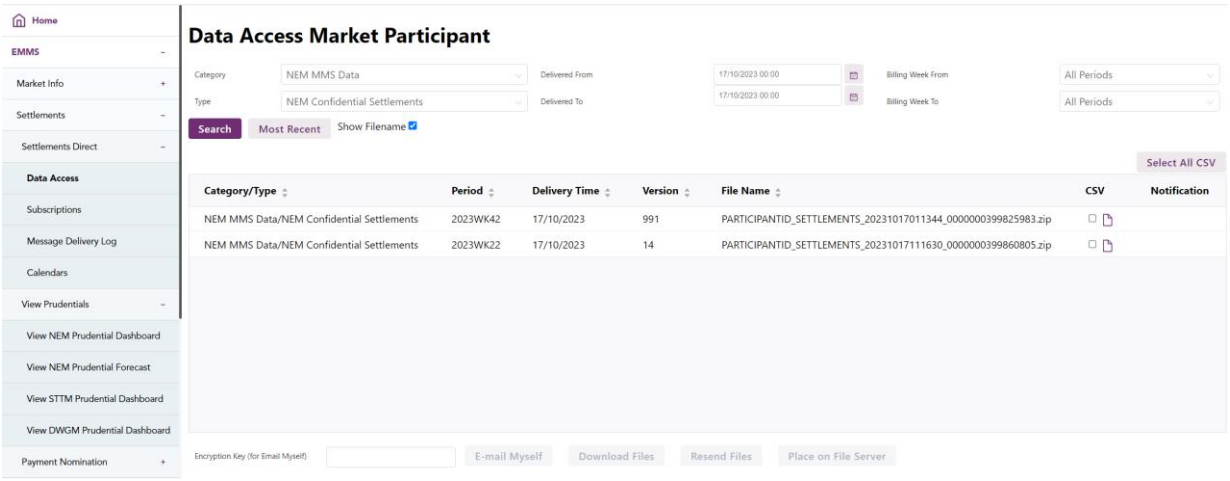
The daily file includes settlements data for each *trading interval* for each *connection point* in ENERGY_TRANSACTION and for each GenSet/NMI in ENERGY_GENSET_DETAIL. The daily file contains data for (D-1).

The files are named as follows “PARTICIPANTID _SETTLEMENTS_DATETIME_IDENTIFIER.zip”.

As part of AEMO’s 6 monthly data model release NEM MMS Data files may be updated, e.g. an extra column is added. *market participants* need to subscribe to these new file formats via the Settlements Direct Subscriptions service otherwise the data files on Settlements Direct will be published in the old file format and end with “_LEGACY.zip”, the naming convention applied retrospectively to published files.

No settlements data is provided for interim runs.

Figure 6 NEM confidential settlements data



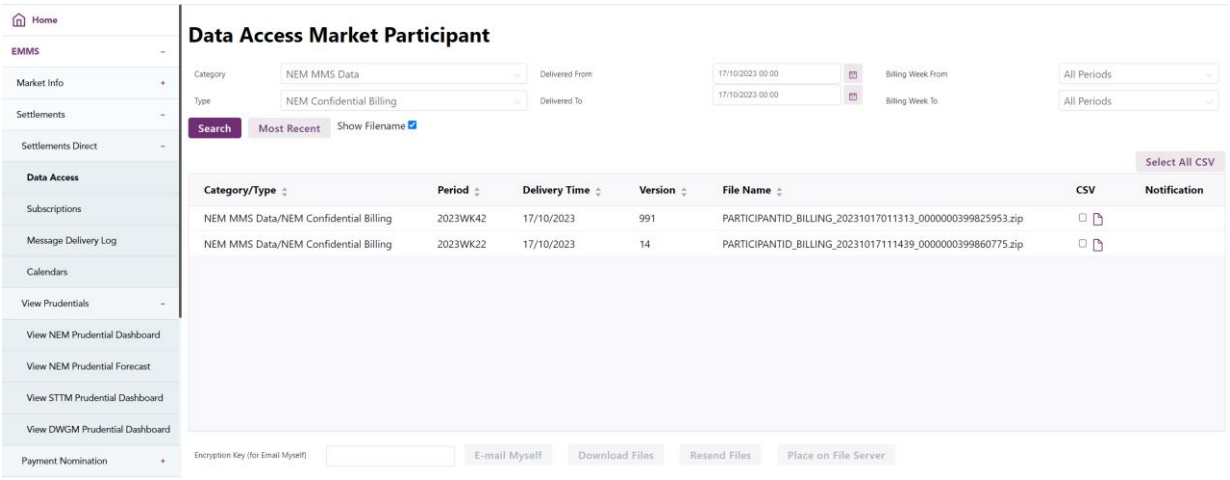
5.3. NEM confidential billing data

Confidential NEM billing data for each *market participant* is posted for whole settlement weeks in Settlements Direct for each posted Preliminary, Final and Revision run. Daily billing estimates are also published at D+1, with version numbers 990 (Sunday) to 996 (Saturday). *Market participants* only have access to their own confidential billing data.

The daily file includes aggregate billing data for each *connection point* for (D-1). The files are named as follows "PARTICIPANTID_BILLING_DATETIME_IDENTIFIER.zip". As discussed above they may also end with "_LEGACY.zip".

No billing data is provided for interim data.

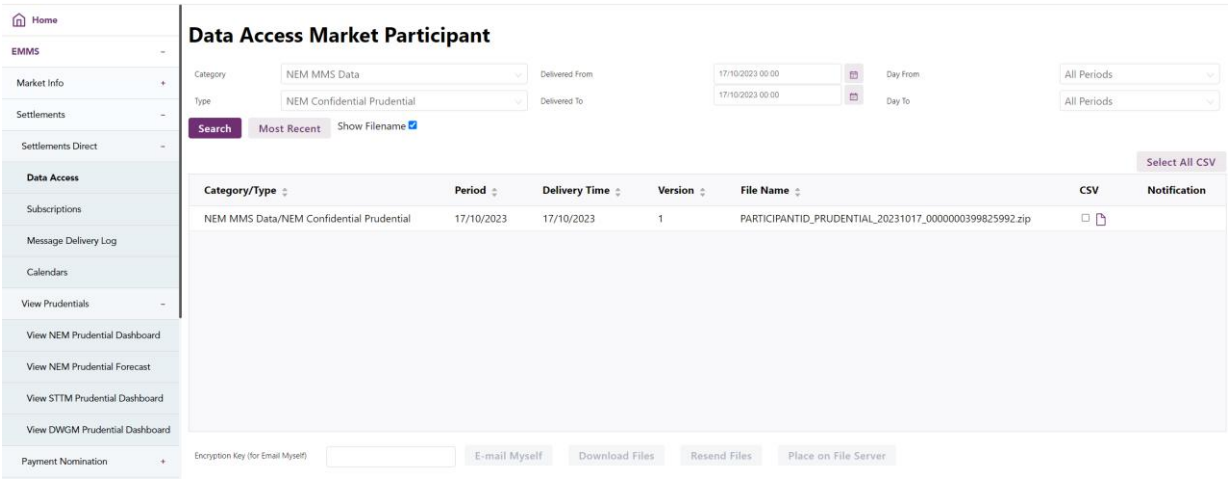
Figure 7 NEM confidential billing data



5.4. NEM confidential prudential data

Confidential NEM prudential files for each *market participant* are published daily and aggregate the data from settlement estimation and any other billing. *Market participants* only have access to their own confidential prudentials data.

Figure 8 NEM confidential prudential data



Version release history

Version	Effective date	Summary of changes
2.0	3 June 2024	• New AEMO template. • Updated text in multiple places to reflect the five-minute settlement rule. • Amendments to the methodology for determining settlement estimates for previous day energy at a TNI level when no meter data is available. • Edited document for clarity, minor drafting improvements.
1.0	27 November 2014	First Issue