AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Guide to Mis-Pricing Information

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Current version release details

Version	Effective date	Summary of changes
5.0	3 June 2024	Updated to specify local price calculations for scheduled loads and bidirectional units

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

1. Introduction

1.1. Purpose and scope

Clause 3.7A(b)(2) of the National Electricity Rules (NER) requires AEMO to publish historical data on *mis-pricing* at *transmission network* nodes in the National Electricity Market (NEM). This Guide explains the *mis-pricing* data that AEMO publishes, including:

- Why mis-pricing is important;
- How the mis-pricing adjustment (MPA) is calculated; and
- Where mis-pricing data (LOCAL_PRICE_ADJUSTMENT) is published.

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.

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	Definition
DUID	Dispatchable unit identifier
FCAS	Frequency control ancillary service
LHS	Left-hand side
LP	Linear programming
MLF	Marginal loss factor
MPA	Mis-pricing adjustment
MV	Marginal value
NEM	National Electricity Market
NER	National Electricity Rules
RHS	Right-hand side
RRN	Regional reference node
RRP	Regional reference price

1.3. Assumptions

This document assumes familiarity with network constraint formulation and the impact of binding network constraints on dispatch.

2. Mis-pricing concepts

2.1. Definition of mis-pricing

The term “mis-pricing” is used to describe the deviation between the *regional reference price* (RRP) in each region and the “local” or “nodal” price at each connection point within that region that is due to network congestion.

Mis-pricing may be positive or negative. Positive mis-pricing occurs when the local price is lower than the RRP, as described in Appendix A1. Negative mis-pricing occurs when the local price is higher than the RRP, as described in Appendix A2.

2.2. Relationship between mis-pricing and network congestion

The magnitude and frequency of mis-pricing provides information on the level of congestion at a transmission connection point. If mis-pricing is small or infrequent the network may be considered relatively uncongested. If mis-pricing is large and recurrent it indicates that the network is relatively congested.

2.3. Why mis-pricing is important

Mis-pricing is important because the NEM is settled on the RRP but dispatched using local prices. All generators (and loads) within a region effectively receive (and pay) the same RRP for the energy they produce (and consume).[1] However, *scheduled resources* are dispatched according to their local price. The disjoint between the local prices caused by network congestion and the RRPs used for settlement can create financial risks for participants and discourage economic efficiency.

Generators experiencing network congestion do not always have an incentive to offer electricity to the market at their true marginal cost and may use other strategies to ensure that they are dispatched (or decommitted). These strategies can affect the short-term efficiency of dispatch.

Longer-term investment signals are also blunted by relying on RRPs alone. Without further information on local pricing within a region, generators and large industrial and commercial loads may invest at a point which increases congestion. They may also be unaware of an opportunity to invest in a location which reduces congestion.

[1] There are differences between local prices and the RRP due to the marginal loss factor (MLF) applied at each connection point. However, these MLFs are fixed annually and based on average loss and congestion patterns. They do not reflect instantaneous network congestion.

3. Mis-pricing calculations

3.1. Mis-pricing at a connection point

This section discusses mis-pricing at a connection point. The mis-pricing data that AEMO publishes, and which is applicable to dispatchable unit identifiers (DUIDs), is discussed in Section 4.

The mis-pricing adjustment at a connection point is defined as:

$$\mathrm{MPA}_i = -\sum\nolimits_n (\mathrm{k}_i^n \times \mathrm{MV}^n) \qquad (1)$$

where

MPA_i	mis-pricing adjustment at connection point i
k_i^n	coefficient of connection point i on the left-hand side (LHS) of binding network constraint n
MV^n	marginal value of binding network constraint n containing connection point i

This formula takes the marginal value of each binding network constraint with the connection point on its LHS and multiplies it with the coefficient of the connection point. It then sums the results because the connection point might appear in more than one binding network constraint.

Note that:

- The mis-pricing calculation uses five-minute dispatch data.
- Only binding network constraints are considered.[2]
- The mis-pricing adjustment in formula (1) has the opposite sign to the LOCAL_PRICE_ADJUSTMENT in the MMS Data Model, which is shown in formula (3). Mis-pricing adjustment applies to connection points, whereas LOCAL_PRICE_ADJUSTMENT applies to DUIDs.

[2] Non-binding constraints have a marginal value of zero. They would not alter the evaluation of formula (1). Other constraints that may bind but are not considered include:

- FCAS constraints
- Constraints invoked to manage non-conformance
- Constraints invoked during AEMO intervention events
- Constraints invoked to reflect Network Support Agreements between Transmission Network Service Providers and market participants

These types of constraints are not considered because they do not contribute to the mis-pricing that arises from network congestion.

3.2. Local prices at a connection point

The local price at a connection point is related to the mis-pricing at that connection point by the following formula:

$$\mathrm{LocalPrice}_i = \mathrm{RRP}_i - \mathrm{MPA}_i \qquad (2)$$

where

$\mathrm{LocalPrice}_i$	local price at connection point i
RRP_i	regional reference price for the region containing connection point i
MPA_i	mis-pricing adjustment at connection point i

The local price at a connection point is lower than the RRP when mis-pricing is positive, and higher than the RRP when mis-pricing is negative. Formula (2) applies to connection points only. Formulas (4) and (5) should be used to calculate the local price for DUIDs.

4. Mis-pricing data published by AEMO

This section discusses the mis-pricing data that AEMO publishes, and how it should be used to calculate the local price for a DUID.

AEMO publishes mis-pricing data for DUIDs in the DISPATCH_LOCAL_PRICE table of the MMS Data Model. The contents of DISPATCH_LOCAL_PRICE are described in Table 1. A sample from DISPATCH_LOCAL_PRICE is shown in Figure 1.

Table 1: DISPATCH_LOCAL_PRICE field descriptions

Field	Description
SETTLEMENTDATE	The five-minute period ending at the date and time shown. All times are market time (AEST).
DUID	The DUID(s) at the transmission connection point where the local price adjustment is being measured. DUIDs are provided in preference to transmission connection points because they are more widely understood. The sign convention for the local price adjustment for a DUID depends on the type of DUID.
LOCAL_PRICE_ADJUSTMENT	LOCAL_PRICE_ADJUSTMENT is calculated for each DUID as follows: $$LOCAL\_PRICE\_ADJUSTMENT_{DUID} = \sum_n (\mathrm{k}^n_{DUID} \times \mathrm{MV}^n) \qquad (3)$$ where $LOCAL\_PRICE\_ADJUSTMENT_{DUID}$ Local price adjustment for the DUID k^n_{DUID} coefficient of the DUID on the LHS of binding network constraint n MV^n marginal value of binding network constraint n containing the DUID Please note that the LOCAL_PRICE_ADJUSTMENT in formula (3) applies to DUIDs and has the opposite sign to the mis-pricing adjustment in formula (1), which applies to connection points.

Field	Description
LOCALLY_CONSTRAINED	A key to indicate that nature of the binding network constraint(s) that are causing mis-pricing for a DUID: 0 = no network constraints are binding 1 = at least one system normal constraint is binding and no outage constraints are binding 2 = at least one outage constraint is binding Note that if no network constraints are binding the local price adjustment would be zero because all marginal values would be zero. AEMO no longer publishes mis-pricing data when the local price adjustment is zero.

Figure 1: DISPATCH_LOCAL_PRICE sample

SETTLEMENTDATE	DUID	LOCAL_PRICE_ADJUSTMENT	LOCALLY_CONSTRAINED
04/04/2019 10:50:00	BANN1	-1123.11	2
04/04/2019 10:50:00	BLOWERNG	3.71	1
04/04/2019 10:50:00	BOCORWF1	3.71	1
04/04/2019 10:50:00	BROKENH1	44.25	1
04/04/2019 10:50:00	COLEASF1	3.71	1
04/04/2019 10:50:00	CROOKWF2	3.71	1
04/04/2019 10:50:00	DARTM1	-15.98	1
04/04/2019 10:50:00	GANNSF1	-209.63	2
04/04/2019 10:50:00	GULLRSF1	3.71	1
04/04/2019 10:50:00	GULLRWF1	3.71	1
04/04/2019 10:50:00	GUNNING1	3.71	1
04/04/2019 10:50:00	GUTHEGA	-23.46	1
04/04/2019 10:50:00	HUMENSW	38.92	1
04/04/2019 10:50:00	HUMEV	38.92	1
04/04/2019 10:50:00	KIATAWF1	-171.44	2
04/04/2019 10:50:00	MCKAY1	-6.16	1
04/04/2019 10:50:00	MURRAY	-21.11	1
04/04/2019 10:50:00	SAPHWF1	-4.17	1
04/04/2019 10:50:00	SNOWYP	-12.57	1
04/04/2019 10:50:00	STWF1	-1078.72	2
04/04/2019 10:50:00	TARALGA1	3.71	1
04/04/2019 10:50:00	TUMUT3	12.57	1
04/04/2019 10:50:00	UPPTUMUT	20.20	1
04/04/2019 10:50:00	URANQ11	21.74	1
04/04/2019 10:50:00	URANQ12	21.74	1
04/04/2019 10:50:00	URANQ13	21.74	1
04/04/2019 10:50:00	URANQ14	21.74	1

The data from this table can be joined to the DISPATCHPRICE table to calculate local prices as follows:

For a scheduled or semi-scheduled generator, bidirectional unit, or wholesale demand response unit DUID:

$$\text{LocalPrice}_{\text{DUID}} = \text{RRP}_{\text{DUID}} + \text{LOCAL\_PRICE\_ADJUSTMENT}_{\text{DUID}} \qquad (4)$$

For a scheduled load DUID:

$$\text{LocalPrice}_{\text{DUID}} = \text{RRP}_{\text{DUID}} - \text{LOCAL\_PRICE\_ADJUSTMENT}_{\text{DUID}} \qquad (5)$$

where

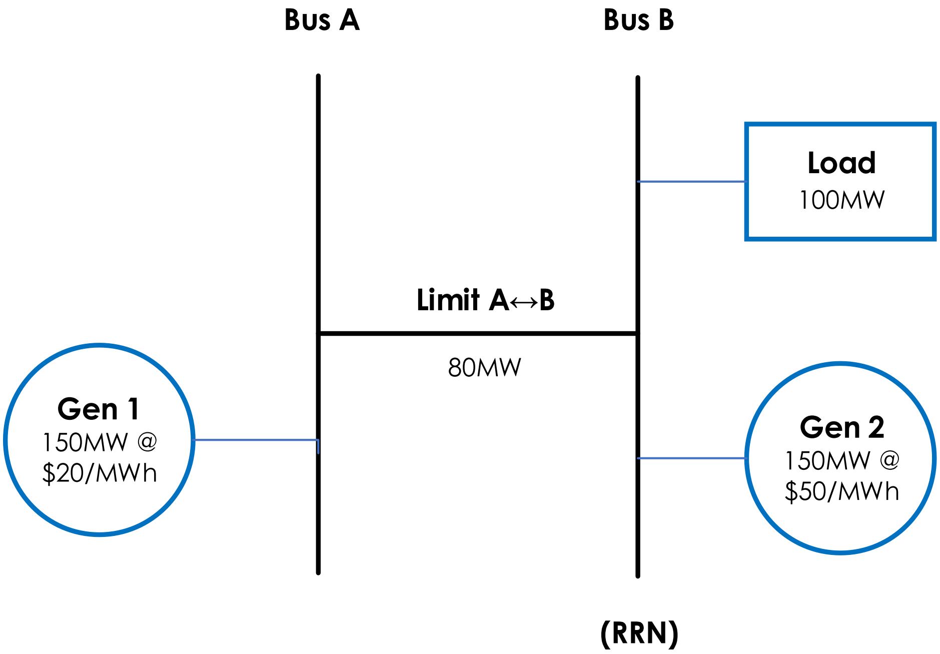
$\text{LocalPrice}_{\text{DUID}}$	local price at the relevant DUID
RRP_{DUID}	RRP for the region containing the relevant DUID
$\text{LOCAL\_PRICE\_ADJUSTMENT}_{\text{DUID}}$	the LOCAL_PRICE_ADJUSTMENT for the relevant DUID

Appendix A. Positive mis-pricing

Mis-pricing at a connection point is positive when the local price is lower than the RRP and a binding network constraint causes a generator at the connection point to be constrained off.

Consider the situation in Figure 2.

Figure 2: Positive mis-pricing example



Gen 1 is offering 150 MW at $20/MWh at Bus A

Gen 2 is offering 150 MW at $50/MWh at the RRN (Bus B)

Load at the RRN is 100 MW

Bus A is connected to the RRN by a transmission line with a limit of 80 MW

Transmission losses are ignored

The linear programming (LP) problem can be written as:

$$\text{minimise } (20\mathrm{G}_1 + 50\mathrm{G}_2) \qquad \text{(a)}$$

subject to:

$$\mathrm{G}_1 \leq 80 \text{ MW} \qquad \text{(b)}$$

$$\mathrm{G}_1 + \mathrm{G}_2 = 100 \text{ MW} \qquad \text{(c)}$$

where G_i = generation at Gen i.

Solution:

The optimal solution is $\mathrm{G}_1 = 80\ \mathrm{MW}$ and $\mathrm{G}_2 = 20\ \mathrm{MW}$, with the total cost $\mathrm{OF} = \$2{,}600$ given by the objective function (a). This solution should be apparent from inspection of Figure 2. The cheapest available generation is at G_1, but only 80 MW of this generation can reach the RRN at Bus B because of the transmission limit A↔B, meaning that the remaining 20 MW of demand must be supplied by the more expensive G_2. Furthermore, since only G_2 can supply any additional demand at the RRN, the RRP must be cost of supply from G_2 i.e. $50/MWh.

Note that the network constraint (b) is binding. The marginal value of this constraint is calculated as the change in the value of the objective function after relaxing the right-hand side (RHS) of the constraint by 1 MW. Changing the RHS of (b) to 81 MW means that G_1 can now supply 81 MW, while G_2 will be dispatched for 19 MW.

Therefore

$$\Delta\mathrm{OF} = \Delta\mathrm{G}_1 + \Delta\mathrm{G}_2 = +20 - 50 = -\$30 = \mathrm{MV}$$

$$\mathrm{MPA}_\mathrm{A} = -1 \times \mathrm{MV} = \$30$$

$$\mathrm{LocalPrice}_\mathrm{A} = \mathrm{RRP} - \mathrm{MPA}_\mathrm{A} = \$50 - \$30 = \$20/\mathrm{MWh}$$

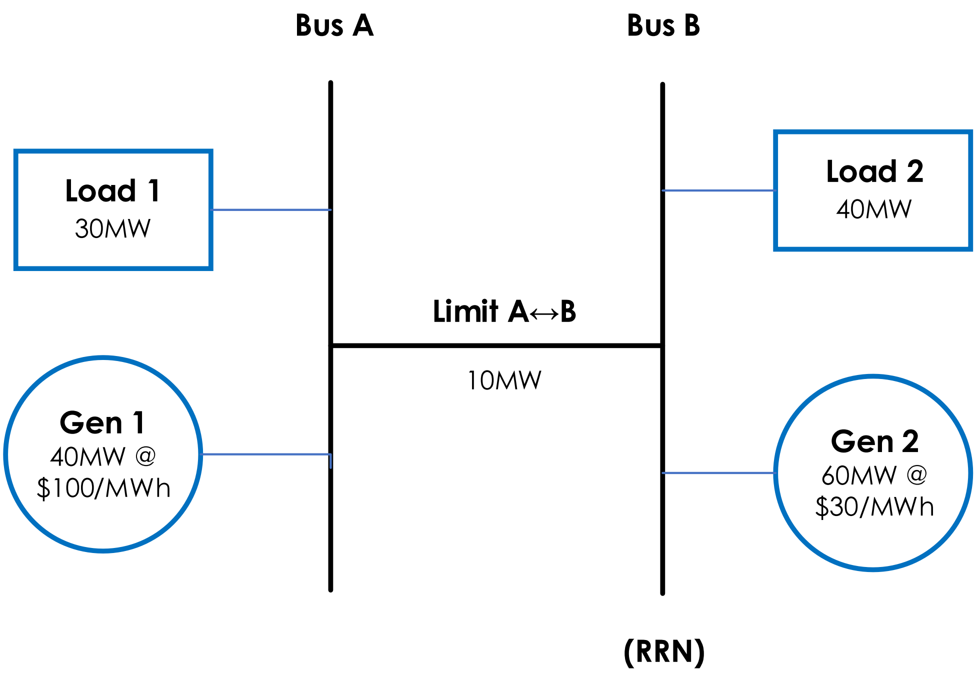
The local price at Bus A should also be apparent from inspection of Figure 2. A load at Bus A can be supplied by G_1 at a cost of $20/MWh. Note that the mis-pricing amount at Bus A is positive because the binding network constraint has caused G_1 to be constrained off.

Appendix B. Negative mis-pricing

Mis-pricing at a connection point is negative when the local price is higher than the RRP and a binding network constraint causes a generator at the connection point to be constrained on.

Consider the situation in Figure 3.

Figure 3: Negative mis-pricing example



Gen 1 is offering 40 MW at $100/MWh at Bus A

Gen 2 is offering 60 MW at $30/MWh at the RRN (Bus B)

Load 1 at Bus A is 30 MW

Load 2 at the RRN is 40 MW

Bus A is connected to the RRN by a transmission line with a limit of 10 MW

Transmission losses are ignored

The linear programming problem can be written as:

$$\text{minimise } (100\mathrm{G}_1 + 30\mathrm{G}_2) \qquad \text{(w)}$$

subject to:

$$\mathrm{G}_1 \geq \text{Load } 1 - 10 \text{ MW} = 20 \text{ MW} \qquad \text{(x)}$$

$$\mathrm{G}_2 \geq \text{Load } 2 - 10 \text{ MW} = 30 \text{ MW} \qquad \text{(y)}$$

$$\mathrm{G}_1 + \mathrm{G}_2 = 70 \text{ MW} \qquad \text{(z)}$$

where G_i = generation at Gen i.

Solution:

The optimal solution is $\mathrm{G_1} = 20\ \mathrm{MW}$ and $\mathrm{G_2} = 50\ \mathrm{MW}$, with the total cost $\mathrm{OF} = \$3{,}500$ given by the objective function (w). This solution should be apparent from inspection of Figure 3. The cheapest available generation is at $\mathrm{G_2}$, but only 10 MW of this generation can reach Load 1 at Bus A because of the transmission limit A↔B, meaning that the remaining 20 MW of demand at Load 1 must be supplied by the more expensive $\mathrm{G_1}$. Furthermore, since $\mathrm{G_2}$ is the cheapest available generation and is supplying only 50 MW from its capacity of 60 MW, any additional demand at the RRN can be supplied from $\mathrm{G_2}$ at $30/MWh.

Note that the network constraint (x) is binding (but network constraint (y) is not because $\mathrm{G_2} = 50\ \mathrm{MW} > 30\ \mathrm{MW}$). The marginal value of constraint (x) is calculated as the change in the value of the objective function after changing the RHS of the constraint by 1 MW. Changing the RHS of (x) to 21 MW means that $\mathrm{G_1}$ must now be dispatched for 21 MW, and consequently $\mathrm{G_2}$ will be reduced to 49 MW.

Therefore

$$\Delta\mathrm{OF} = \Delta\mathrm{G_1} + \Delta\mathrm{G_2} = +100 - 30 = \$70 = \mathrm{MV} > 0$$

$$\mathrm{MPA_A} = -1 \times \mathrm{MV} = -\$70$$

$$\mathrm{LocalPrice_A} = \mathrm{RRP} - \mathrm{MPA_A} = \$30 - (-\$70) = \$100/\mathrm{MWh}$$

The local price at Bus A should be apparent from inspection of Figure 3. An increase in Load 1 can be supplied only by $\mathrm{G_1}$ at a cost of $100/MWh, because the transmission limit A↔B prevents any cheaper supply from $\mathrm{G_2}$. Note that the mis-pricing amount at Bus A is negative because the binding network constraint has caused $\mathrm{G_1}$ to be constrained on.

VERSION CONTROL

Version	Release date	Changes
4.0	01/11/2021	Updated for wholesale demand response
3.0	05/03/2021	Clarified the difference between the LOCAL_PRICE_ADJUSTMENT field in the MMS Data Model and the historic definition of mis-pricing adjustment.
2.0	12/07/2019	Updated template. Removed references to quarterly mis-pricing information resource. (Discontinued after 2015 CIR consultation.) Modified terminology to incorporate five-minute settlement.