Guide to Mis-Pricing Information

November 2021

NER 3.7A(b)(2)

Important notice

PURPOSE

AEMO has prepared this document to provide general information about the mis-pricing data that AEMO publishes under clause 3.7A(b)(2) of the National Electricity Rules (NER), as at the date of publication.

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VERSION CONTROL

Version	Release date	Changes
4.0	1/11/2021	Updated for wholesale demand response
3.0	5/03/2021	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.

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1. Introduction

1.1   Purpose of this document

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 document 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   Assumptions

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

The central dispatch process treats a wholesale demand response unit in a similar manner to a scheduled generating unit when determining the unit's dispatch MW target. The mis-pricing calculation for a wholesale demand response unit can be referred to the mis-pricing calculation for generators in this document.

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, generators and scheduled loads 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.

3. Mis-pricing calculations

3.1   Mis-pricing

The mis-pricing adjustment at a connection point can be expressed most concisely and unambiguously as:

$$\text{MPA}_i = - \sum_n (\text{k}_i^n \times \text{MV}^n) \qquad\qquad (1)$$

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]

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[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.

[2] Non-binding constraints have a marginal value of zero. They would not alter the evaluation of Equation (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

3.2   Local prices

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

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

where

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 is lower than the RRP when mis-pricing is positive, and higher than the RRP when mis-pricing is negative. Please note that the definition of the mis-pricing adjustment has the opposite sign to the LOCAL_PRICE_ADJUSTMENT published in the MMS Data Model.

4. Mis-pricing data

AEMO publishes mis-pricing data 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 dispatchable unit identifier(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. Note that if a scheduled generator and a scheduled load are located at the same connection point their local price adjustments will be the same size but opposite signs.
LOCAL_PRICE_ADJUSTMENT	The sum of the constraint marginal value mulitiplied by the constraint coefficient for all binding constraints containing this DUID. Please note that this has the opposite sign to the mis-pricing adjustment in formula (1) in this document.

LOCALLY_CONSTRAINED	A key to indicate that nature of the binding network constraint(s) that are causing mis-pricing:
	    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

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

Field	Description
	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:

$$LocalPrice_{DUID} = RRP_{DUID} + LOCAL\_PRICE\_ADJUSTMENT_{DUID} \qquad (3)$$

where

|	
$LocalPrice_{DUID}$	local price at the relevant DUID
RRP_{DUID}	regional reference price for the region containing the relevant DUID
$LOCAL\_PRICE\_ADJUSTMENT_{DUID}$	the LOCAL_PRICE_ADJUSTMENT for the relevant DUID

A1. Positive mis-pricing

Mis-pricing at a connection point is positive when 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
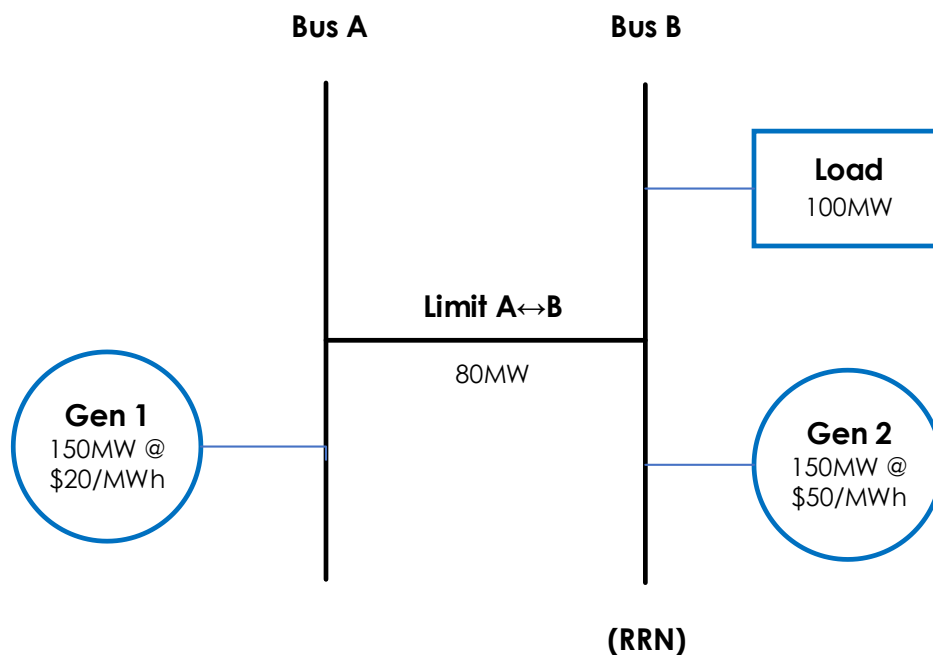
- Gen 1 is offering 150 MW at $20/MWh at Bus A
- Gen 2 is offering 150 MW at $50/MWh at the RRN (Bus B)
- Load at the RRN is 100 MW
- Bus A is connected to the RRN by a transmission line with a limit of 80 MW
- Transmission losses are ignored

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

$$\text{minimise } (20G_1 + 50G_2) \qquad (3)$$

subject to:

$$G_1 \leq 80 \text{ MW} \qquad (4)$$

$$G_1 + G_2 = 100 \text{ MW}$$

where G_i = generation at Gen i.

Solution:

The optimal solution is $G_1 = 80$ MW and $G_2 = 20$ MW, with the total cost $OF = \$2,600$ given by the objective function (3). 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 (4) 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 (4) to 81 MW means that G_1 can now supply 81 MW, while G_2 will be dispatched for 19 MW.

Therefore

$$\Delta OF = \Delta G_1 + \Delta G_2 = +20 - 50 = -\$30 = MV < 0$$

$$MPA_A = -1 \times MV = \$30$$

$$LocalPrice_A = RRP - MPA_A = \$50 - \$30 = \$20/MWh$$

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.

A2. Negative mis-pricing

Mis-pricing at a connection point is negative when 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
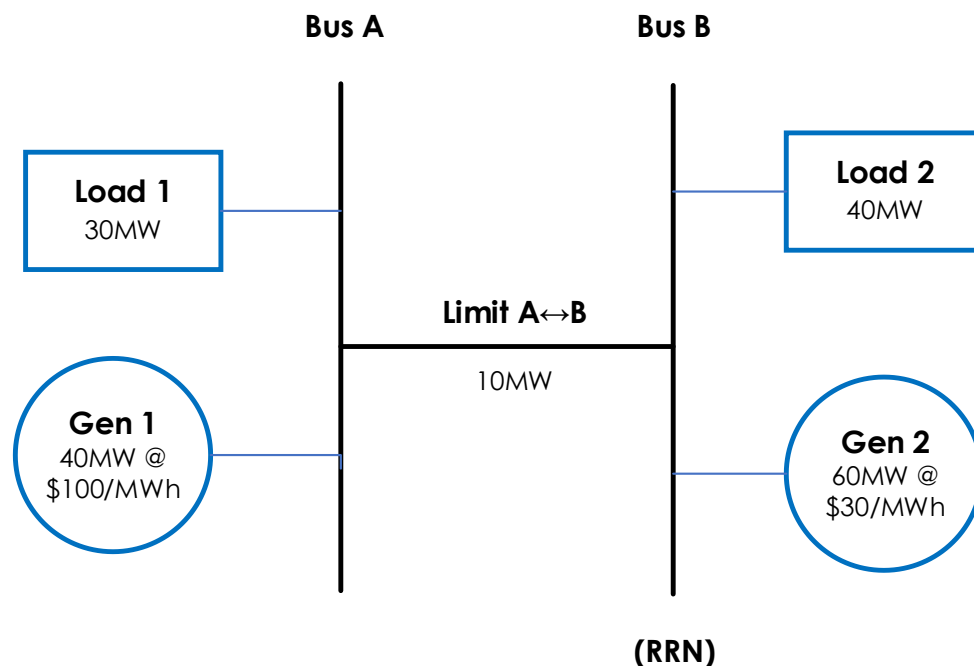
- Gen 1 is offering 40 MW at $100/MWh at Bus A
- Gen 2 is offering 60 MW at $30/MWh at the RRN (Bus B)
- Load 1 at Bus A is 30 MW
- Load 2 at the RRN is 40 MW
- Bus A is connected to the RRN by a transmission line with a limit of 10 MW
- Transmission losses are ignored

The linear programming problem can be written as:

$$\text{minimise } (100G_1 + 30G_2) \qquad (5)$$

subject to:

$$G_1 \geq \text{Load } 1 - 10 \text{ MW} = 20 \text{ MW} \qquad (6)$$

$$G_2 \geq \text{Load } 2 - 10 \text{ MW} = 30 \text{ MW} \qquad (7)$$

$$G_1 + G_2 = 70 \text{ MW}$$

where G_i = generation at Gen i.

Solution:

The optimal solution is $G_1 = 20 \text{ MW}$ and $G_2 = 50 \text{ MW}$, with the total cost $\text{OF} = \$3,500$ given by the objective function (5). This solution should be apparent from inspection of Figure 3. The cheapest available generation is at 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 G_1. Furthermore, since 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 G_2 at \$30/MWh.

Note that the network constraint (6) is binding (but network constraint (7) is not because $G_2 = 50 \text{ MW} > 30 \text{ MW}$). The marginal value of constraint (6) is calculated as the change in the value of the objective function after relaxing the RHS of the constraint by 1 MW. Changing the RHS of (6) to 21 MW means that G_1 must now be dispatched for 21 MW, and consequently G_2 will be reduced to 49 MW.

Therefore

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

$$\text{MPA}_A = -1 \times \text{MV} = -\$70$$

$$\text{LocalPrice}_A = \text{RRP} - \text{MPA}_A = \$30 - (-\$70) = \$100/\text{MWh}$$

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

Glossary

This document uses many terms that have meanings defined in the National Electricity Rules (NER). The NER meanings are adopted unless otherwise specified. Other specific terms and abbreviations used in this document have the meanings given in the table below.

Term	Definition
FCAS	Frequency Control Ancillary Service
LHS	Left-hand side
LP	Linear programming
MLF	Marginal Loss Factor
NEM	National Electricity Market
NER	National Electricity Rules
RHS	Right-hand side
RRP	Regional Reference Price