# ATTACHMENT B – ILLUSTRATIONS OF THE CONSEQUENCES OF DIFFERENT APPROACHES USED TO CALCULATE THE MLF

The following examples illustrate how one intra-regional marginal loss factor (MLF) for a transmission network connection point (connection point) with both energy generation and energy consumption can result in significant inefficiencies in the central dispatch process and in the calculation of intra-regional residues (IRR). The MLF for Generator A is different in each example to demonstrate the impact of inaccurate MLFs. The following assumptions were also made:

- There is only one region with two Generators and two Customers
- Energy offers at the connection point are submitted by two Generators A and B in a maximum of 3 bands – these offers are the same in each example
- Generator A offer relates to a hydro pumped storage generating unit, Generator B offer relates to a base load generator
- Total generation to be dispatched is 600 MW
- Customers A and B are consuming a total of 540 MW
- Transmission losses in the simplified network are 10 percent.

Example 1 – Single volume weighted MLF (primarily energy generation)

During the financial year, Generator A has predominantly operated as a generator with infrequent periods of operation as a pump. The 30% net energy balance condition has not been met, hence one volume weighted MLF is determined for Generator A which is 0.97. Generator B is a base load generating unit with an MLF of 0.87.

The energy offers submitted by Generators A and B are as follows:

| **Generator A** | | |
|---|---|---|
| **Total Capacity** | **400 MW** | |
| **MLF** | **0.97** | |
| **Price at Generator ($)** | **Offered MW** | **Price at RRN ($)** |
| 60 | 10 | 61.86 |
| 50 | 190 | 51.55 |
| 40 | 200 | 41.24 |

| **Generator B** | | |
|---|---|---|
| **Total Capacity** | **610 MW** | |
| **MLF** | **0.87** | |
| **Price at Generator ($)** | **Offered MW** | **Price at RRN ($)**[1] |
| 35 | 190 | 40.23 |
| 20 | 200 | 22.99 |
| 10 | 220 | 11.49 |

[1] These figures have been rounded to the nearest dollar.

Based on these offers the dispatch outcome is:

| Dispatch Outcome | | |
|---|---|---|
| **Generator** | **MW** | **Price at RRN ($)[2]** |
| Generator B | 180 | **40.23** |
| Generator B | 200 | 22.99 |
| Generator B | 220 | 11.49 |

| | |
|---|---|
| ***Total MW Dispatched*** | **600** |
| ***Load*** | **540** |
| ***Transmission Loss*** | **60** |
| ***Spot Price($)*** | **40.23** |

NEMDE dispatches Generator B because its offers in all price bands are cheaper than Generator A's offers when compared at the regional reference node (RRN). The dispatch process attempts to minimise the marginal cost of producing electricity, hence Generator B is dispatched because it has offered the least expensive generation. Generator B supplies the total generation (that is, 600 MW) into the transmission network. The following payments are made to Customers and Generators in the settlements process:

| Customer | Load | MLF | Spot Price x MLF ($) | Payment by Market Customer ($)[3] |
|---|---|---|---|---|
| A | 240 | 1.02 | 41.03 | 9,848 |
| B | 300 | 1.01 | 40.63 | 12,190 |
| | | | **TOTAL** | 22,038 |

| Generator | Dispatch | MLF | Spot Price x MLF ($) | Payment to Generator ($)[4] |
|---|---|---|---|---|
| A | 0 | 0.97 | 39.02 | 0 |
| B | 600 | 0.87 | 35.00 | 21,000 |
| | | | **TOTAL** | 21,000 |
| | | | | |
| | | | **IRR ($)** | **1,038** |

The settlement outcome is that AEMO collects $22,038 from Customers and pays Generator B $21,000 the settlement residue is $1,038. As mentioned in AEMO's Rule change proposal, marginal pricing tends to over-recover for the cost of transmission losses.

Example 2 – Single volume weighted MLF (energy generation and consumption)

During the financial year, drought conditions prevailed and Generator A operated as a pump more often to store water in the reservoir for a significant period of time. This resulted in the 30% net energy balance condition being met. AEMO has determined a volume weighted average MLF for

[2] ibid.

[3] ibid.

[4] ibid.

Generator A which is unusually high (3.03). Generator B's volume weighted average MLF has been unaffected because it is a base load generating unit, its MLF is 0.87

The energy offers submitted by Generators are as follows:

| **Generator A** | | |
|---|---|---|
| **Total Capacity** | **400 MW** | |
| **MLF** | **3.03** | |
| **Price at Generator ($)** | **Offered MW** | **Price at RRN ($)** |
| 60 | 10 | 19.80 |
| 50 | 190 | 16.50 |
| 40 | 200 | 13.20 |

| **Generator B** | | |
|---|---|---|
| **Total Capacity** | **610 MW** | |
| **MLF** | **0.87** | |
| **Price at Generator ($)** | **Offered MW** | **Price at RRN ($)**[5] |
| 35 | 190 | 40.23 |
| 20 | 200 | 22.99 |
| 10 | 220 | 11.49 |

Based on the offers submitted the dispatch outcome is:

| **Dispatch** | | |
|---|---|---|
| **Generator** | **MW** | **Price at RRN ($)**[6] |
| Generator A | 180 | **16.50** |
| Generator A | 200 | 13.20 |
| Generator B | 220 | 11.49 |

| | |
|---|---|
| **Total MW Dispatched** | **600** |
| **Load** | **540** |
| **Transmission Loss** | **60** |
| **Spot Price ($)** | **16.50** |

In this example, the offers submitted by Generator A and B are identical to those in Example 1. However, the MLF for Generator A is now 3.03 and this has changed the dispatch and settlement outcomes. NEMDE has now dispatched 380 MW of Generator A due to its higher MLF. In effect, the distorted MLF has caused NEMDE to dispatch the more expensive generator.

[5] ibid.

[6] ibid.

The following payments are made by Customers and to Generators in the settlements process:

| Customer | Load | MLF | Spot Price x MLF ($) | Payment by Market Customer ($)[7] |
|---|---|---|---|---|
| A | 200 | 1.02 | 16.83 | 3,366 |
| B | 340 | 1.01 | 16.67 | 5,667 |
| | | | **TOTAL** | 9,033 |

| Generator | Dispatch | MLF | Spot Price x MLF ($) | Payment to Generator ($)[8] |
|---|---|---|---|---|
| A | 380 | 3.03 | 50.00 | 19,000 |
| B | 220 | 0.87 | 14.36 | 3,158 |
| | | | **TOTAL** | 22,158 |

| | |
|---|---|
| **IRR ($)** | **-13,125** |

Example 3 – Single time weighted MLF (energy generation and consumption)

As is the case for Example 2, during the financial year drought conditions prevailed and Generator A operated more frequently as a pump to store water in the reservoir for a significant period of time. The increased amount of pumping resulted in the 30% net energy balance condition. In this example, AEMO has determined the MLF using time weighted averaging, resulting in Generator A's MLF being 1.02. Generator B's MLF has been unaffected, it is a base load generating unit with an MLF of 0.87.

The offers submitted by generating units are identical to the previous examples as follows:

**Generator A**
**Total Capacity 400 MW**
**MLF 1.02**

| Price at Generator ($) | Offered MW | Price at RRN ($) |
|---|---|---|
| 60 | 10 | 58.82 |
| 50 | 190 | 49.02 |
| 40 | 200 | 39.22 |

**Generator B**
**Total Capacity 610 MW**
**MLF 0.87**

| Price at Generator ($) | Offered MW | Price at RRN ($)[9] |
|---|---|---|
| 35 | 190 | 40.23 |
| 20 | 200 | 22.99 |
| 10 | 220 | 11.49 |

[7] ibid.

[8] ibid.

[9] ibid.

Based on the energy bids submitted the dispatch outcome is:

| Dispatch | | |
|---|---|---|
| **Generator** | **MW** | **Price at RRN ($)**[10] |
| Generator A | 180 | **39.22** |
| Generator B | 200 | 22.99 |
| Generator B | 220 | 11.49 |

| | |
|---|---|
| **Total MW Dispatched** | **600** |
| **Load** | **540** |
| **Transmission Loss** | **60** |
| **Spot Price ($)** | **39.22** |

In this example, NEMDE has dispatched Generator A and Generator B because of the effect Generator A's higher MLF has on the regional reference price; this has made 180 MW of its generation comparably cheaper to that of Generator B's generation. In practice, the distorted MLF has caused NEMDE to dispatch the more expensive generator.

The following payments are made to Customers and Generators in the settlements process:

| Customer | Load | MLF | Spot Price x MLF ($) | Payment by Market Customer ($)[11] |
|---|---|---|---|---|
| A | 200 | 1.02 | 40.00 | 8,000 |
| B | 340 | 1.01 | 39.61 | 13,467 |
| | | | ***TOTAL*** | 21,467 |

| Generator | Dispatch | MLF | Spot Price x MLF ($) | Payment to Generator ($)[12] |
|---|---|---|---|---|
| A | 180 | 1.02 | 40.00 | 7,200 |
| B | 420 | 0.87 | 34.12 | 14,329 |
| | | | **TOTAL** | 21,529 |

| | |
|---|---|
| **IRR ($)** | **-62.75** |

Although the MLF is less distorted, a price distortion is occurring which leads to an inefficient dispatch outcome and the resultant IRR is negative.

Example 4 – Two volume weighted MLFs (energy generation and consumption)

10 ibid.

11 ibid.

12 ibid.

During the financial year, drought conditions prevailed and Generator A operated more frequently as a pump to store water in the reservoir for a significant period of time. The increased amount of pumping resulted in the 30% net energy balance condition being met and AEMO determined two separate volume weighted MLFs for generation and consumption, the respective MLFs are 0.995 and the MLF for consumption is 1.007. If AEMO had been required to use one volume weighted average MLF for Generator A it would have been 3.03, which is unusually high, this is demonstrated in Example 2.

Generator B's volume weighted average MLF has been unaffected because it is a base load generating unit, its MLF is 0.87.

The energy offers submitted by Generators A and B are as follows:

| **Generator A** | | |
|---|---|---|
| **Total Capacity** | **400 MW** | |
| **MLF** | **0.995** | |
| **Price at Generator ($)** | **Offered MW** | **Price at RRN ($)** |
| 60 | 10 | 60.30 |
| 50 | 190 | 50.25 |
| 40 | 200 | 40.20 |

| **Generator B** | | |
|---|---|---|
| **Total Capacity** | **610 MW** | |
| **MLF** | **0.87** | |
| **Price at Generator ($)** | **Offered MW** | **Price at RRN ($)**[13] |
| 35 | 190 | 40.23 |
| 20 | 200 | 22.99 |
| 10 | 220 | 11.49 |

Based on these offers the dispatch outcome is:

| **Dispatch Outcome** | | |
|---|---|---|
| **Generator** | **MW** | **Price at RRN ($)**[14] |
| Generator A | 180 | **40.20** |
| Generator B | 200 | 22.99 |
| Generator B | 220 | 11.49 |

| | |
|---|---|
| ***Total MW Dispatched*** | **600** |
| ***Load*** | **540** |
| ***Transmission Loss*** | **60** |
| ***Spot Price*($)** | **40.20** |

In this example NEMDE has dispatched Generator A and Generator B, however 180 MW from Generator A has only been dispatched because of the effect its MLF has on the regional reference price which has made 180 MW of its generation comparably cheaper to that of Generator B's generation.

[13] ibid.

[14] ibid.

The following payments are made to Customers and Generators in the settlements process:

| Customer | Load | MLF | Spot Price x MLF ($) | Payment by Market Customer ($)[15] |
|---|---|---|---|---|
| A | 240 | 1.02 | 41.01 | 9,841 |
| B | 300 | 1.01 | 40.60 | 12,181 |
| | | | **TOTAL** | 22,022 |

| Generator | Dispatch | MLF | Spot Price x MLF ($) | Payment to Generator ($)[16] |
|---|---|---|---|---|
| A | 180 | 0.995 | 39.02 | 7,200 |
| B | 420 | 0.87 | 35.00 | 14,689 |
| | | | **TOTAL** | 21,000 |

| | |
|---|---|
| **IRR ($)** | **1,022** |

AEMO settles the market by collecting $22,022 from Market Customers and paying Generator A and B a total of $21,000 the settlement residue is $1,022. The outcome is very similar to Example 1 where the 30% net energy balance condition was not met and one volume weighted MLF is applied. Although the 30% net energy balance condition is met, applying two MLFs to this connection point would avoid inefficient dispatch outcome and price distortion that can be observed in the previous two examples. Further, the resultant settlement residue is now positive, that is the MLFs are able to recover the cost of transmission losses.

[15] ibid.

[16] ibid.