

MARKET EVENT REPORT - 5 SEPTEMBER 2011

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DRAFT

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Abbreviations and Symbols

Abbreviation	Term
AEMO	Australian Energy Market Operator Ltd
DI	dispatch interval
EMS	Energy Management System
FCAS	frequency control ancillary service
ICCP	Inter-control Centre Communication Protocol
MII	manifestly incorrect input
MVA	megavolt ampere
MW	megawatt
MWh	megawatt hour
NEM	National Electricity Market
NER	National Electricity Rules, or the Rules
QNI	Queensland - New South Wales 330kV interconnector
SCADA	Supervisory Control and Data Acquisition
TNSP	Transmission Network Service Provider

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1 Introduction

On 5 September 2011 AEMO's automated procedures for detecting a manifestly incorrect input (MII) identified the prices for dispatch intervals (DIs) ending 1105 hrs and 1110 hrs as subject to review, in accordance with clause 3.9.2B of the National Electricity Rules (NER). Incorrect dynamic ratings for the Calvale-Wurdong No.871 and the Calvale-Stanwell No.855 275 kV lines were used as inputs to the central dispatch process after a planned failover by Powerlink of its SCADA database.

AEMO determined that these DIs contained MIIs and replaced all energy prices and frequency control ancillary services (FCAS) prices for the DIs with the corresponding prices for DI ending 1100 hrs.

Subsequent investigation revealed that action taken to remove the incorrect inputs from dispatch meant that AEMO's determination that DIs ending 1105 hrs and 1110 hrs contained MIIs was not correct. Two earlier DIs ending 1055 hrs and 1100 hrs did however contain incorrect inputs, but they were not detected by the automated procedures as subject to review.

A Price Revision Incident Report is published on the AEMO web site.¹ The purpose of this Market Event Report is to address the issues raised in section 5 of the Price Revision Incident Report.

This report provides a summary of the event details, which incorporates information that was provided by Powerlink. The report points out that the incidence of DIs genuinely affected by incorrect inputs, relative to the number of DIs triggered as subject to review is very low, whilst true incorrect inputs often go undetected. In view of this event, and taking into consideration the low success rate of the price revision process, AEMO intends to propose a change to the NER to remove the price revision requirement from the NER.

This report also reports on progress on action recommended from a previous Pricing Revision Incident Report in relation to a manifestly incorrect input that affected dispatch on 17 February 2011.

2 Event Details

At approximately 1030 hrs a scheduled database update was performed by Powerlink. When the databases were restored a number of SCADA items were transmitted to AEMO with incorrect values, including zero values for the 871 and 855 line ratings. AEMO's central dispatch systems automatically ignored the zero rating values and replaced them with the last received non-zero rating values of around 920 MVA for both lines.

At 1049 hrs, the ratings transmitted by Powerlink for the lines changed from zero to 10 MW, increasing by 10 MW per minute. AEMO's central dispatch systems treated this new rating as genuine and used this number in dispatch. Constraints associated with the lines violated and the Queensland 5-minute prices reached the Market Price Cap of \$12,500 per MWh in DI ending 1055 hrs, from \$28.54 per MWh for DI ending 1050 hrs, caused by the need to dispatch high priced plant to satisfy the new network limits. The constraint violations resulted in a relatively small change in dispatched interconnector flow in these DIs.

AEMO's processes for automated processes for identifying DIs as subject to review due to possible incorrect inputs requires a change in both price and interconnector flow before the price revision process is triggered. Accordingly, DI ending 1055 hrs was not identified as subject to review despite the incorrect inputs.

At 1057 hrs, on advice from Powerlink, AEMO manually changed (or handdressed) the 871 and 855 line ratings to 855 MVA – from their current incorrect values of 60 MVA – and these values were used in central dispatch from DI ending 1105 hrs onwards.

¹ AEMO. Price Revision Incident Report – 5 September 2011. Available at <http://www.aemo.com.au/reports/nemreports.html#revisions>

Significant rebidding of generation capacity to negative price bands and a decrease in Queensland demand, presumably in response to the high energy price, resulted in 5-minute prices reducing to \$5.77 per MWh for DI ending 1105 hrs, reaching the Market Floor Price of -\$1,000 per MWh for DI ending 1110 hrs. The increase in line ratings and the rebidding of generation capacity resulted in changes to the Queensland energy price and Terranora interconnector target flow above their MII trigger thresholds for DI ending 1105 hrs.

As a result, DI ending 1105 hrs and subsequent DIs were identified as subject to review.

Despite the action to handress the ratings of the lines, AEMO determined that bad quality data were still being used in central dispatch and rejected all energy and FCAS prices for DIs ending 1105 hrs and 1110 hrs. The rejected prices for these DIs were automatically replaced with the corresponding prices for DI ending 1100 hrs. AEMO subsequently determined that no further incorrect inputs were used in DIs ending 1105 and 1110 hrs and that its decision to reject the prices was incorrect.

3 Further Actions from Price Revision Incident Reports

3.1 Effectiveness of the Automated Procedures

For a DI to be automatically identified as subject to review, a price trigger in a region and at least one of that region's interconnector flow triggers are required. The automated procedures also trigger all subsequent DIs as subject to review for 30 minutes or until AEMO either accepts or rejects the prices.

Table 1 lists the relevant energy prices and Table 2 lists the relevant interconnector target flows for DIs ending 1050 hrs to 1100 hrs.

Table 1 Queensland Energy Prices

PRICES (\$/MWh)	1050 HRS	1055 HRS	1100 HRS	1105 HRS	1110 HRS
Original Qld energy price	\$28.54	\$12,500.00	\$91.78	\$5.77	-\$1,000.00
Final Qld energy price	\$28.54	\$12,500.00	\$91.78	\$91.78	\$91.78

Table 2 Queensland Interconnector Target Flows

MW FLOWS	1050 HRS	1055 HRS	1100 HRS	1105 HRS	1110 HRS
Terranora target flow N-Q-MNSP1	-60	17	64	-19	-96
QNI target flow NSW1-QLD1	-215	-229	-322	-220	-237

The automated did not trigger correctly on two occasions for this event:

- The initial incorrect input in DI ending 1055 hrs was not triggered at all (a "false negative").
- The corrective action to remove the incorrect input from DI ending 1105 hrs caused the automated procedures to trigger (a "false positive").

False Negative in DI ending 1055 hrs: This occurred because the change in interconnector dispatched flow for both Terranora and QNI remained below the MII trigger level due to violations of the constraints associated with 855 and 871 lines, and constraints that restricted flow from Queensland to New South Wales on QNI.

The three constraint equations Q>>BCLC_BCGL_CLWU, Q>>NIL_855_871, Q>>NIL_871_855² violated for DI ending 1055 hrs, resulting in the Queensland 5-minute energy prices reaching the Market Price Cap of \$12,500 per MWh.

The changes (increases) in southward flow were limited due to a prior outage of the Armidale-Dumaresq No.8E line. FCAS constraint equations were limiting southward flow on the QNI interconnector to manage the Lower FCAS requirements for Queensland for the loss of the parallel No. 8C line, which would have resulted in the separation of Queensland from New South Wales. As the Terranora interconnector target flow change of 77 MW was also below the relevant trigger threshold of 80 MW, the automated procedures for detecting MIIs did not identify DI ending 1055 hrs as subject to review, despite containing incorrect inputs.

The market participant response to the high Queensland energy price for DI ending 1055 hrs resulted in an increase in both Queensland export and the local FCAS lower requirement for DI ending 1100 hrs.

AEMO has reviewed alternative trigger criteria, including examination of inputs data and alternative outputs such as change in interconnector calculated limits. Each alternative would tend to significantly increase the incidence of false positives without a significant improvement to the number of false negatives.

False Positive in DI ending 1105 hrs: This occurred because the substantial increase in ratings of 855 and 871 lines (which had been handdressed by AEMO) and rebidding of generation in response to the high prices (which were still subject to review) in DI ending 1055 hrs, which resulted in a substantial change in dispatch interconnector flow and a large reduction in the price in Queensland.

For DI ending 1110 hrs, 3960 MW of generation capacity in Queensland was offered at negative prices, up from 2839 MW for DI ending 1055 hrs when the high price occurred.

The increase in negative generation offers coincided with a reduction in demand of approximately 200 MW, presumably in response to the high 5-minute energy price.

The target interconnector flow on Terranora reversed to New South Wales, with the flow change of 83 MW and the corresponding change in the Queensland 5 minute price sufficient to trigger DI ending 1105 hrs and subsequent intervals as subject to review, despite the DI containing no incorrect input.

Annual review of the automated procedures: AEMO review the MII trigger thresholds for prices and interconnector flows yearly (as per clause 3.9.2B(k) of the NER) and adjust these to minimise false positives³. Despite this, the number of triggered DIs that was affected by MIIs remained insignificant. Figure 1 shows the number of DIs that contained an MII, as a percentage of all DIs triggered as subject to review since the price revision process was implemented on 1 July 2006.

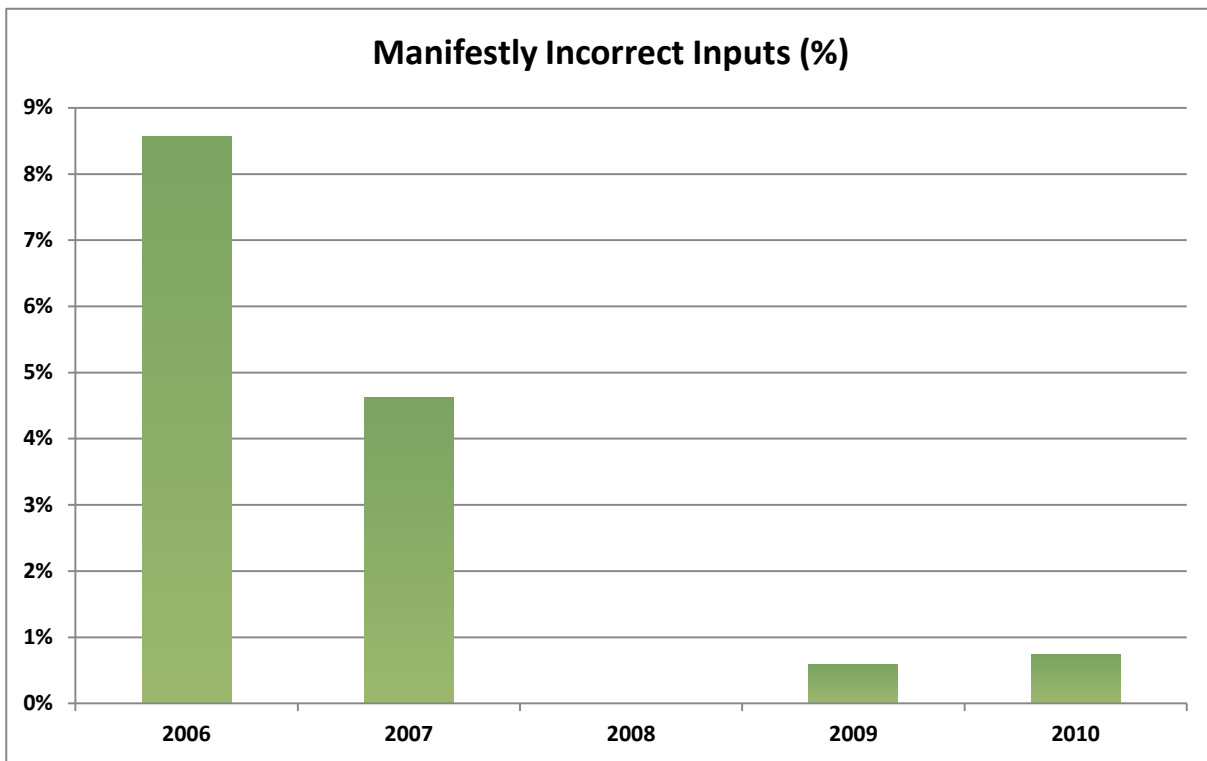
AEMO has investigated the use of a different dispatch outputs as a trigger parameter to avoid false negatives, using a change in the interconnector flow limits instead of flow targets. Applying this method to data for 2010 and 2011 managed to capture DI 1055 hrs on 5 September as potentially affected by an MII, but the number of false positives would have increased from 184 to 227.

AEMO considers that further adjustments to these trigger levels will not noticeably improve the performance of the automated process.

² Refer to the Appendix.

³ DIs marked as subject to review, but containing no manifestly incorrect inputs

Figure 1 Percentage of Triggered Dispatch Intervals Containing a Manifestly Incorrect Input



3.2 Dynamic Ratings Provided by Powerlink

The following section has been prepared using information provided in part by Powerlink.

Powerlink’s real time ratings application (RTR) calculates a dynamic line rating for a selected number of feeders based on standard algorithms. Resultant ratings information is automatically transmitted to AEMO over the Powerlink-AEMO Inter-control Centre Communication Protocol (ICCP) for use by AEMO.

To avoid sudden changes to ratings, such as due to rapid weather changes or transitions from day to night ratings, a ramping function limits rating changes sent to AEMO to 10 MVA per minute.

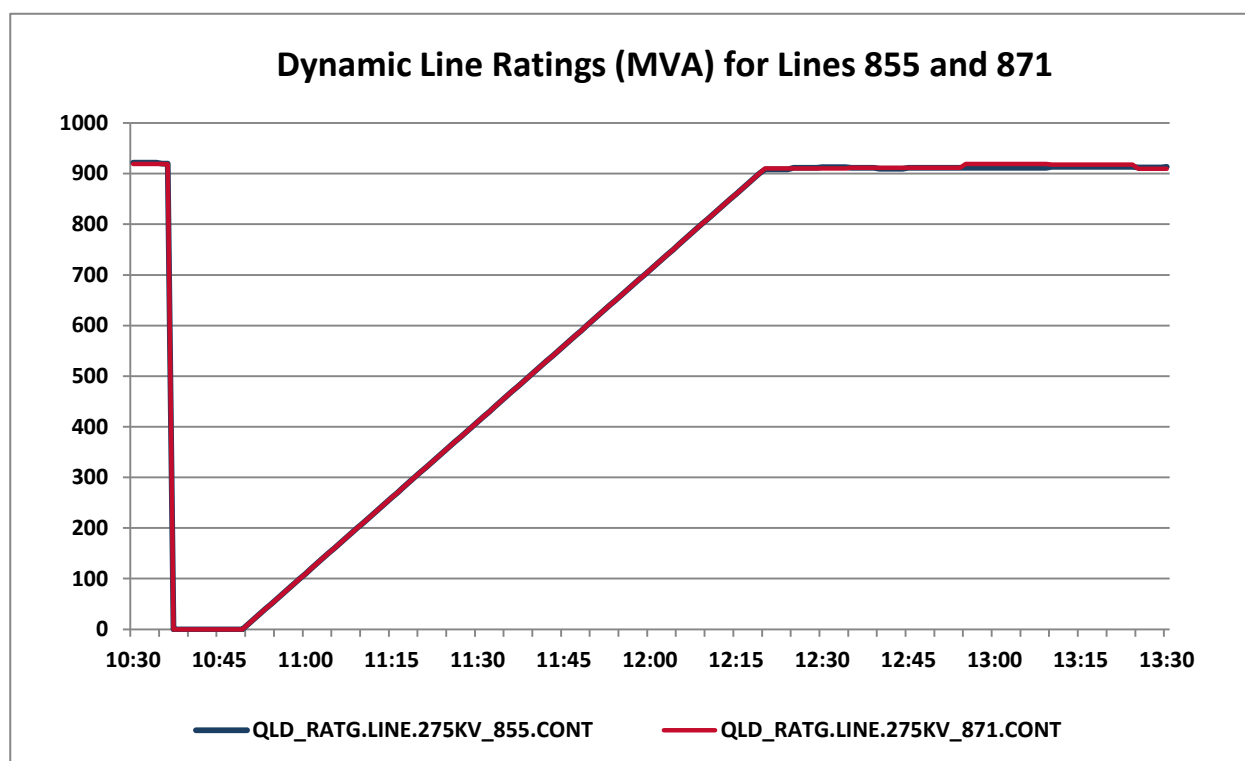
At 1030 hrs a scheduled update to Powerlink’s Energy Management System (EMS) was performed, which included changes to databases on the Powerlink EMS. When the Powerlink EMS databases were restored into production, database points were initialised and flagged as bad quality. This was system normal behaviour. These default values persist until they are updated by SCADA, manually entered or are updated by other applications (such as the RTR algorithm).

The database points used for feeder ratings were restored to a value of 0 (zero) MVA and flagged as bad quality at 10:42:48 when the update was completed. The RTR application recalculated ratings for the 855 and 871 lines at 10:49:03 and new ratings for the feeders were calculated. This output from the RTR application was written to the Powerlink EMS correctly as a good quality point.

When this good quality value was passed to the ramping function, it started ramping from 0 (its previous, bad quality value) towards the new rating supplied by the algorithm. The first good quality values for the 871 and 855 line were therefore transmitted to AEMO as 10MVA at 10:49:44, and then began to increment at 10 MVA per minute as designed.

The transmitted values for the 871 and 855 line ratings are shown in Figure 2.

Figure 2 Dynamic line ratings received from Powerlink for Calvale–Wurdong and Calvale–Stanwell lines



Line ratings of 60 MVA were used in central dispatch for DIs ending 1055 hrs and 1100 hrs. At 1057 hrs, on advice from Powerlink, AEMO manually changed the automatic results for feeders 871 and 855 line ratings to 855 MVA (from 60 MVA) and these values were used in central dispatch from DI ending 1105 hrs onwards.

Since this incident, Powerlink has advised it has changed its procedures so that default values for line ratings are equal to the static rating for each line, rather than zero. This change will avoid similar outcomes occurring in the future.

3.3 AEMO Procedures for Managing Dispatch Intervals Subject to Review

Section 20 of AEMO's Power System Operating Procedure – Dispatch SO_OP3705⁴ describes the procedures followed by AEMO when a dispatch interval is identified as subject to review by the automated procedures discussed in section 3.1 above.

AEMO's review of the incident on 5 September 2011 identified the following aspects of these procedures:

- When the automated procedure is triggered, the DI is identified as subject to review and energy and FCAS prices in the affected region are identified as non-firm. The subsequent five DIs will also be identified as subject to review unless AEMO either accepts or rejects the price.
- If AEMO accepts the prices, all DIs that have been identified as subject to review will be made firm and the prices will not be changed.
- If AEMO rejects the prices, the regional energy and FCAS prices in all DIs that have been identified as subject to review will be changed using to most recent "firm" price.
- If AEMO accepts or rejects the prices, no further DIs will be identified as subject to review for that trigger, regardless of whether the incorrect input is still present. Although AEMO has up to 30 minutes to determine a manifestly incorrect input has affected dispatch, the

⁴ System Operating Procedure dispatch SO_OP3705. AEMO. Revised 20 December 2011. Available at <http://www.aemo.com.au/electricityops/3705.html>.

maximum number of DIs that can be revised will be limited if AEMO responds within 30 minutes.

AEMO has also reviewed the circumstances under which it incorrectly concluded a manifestly incorrect input affected DI ending 1105 hrs. This came about because AEMO's EMS system continued to indicate line limit violations despite the fact that the incorrect limits had been manually altered on advice from Powerlink.

On AEMO's EMS, transmission line ratings are provided at each end of a line. The central dispatch process is configured to use the flow and ratings from one end of each line, and these ratings were handdressed initially. The effect of the sudden relaxation of the limit in the market systems resulted in large changes in Queensland price (which fell) and interconnector flow that triggered the MII automated process. However, a low rating remained in AEMO's EMS and continued violations were indicated in EMS, which led AEMO's control room to conclude that incorrect inputs were still likely to be affecting central dispatch. The ratings at the other end of the lines were subsequently handdressed and all AEMO EMS violations were cleared.

AEMO concludes that its processes and procedures are correct and do not require modification or clarification. The circumstances of the event have been highlighted to AEMO staff for future reference.

3.4 NER Provisions Relating to Manifestly Incorrect Inputs

The price revision process was implemented in July 2006 in response to a NER change proposal by NEMMCO. In its determination⁵, the AEMC reasoned that:

- Investment decisions for the provision of energy and market ancillary services will be based on higher quality and more reliable information that better reflects the value of the services.
- Consumers of energy and market ancillary services will face prices that are more efficient because they better reflect the market value of the service.
- Users of energy and market ancillary services will be better informed in real time as to the quality of the price signals they see, so that their physical response can be better informed.

In February 2009 the MII provisions were amended to remove the performance standard for identifying manifestly incorrect input⁶ in response to a NER change proposal by NEMMCO. This removed a requirement that the automated procedures be designed so that at least the majority of DIs subject to review are found to have had manifestly incorrect inputs. In its determination, the AEMC reasoned that, through the benefit of experience, the performance standard was unachievable. NEMMCO reasoned this was a result of a substantial improvement in the performance of SCADA systems to provide reliable data to NEM central dispatch.

The price revision process was implemented on 1 July 2006 in response to spurious prices during the first five years of the NEM, usually caused by SCADA failure. Clause 3.9.2B (j) of the NER v9 stated that the automated procedures must be designed "...so that at least the majority of dispatch intervals subject to review are found to have had manifestly incorrect inputs". In the years following the implementation of the price revision process, SCADA systems and data quality verification procedures markedly improved. This reduced the incidence of DIs affected by MIIs to the extent that the performance standards for identifying an MII (as stipulated in clause 3.9.2B (j)) could not be achieved, resulting in the removal of the Rule clause in February 2009.

Due to the low incidence of true MIIs, the spot and financial markets respond to prices that are published as "Not Firm" as if they were "Firm". An example of this behaviour was seen on 1 July

⁵ "Revision to dispatch pricing due to manifestly incorrect inputs: Final Rule Determination". AEMC. 17 November 2005. Available at: <http://www.aemc.gov.au/Electricity/Rule-changes/Completed/Revision-to-dispatch-pricing-due-to-manifestly-incorrect-inputs.html>

⁶ "Removal of Performance Standard for Identifying Manifestly Incorrect Inputs: Final Rule Determination". AEMC. 26 February 2009. Available at: <http://www.aemc.gov.au/Electricity/Rule-changes/Completed/Removal-of-Performance-Standard-for-Identifying-Manifestly-Incorrect-Inputs.html>

2010 and is shown in graph 3. The 5-minute prices for South Australia increased from \$43.77 per MWh for DI 1145 hrs to \$4296.02 per MWh for DI 1150 hrs. In Victoria the 5-minute prices increased from \$28.95 per MWh to \$3246.42 per MWh for the same DIs. DI 11:50 hrs was triggered as “subject to review” and the prices were published as “Not Firm”.

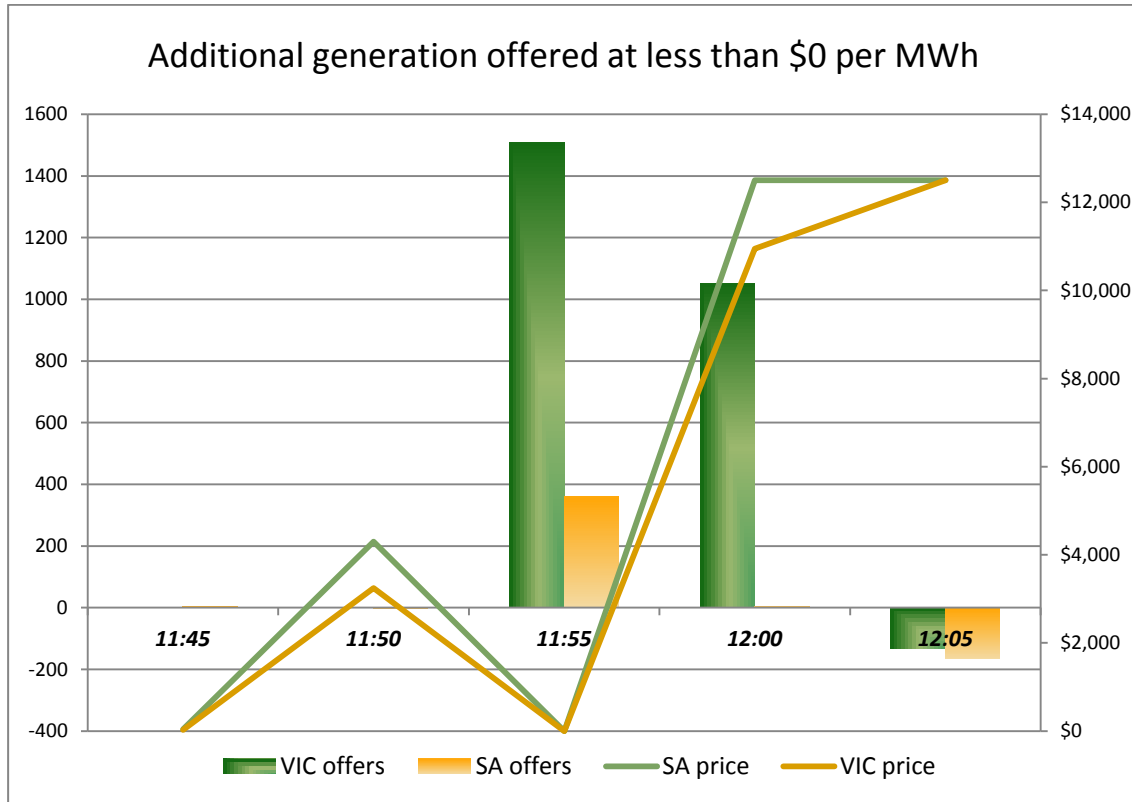


Figure 4 Increase in generation offers at negative prices in response to a high non-firm price

For DI ending 1155 hrs, generating units in South Australia and Victoria re-offered a total of 1870 MW to negatively priced bands. An additional 1056 MW was offered at negative prices for DI ending 1200 hrs, bringing the total change in offered generation capacity in the price band to 2926 MW. The high 5-minute prices for DI 1150 hrs were ultimately rejected and replaced with the last good prices of \$43.77 per MWh and \$28.95 per MWh for South Australia and Victoria respectively⁷.

This means that even if it is ascertained that a DI contained an MII, the error cannot effectively be reversed since the market has already responded to the published price. Additionally price revision incidents are rare, having occurred twice in 2011, once in 2010 and twice in 2009. This means the long term effects of price revisions are small and do not appear to be affecting investment decisions or the risk profile of market participants.

AEMO concludes that the current MII process is of little value to the market in the short or long term, and that short-term price certainty is more beneficial to the market than identifying DIs that can potentially contain an MII.

3.5 Price Revision Incident of 17 February 2011

A separate incident affecting ratings of the same lines occurred on 17 February 2011. In the report⁸, AEMO noted it was reviewing market information it publishes immediately following price revisions due to manifestly incorrect inputs. As a result of this review, AEMO now publishes an

⁷ See AEMO Price Revision Incident Report available at <http://www.aemo.com.au/reports/0150-0070.pdf>.

⁸ See AEMO Price Revision Incident Report available at <http://www.aemo.com.au/reports/0150-0119.pdf>.

audit trail of price revisions made by AEMO under this process. This change was implemented in November 2011.

Although this incident affected the same lines, the circumstances were different and not related to the incident of 5 September 2011.

4 Recommendations

AEMO recommends:

1. No changes be made to the automated procedures for identifying dispatch intervals as subject to review. Although any potential design changes are more likely to reduce the occurrence of “false negatives” in the automated procedures, they are also likely to increase the occurrence of “false positives” as well.
2. Removal of the procedures in clause 3.9.2B of the NER relating to price where AEMO determines a manifestly incorrect input. The current process is not achieving its original objectives and is not affecting operational, investment or risk management decisions made market participants.

AEMO notes that actions taken by Powerlink to its database procedures and by AEMO in highlighting its procedures to staff should reduce the overall impact of such incidents in future.

AEMO also notes that it now publishes audit trail information on price revision incidents.

5 Appendix – Violated Network Constraint Equations

5.1 Q>>BCLC_BCGL_CLWU

Constraint type: LHS<=RHS

Constraint description: Out = Bouldercombe to Larcom Creek (811), avoid O/L Calvale to Wurdong (871) on trip of Bouldercombe to Gladstone (812), Feedback

LHS

0.9999 x Barcaldine GT
 0.1184 x Millmerran unit 1
 0.1184 x Millmerran unit 2
 + Barron Gorge hydro unit 1
 + Barron Gorge hydro unit 2
 0.1372 x Braemar 1 GT unit 1
 0.1372 x Braemar 1 GT unit 2
 0.1372 x Braemar 1 GT unit 3
 0.1372 x Kogan Creek
 0.1372 x Braemar 2 GT unit 5
 0.1372 x Braemar 2 GT unit 6
 0.1372 x Braemar 2 GT unit 7
 0.1372 x Darling Downs GT
 0.9999 x Callide B unit 1
 0.9999 x Callide B unit 2
 0.9999 x Callide C unit 3
 0.9999 x Callide C unit 4
 0.1593 x Condamine CCGT
 0.9999 x Collinsville unit 1
 0.9999 x Collinsville unit 2
 0.9999 x Collinsville unit 3
 0.9999 x Collinsville unit 4
 0.9999 x Collinsville unit 5
 + Townsville GT Yabulu unit 2
 -0.9668 x Gladstone unit 1
 -0.9668 x Gladstone unit 2
 -0.9908 x Gladstone unit 3
 -0.9908 x Gladstone unit 4
 -0.9668 x Gladstone unit 5
 -0.9668 x Gladstone unit 6
 + Kareeya hydro unit 1
 + Kareeya hydro unit 2
 + Kareeya hydro unit 3
 + Kareeya hydro unit 4
 0.9999 x Mackay GT
 + Mt Stuart GT unit 1
 + Mt Stuart GT unit 2
 + Mt Stuart GT unit 3
 0.1017 x Oakey GT unit 1
 0.1017 x Oakey GT unit 2
 0.1593 x Roma GT unit 7
 0.1593 x Roma GT unit 8
 0.9999 x Stanwell unit 1
 0.9999 x Stanwell unit 2
 0.9999 x Stanwell unit 3
 0.9999 x Stanwell unit 4
 0.07009 x Swanbank E GT
 0.1593 x Tarong North
 0.1593 x Tarong unit 1
 0.1593 x Tarong unit 2
 0.1593 x Tarong unit 3
 0.1593 x Tarong unit 4
 + Townsville GT Yabulu unit 1
 0.1236 x MW flow north on QNI

RHS

2.689 x (Qld: 871 Calvale to Wurdong 275kV Emergency Rating
 - MVA on 871 275kV feeder from Calvale, Line end switched MW
 - 0.7425 x [MW flow on 812 275kV feeder at Bouldercombe, line end switched MW]
 - 35 {Operating_Margin}
 + 0.1593 x [Condamine CCGT]
 - 0.9668 x [Gladstone unit 1]
 - 0.9668 x [Gladstone unit 2]
 - 0.9908 x [Gladstone unit 3]
 - 0.9908 x [Gladstone unit 4]
 - 0.9668 x [Gladstone unit 5]
 - 0.9668 x [Gladstone unit 6]
 + 0.1593 x [Tarong North]
 + 0.1593 x [Tarong unit 1]
 + 0.1593 x [Tarong unit 2]
 + 0.1593 x [Tarong unit 3]
 + 0.1593 x [Tarong unit 4]
 + 0.9999 x [Callide B unit 1]
 + 0.9999 x [Callide B unit 2]
 + 0.9999 x [Stanwell unit 1]
 + 0.9999 x [Stanwell unit 2]
 + 0.9999 x [Stanwell unit 3]
 + 0.9999 x [Stanwell unit 4]
 + 0.1372 x [Braemar 1 GT unit 1]
 + 0.1372 x [Braemar 1 GT unit 2]
 + 0.1372 x [Braemar 1 GT unit 3]
 + 0.1372 x [Braemar 2 GT unit 5]
 + 0.1372 x [Braemar 2 GT unit 6]
 + 0.1372 x [Braemar 2 GT unit 7]
 + 0.9999 x [Callide C unit 3]
 + 0.9999 x [Callide C unit 4]
 + 0.07009 x [Swanbank E GT]
 + 0.9999 x [Barcaldine GT]
 + Barron Gorge hydro unit 1
 + Barron Gorge hydro unit 2
 + 0.9999 x [Collinsville unit 1]
 + 0.9999 x [Collinsville unit 2]
 + 0.9999 x [Collinsville unit 3]
 + 0.9999 x [Collinsville unit 4]
 + 0.9999 x [Collinsville unit 5]
 + Kareeya hydro unit 1
 + Kareeya hydro unit 2
 + Kareeya hydro unit 3
 + Kareeya hydro unit 4
 + Townsville GT (Yabulu) unit 2
 + Townsville GT (Yabulu) unit 1
 + 0.1017 x [Oakey GT unit 1]
 + 0.1017 x [Oakey GT unit 2]
 + 0.1593 x [Roma GT unit 7]
 + 0.1593 x [Roma GT unit 8]
 + 0.1184 x [Millmerran unit 1]
 + 0.1184 x [Millmerran unit 2]
 + 0.1372 x [Kogan Creek]
 + 0.1372 x [Darling Downs GT]
 + 0.9999 x [Mackay GT]
 + Mt Stuart GT unit 1
 + Mt Stuart GT unit 2
 + Mt Stuart GT unit 3
 + 0.1236 x [MW flow north on the QNI AC Interconnector]

5.2 Q>>NIL_855_871

Constraint type: LHS<=RHS

Constraint description: Out = Nil, avoid overload on Calvale to Wurdong (871) line on trip of Calvale to Stanwell (855) line, Feedback

LHS

-0.5548 x Barcaldine GT
 0.1195 x Millmerran unit 1
 0.1195 x Millmerran unit 2
 -0.7531 x Barron Gorge hydro unit 1
 -0.7531 x Barron Gorge hydro unit 2
 0.1379 x Braemar 1 GT unit 1
 0.1379 x Braemar 1 GT unit 2
 0.1379 x Braemar 1 GT unit 3
 0.1379 x Kogan Creek
 0.1379 x Braemar 2 GT unit 5
 0.1379 x Braemar 2 GT unit 6
 0.1379 x Braemar 2 GT unit 7
 0.1379 x Darling Downs GT
 + Callide B unit 1
 + Callide B unit 2
 + Callide C unit 3
 + Callide C unit 4
 0.1595 x Condamine CCGT
 -0.7455 x Collinsville unit 1
 -0.7455 x Collinsville unit 2
 -0.7455 x Collinsville unit 3
 -0.7455 x Collinsville unit 4
 -0.7455 x Collinsville unit 5
 -0.7526 x Townsville GT (Yabulu) unit 2
 -0.9315 x Gladstone unit 1
 -0.9315 x Gladstone unit 2
 -0.9657 x Gladstone unit 3
 -0.9657 x Gladstone unit 4
 -0.9315 x Gladstone unit 5
 -0.9315 x Gladstone unit 6
 -0.753 x Kareeya hydro unit 1
 -0.753 x Kareeya hydro unit 2
 -0.753 x Kareeya hydro unit 3
 -0.753 x Kareeya hydro unit 4
 -0.7477 x Mackay GT
 -0.752 x Mt Stuart GT unit 1
 -0.752 x Mt Stuart GT unit 2
 -0.752 x Mt Stuart GT unit 3
 0.106 x Oakey GT unit 1
 0.106 x Oakey GT unit 2
 0.1595 x Roma GT unit 7
 0.1595 x Roma GT unit 8
 -0.8245 x Stanwell unit 1
 -0.8245 x Stanwell unit 2
 -0.8245 x Stanwell unit 3
 -0.8245 x Stanwell unit 4
 0.1595 x Tarong North
 0.1595 x Tarong unit 1
 0.1595 x Tarong unit 2
 0.1595 x Tarong unit 3
 0.1595 x Tarong unit 4
 -0.7526 x Townsville GT Yabulu unit 1
 0.1246 x MW flow north on QNI

RHS

2.862 x (-1 x [MVA on 871 275kV feeder from Calvale, Line end switched MW]
 - 0.645 x [MW flow on 855 275kV feeder at Calvale, Line end switched MW]
 + Qld: 871 Calvale to Wurdong 275kV Emergency Rating
 - 35 (Operating_Margin)
 - 0.9315 x [Gladstone unit 1]
 - 0.9315 x [Gladstone unit 2]
 - 0.9657 x [Gladstone unit 3]
 - 0.9657 x [Gladstone unit 4]
 - 0.9315 x [Gladstone unit 5]
 - 0.9315 x [Gladstone unit 6]
 + 0.1595 x [Tarong unit 1]
 + 0.1595 x [Tarong unit 2]
 + 0.1595 x [Tarong unit 3]
 + 0.1595 x [Tarong unit 4]
 + Callide B unit 1
 + Callide B unit 2
 - 0.8245 x [Stanwell unit 1]
 - 0.8245 x [Stanwell unit 2]
 - 0.8245 x [Stanwell unit 3]
 - 0.8245 x [Stanwell unit 4]
 + 0.1379 x [Braemar 1 GT unit 1]
 + 0.1379 x [Braemar 1 GT unit 2]
 + 0.1379 x [Braemar 1 GT unit 3]
 + 0.1379 x [Kogan Creek]
 + 0.1379 x [Braemar 2 GT unit 5]
 + 0.1379 x [Braemar 2 GT unit 6]
 + 0.1379 x [Braemar 2 GT unit 7]
 + 0.1379 x [Darling Downs GT]
 + 0.1595 x [Condamine CCGT]
 + Callide C unit 3
 + Callide C unit 4
 + 0.1595 x [Tarong North]
 - 0.7531 x [Barron Gorge hydro unit 1]
 - 0.7531 x [Barron Gorge hydro unit 2]
 - 0.7455 x [Collinsville unit 1]
 - 0.7455 x [Collinsville unit 2]
 - 0.7455 x [Collinsville unit 3]
 - 0.7455 x [Collinsville unit 4]
 - 0.7455 x [Collinsville unit 5]
 - 0.753 x [Kareeya hydro unit 1]
 - 0.753 x [Kareeya hydro unit 2]
 - 0.753 x [Kareeya hydro unit 3]
 - 0.753 x [Kareeya hydro unit 4]
 - 0.7526 x [Townsville GT (Yabulu) unit 2]
 - 0.7526 x [Townsville GT (Yabulu) unit 1]
 + 0.1595 x [Roma GT unit 7]
 + 0.1595 x [Roma GT unit 8]
 + 0.1195 x [Millmerran unit 1]
 + 0.1195 x [Millmerran unit 2]
 - 0.5548 x [Barcaldine GT]
 - 0.7477 x [Mackay GT]
 - 0.752 x [Mt Stuart GT unit 1]
 - 0.752 x [Mt Stuart GT unit 2]
 - 0.752 x [Mt Stuart GT unit 3]
 + 0.106 x [Oakey GT unit 1]
 + 0.106 x [Oakey GT unit 2]
 + 0.1246 x [MW flow north on the QNI AC Interconnector]

5.3 Q>>NIL_871_855

Constraint type: LHS<=RHS

Constraint description: Out= Nil, avoid O/L 855 Calvale to Stanwell 275kV line on trip of 871 Calvale to Wurdong 275kV line, Feedback

LHS

-0.8011 x Barcaldine GT
 0.0773 x Millmerran unit 1
 0.0773 x Millmerran unit 2
 -0.9276 x Barron Gorge hydro unit 1
 -0.9276 x Barron Gorge hydro unit 2
 0.08963 x Braemar 1 GT unit 1
 0.08963 x Braemar 1 GT unit 2
 0.08963 x Braemar 1 GT unit 3
 0.08963 x Kogan Creek
 0.08963 x Braemar 2 GT unit 5
 0.08963 x Braemar 2 GT unit 6
 0.08963 x Braemar 2 GT unit 7
 0.08963 x Darling Downs GT
 0.6529 x Callide B unit 1
 0.6529 x Callide B unit 2
 0.6529 x Callide C unit 3
 0.6529 x Callide C unit 4
 0.1041 x Condamine CCGT
 -0.9118 x Collinsville unit 1
 -0.9118 x Collinsville unit 2
 -0.9118 x Collinsville unit 3
 -0.9118 x Collinsville unit 4
 -0.9118 x Collinsville unit 5
 -0.9268 x Townsville GT Yabulu unit 2
 -0.6314 x Gladstone unit 1
 -0.6314 x Gladstone unit 2
 -0.5696 x Gladstone unit 3
 -0.5696 x Gladstone unit 4
 -0.6314 x Gladstone unit 5
 -0.6314 x Gladstone unit 6
 -0.9276 x Kareeya hydro unit 1
 -0.9276 x Kareeya hydro unit 2
 -0.9276 x Kareeya hydro unit 3
 -0.9276 x Kareeya hydro unit 4
 -0.9191 x Mackay GT
 -0.9265 x Mt Stuart GT unit 1
 -0.9265 x Mt Stuart GT unit 2
 -0.9265 x Mt Stuart GT unit 3
 0.1041 x Roma GT unit 7
 0.1041 x Roma GT unit 8
 - Stanwell unit 1
 - Stanwell unit 2
 - Stanwell unit 3
 - Stanwell unit 4
 0.1041 x Tarong North
 0.1041 x Tarong unit 1
 0.1041 x Tarong unit 2
 0.1041 x Tarong unit 3
 0.1041 x Tarong unit 4
 -0.9267 x Townsville GT Yabulu unit 1
 0.08076 x MW flow north on QNI

RHS

2.472 x (Qld: 855 Calvale to Stanwell 275kV Continuous Rating
 - MW flow on 855 275kV feeder at Calvale, Line end switched MW
 - 0.58 x [MVA on 871 275kV feeder from Calvale, Line end switched MW]
 - 35 {Operating_Margin}
 - 0.6314 x [Gladstone unit 1]
 - 0.6314 x [Gladstone unit 2]
 - 0.5696 x [Gladstone unit 3]
 - 0.5696 x [Gladstone unit 4]
 - 0.6314 x [Gladstone unit 5]
 - 0.6314 x [Gladstone unit 6]
 + 0.1041 x [Tarong unit 1]
 + 0.1041 x [Tarong unit 2]
 + 0.1041 x [Tarong unit 3]
 + 0.1041 x [Tarong unit 4]
 + 0.6529 x [Callide B unit 1]
 + 0.6529 x [Callide B unit 2]
 - Stanwell unit 1
 - Stanwell unit 2
 - Stanwell unit 3
 - Stanwell unit 4
 + 0.08963 x [Braemar 1 GT unit 1]
 + 0.08963 x [Braemar 1 GT unit 2]
 + 0.08963 x [Braemar 1 GT unit 3]
 + 0.08963 x [Kogan Creek]
 + 0.08963 x [Braemar 2 GT unit 5]
 + 0.08963 x [Braemar 2 GT unit 6]
 + 0.08963 x [Braemar 2 GT unit 7]
 + 0.08963 x [Darling Downs GT]
 + 0.1041 x [Condamine CCGT]
 + 0.6529 x [Callide C unit 3]
 + 0.6529 x [Callide C unit 4]
 + 0.1041 x [Tarong North]
 - 0.9276 x [Barron Gorge hydro unit 1]
 - 0.9276 x [Barron Gorge hydro unit 2]
 - 0.9118 x [Collinsville unit 1]
 - 0.9118 x [Collinsville unit 2]
 - 0.9118 x [Collinsville unit 3]
 - 0.9118 x [Collinsville unit 4]
 - 0.9118 x [Collinsville unit 5]
 - 0.9276 x [Kareeya hydro unit 1]
 - 0.9276 x [Kareeya hydro unit 2]
 - 0.9276 x [Kareeya hydro unit 3]
 - 0.9276 x [Kareeya hydro unit 4]
 - 0.9268 x [Townsville GT (Yabulu) unit 2]
 - 0.9267 x [Townsville GT (Yabulu) unit 1]
 + 0.1041 x [Roma GT unit 7]
 + 0.1041 x [Roma GT unit 8]
 + 0.0773 x [Millmerran unit 1]
 + 0.0773 x [Millmerran unit 2]
 - 0.8011 x [Barcaldine GT]
 - 0.9191 x [Mackay GT]
 - 0.9265 x [Mt Stuart GT unit 1]
 - 0.9265 x [Mt Stuart GT unit 2]
 - 0.9265 x [Mt Stuart GT unit 3]
 + 0.08076 x [MW flow north on the QNI AC Interconnector]