AUSTRALIAN ENERGY REGULATOR

Final

The events of 31 October 2005

Investigation Report

October 2006

Table of Contents

Glossary

AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
AGC	Automatic Generation Control
MW	Megawatts
NEM	National Electricity Market
NEMDE	National Electricity Market Dispatch Engine
NEMMCO	National Electricity Market Management Company
OPGW	Optical Powerline Ground Wire
PSDCS	Power System Data Communications Standard
QNI	Queensland to New South Wales interconnector
SCADA	Supervisory Control And Data Acquisition
TNSP	Transmission Network Service Provider

1 Summary

On 30 October 2005 an overhead earthwire on a major transmission line between the Wallerawang power station and the South Sydney substation (line 76) failed, probably as a result of a lightning strike. The earthwire fell onto the transmission line causing it to short circuit,and taking the line out of service.

Optical fibre within the earthwire also broke, disrupting communications between the National Electricity Market Management Company (NEMMCO) and two power stations owned by Delta Electricity (Mt Piper and Wallerawang) as well as communications to some of TransGrid's[1] substations:

- The two affected power stations lost access to dispatch instructions automatically generated by NEMMCO's dispatch program (the National Electricity Market Dispatch Engine or NEMDE)
- Voice communications between NEMMCO and the two power stations were disrupted
- NEMMCO did not have direct access to information on output at the two power stations or flows on transmission lines in the affected area
- TransGrid did not have access to data from its substations in the affected area.

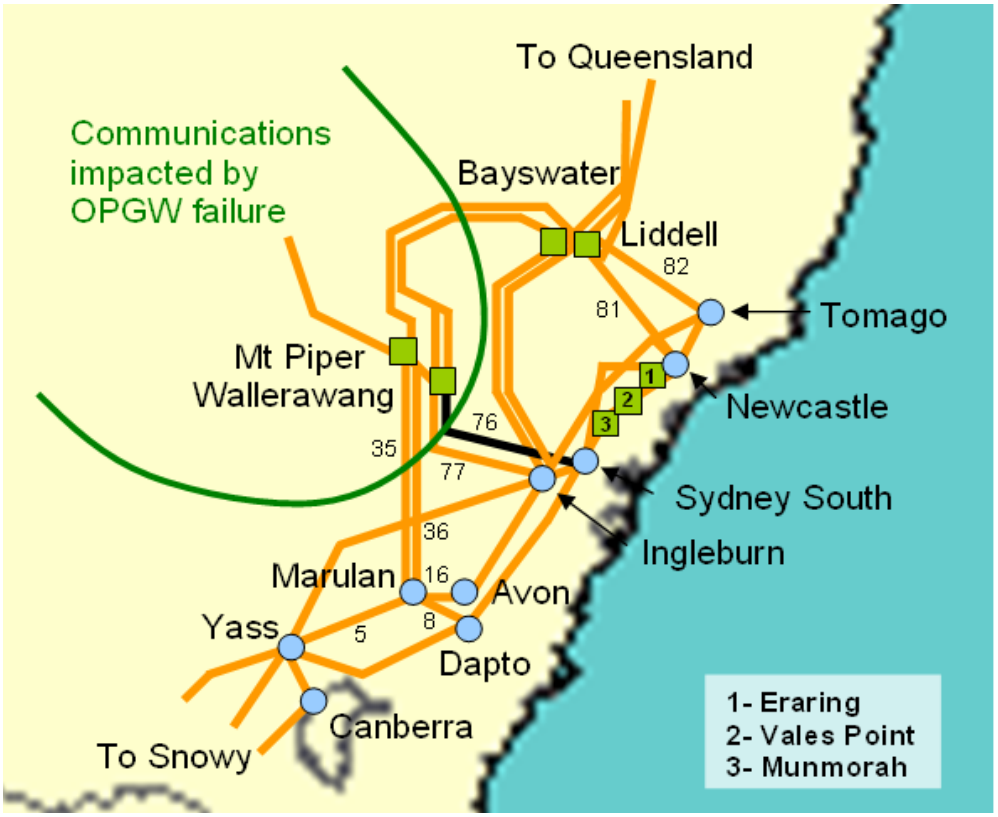
Figure 1 shows the transmission line immediately affected (line 76) and the area affected by the communications failure.The fault was repaired and the lines returned to service on 31 October 2005.

On 31 October 2005 spot prices in New South Wales were over $5000/MWh for five trading intervals peaking at $6724/MWh, power flows on the network were not consistent with secure levels, and NEMMCO and registered participants experienced difficulties with market related communications. A detailed description of the events is provided in chapter 2.

The AER is responsible for monitoring compliance with, and investigating possible breaches of, the National Electricity Law, Regulations and the National Electricity Rules. Given the significance of the event and its implications for price and reliability outcomes, the AER investigated the events on 30/31 October 2005 in order to determine whether registered participants and NEMMCO complied with the Rules. This report presents the AER's conclusions and recommendations.

[1] Transgrid is the Transmission Network Service Provider in New South Wales.

Figure 1: Line 76 and the area affected by the communications failure



Issues identified by the AER

Generator dispatch

The communications failure presented NEMMCO with two immediate dispatch problems:

- Wallerawang and Mt Piper did not have on-line access to NEMDE dispatch instructions.
- NEMMCO did not have direct access to the generators' actual output. NEMMCO utilised procedures established for this type of situation, which included manually substituting the outputs into NEMDE as advised by the generators' operators.

There were some implementation issues which compromised system security.

The first issue was generator conformance with dispatch instructions. Clause 4.9.8(a) of the Rules requires generators to conform with NEMMCO's dispatch instructions unless it would be "a hazard to public safety or materially risk damaging equipment".

In general, generators conformed with dispatch instructions, but on a number of occasions they failed to meet NEMMCO's dispatch target by a significant margin, which contributed to the system security issues.

The AER considers that the requirement for participants to follow dispatch instructions, as specified in clause 4.9.8(a), is fundamental to the secure operation of the power system and must be met whether or not a non-conformance notice has been issued. The AER has explored with NEMMCO the application of the non-conformance provisions of clause 3.8.23 of the Rules and the general responsibilities of participants to follow dispatch instructions outlined in chapter 4 of the Rules. The AER will issue a compliance bulletin to the market outlining its understanding of the requirements of clause 4.9.8(a) and the manner in which the AER intends to enforce these provisions.

The second issue was the frequency with which NEMMCO manually updated the generators' actual outputs into NEMDE.

In order to repair line 76 TransGrid had to take line 77 out of service for safety reasons. When line 77 was taken out of service (at around 9.30 am on Monday 31 October) it introduced new transmission constraints. NEMMCO sought to manage the system security implications of this by invoking constraints that impacted on the output of most New South Wales generators. This had the affect of reducing output at Wallerawang and Mt Piper. NEMDE instructed the generators to reduce output by 30 MW every five minutes (the maximum ramp rate bid in by the generators). However, initially NEMMCO did not frequently update NEMDE to reflect the generators' actual outputs. This meant that every (five minute) dispatch interval NEMDE instructed the generators to reduce output by 30 MW, but from their initial output level, not their actual output level. NEMMCO's first adjustment for Wallerawang was at 10.40 am. Its adjustments for Mt Piper were at 9.30 am and 10.40 am. After that NEMMCO adjusted NEMDE every dispatch interval.

Ahead of the repair to the communications system NEMMCO halted the automatic process and resorted to manual adjustments to NEMDE. This decision appears reasonable. In order for the manual adjustments of generator output to be effective it is necessary for NEMMCO to maintain frequent contact with the generating unit in order to confirm that the unit is maintaining or altering its output in accordance with dispatch targets and to feed this output into NEMDE.

This manual adjustment process could have been more frequent. When combined with the reduced ramp rates offered by Delta Electricity (see discussion below about generator rebidding), the result was considerably higher output from these units than was required to manage system security. This was despite the fact that one of the critical requirements initially identified by NEMMCO for allowing this outage to proceed, was reduced output at the two power stations.

Following from its investigation into this incident the AER will seek an undertaking from NEMMCO to review its procedures for managing market or market systems failures in this regard, to ensure that under similar emergency situations, the process of substitution is timely, and accurately reflects power system conditions.

Generator rebidding

During the high priced periods on 31 October, binding network constraints drove down the output at a number of generators, including Delta Electricity's two effected power stations. In response some of those generators utilised the rebidding Rules to reduce the rate at which the generators output could be changed in a downward direction.

The market systems favour generator ramp rate bids over network security. As a result when a generator is faced with a network constraint that requires its output to be reduced, it can utilise the rebidding mechanisms to reduce its maximum ramp down rate and consequently reduce the commercial impacts on its generating plant.

The AER is concerned that rebidding reduced ramp rates for commercial reasons jeopardised system security. This is supported by NEMMCO's report into this incident, which concluded that rebidding by generators to reduce ramp rates made NEMMCO's management of security more difficult and contributed to the continuing security violations.

The AER will review options to address this issue. In general there are two possible approaches. One is to remove or reduce the incentive for generators to reduce the ramp rate for commercial reasons. The second is an administrative requirement for ramp rate bids to reflect actual generator capacity. The AER intends to develop and submit a Rule change proposal late this year or early next year.

In considering this issue the AER will assess whether other physical bid parameters may be used for commercial reasons, but to the detriment of power system security management.

TNSP obligations for power system data communications

The loss of line 76 led to loss of the sole operational communications facility to two major power stations and nine transmission substations. Clause 4.11.2 of the Rules requires TNSP's to provide and maintain communication facilities to standards established by NEMMCO. These standards are set out in NEMMCO's "Standard for Power System Data Communications – Final Determination" (PSDCS).

The AER reviewed TransGrid's compliance with the obligations in the PSDCS and found that TransGrid met the requirements in this instance. The AER also considers that TransGrid made appropriate efforts to promptly repair the failure, and that its actions were consistent with its obligations under the Rules.

The AER notes that by mid 2008 TransGrid intends to upgrade the capability of its communications facilities to provide redundancy to critical services. The services discussed in this report will be covered by new back up communications facilities. The upgrade should significantly improve performance of the communications system.

Outage of line 77

The repair of the broken earthwire associated with line 76 was complicated by bad weather conditions and the remote location of the failure. In addition, TransGrid determined that in order to remove the broken earthwire it would be necessary, for safety reasons, to take the adjacent line 77 out of service. In other words a simultaneous outage of both lines 76 and 77 was required. Together the two lines form one of the major supply routes from the western generators into Sydney.

TransGrid submitted a request to NEMMCO at 1.30 pm on Sunday 30 October for an outage of line 77 in order to remove the earthwire. TransGrid withdrew this outage request at 4.15 pm as the weather conditions deteriorated, and requested an outage of line 77 from the first available time after daybreak on the morning of Monday 31 October. Notice to the market of this outage was issued at 7.15pm on Sunday. Later that evening NEMMCO issued a further notice indicating that the outage had been deferred, as system security could not be assured. NEMMCO requested that TransGrid review options to manage those security issues.

At 8.50 am on Monday 31 October 2005, TransGrid advised NEMMCO that the failure of the earthwire was now considered a system emergency and the line 77 outage needed to go ahead urgently. Furthermore, weather conditions were again deteriorating, reducing the window in which TransGrid could conduct the necessary works. At 9.10 am, NEMMCO advised TransGrid that (based on further studies and additional security arrangements) the line 77 outage could proceed. NEMMCO did not issue a market notice at this time.

At 9.20 am on 31 October 2005 NEMMCO invoked network constraint sets in the market systems to manage the combined outage of lines 76 and 77, and at 9.25 am line 77 was taken out of service. From the dispatch intervals ending 9.20 am onwards, a number of constraints bound (meaning that the market was impacted) and other constraints were violated (meaning that those constraints were unable to maintain security). Due to the persistence of constraint violations, at 9.55 am NEMMCO requested TransGrid to recall line 77. Line 77 returned to service almost an hour later, at approximately 10.53 am, with the earthwire still entangled in line 76.

During the morning outage, the power system remained insecure for approximately 35 minutes. The AER believes that this period was longer than necessary for a number of reasons including:

- the undesirable interaction and operation of constraints;
- the delay in the recall of line 77;
- the manual updating of generator output at Mount Piper and Wallerawang power stations into the market systems; and
- the low level ramp rates bid in by generators.

At 11.58 am, TransGrid resubmitted its line 77 outage request to NEMMCO. NEMMCO granted permission to proceed with the outage of line 77 at 1.35 pm. The removal of the earthwire was completed at 3.47 pm and line 77 returned to service at 4.20 pm. During this outage a number of network constraints in New South Wales and Queensland bound, with five constraints violated.

Amongst other things this incident highlights the importance of effective constraints to the management of the power system. NEMMCO has advised the AER that the program to fully optimise all network constraints is on track for completion by early 2007. The AER supports NEMMCO's program to fully optimise all network constraints and will seek an undertaking from NEMMCO to regularly review, and update as required, all key constraints.

The AER considers that the information provided by NEMMCO to the market prior to the outage of line 77 at 9.25 am on 31 October was inadequate. Circumstances at the time made the case for market notification particularly strong:

- NEMMCO had concerns about the possible consequences of the outage based on its own studies;
- the outage was likely to impact significantly on the power flows around New South Wales; and
- four of the generators identified by NEMMCO as necessary to manage the outage effectively were without SCADA and dispatch targets.

The AER will seek an undertaking from NEMMCO to review its outage management procedures and training to ensure that every reasonable effort is made to keep the market informed of network issues where there is likely to be a material market impact.

NEMMCO has taken a number of steps prior to the outage and since to convert and correct constraint accuracy, commence the development of an on-line constraint builder, and to refine its procedures. Given these steps, the significant difficulties presented by the loss of communications in this event, and the emergency nature of the outage, the AER believes that NEMMCO's processes are consistent with the principles for maintaining power system security.

Conclusions

In summary, the outcomes of this report are as follows:

- The AER will not take action for breach of the Rules with respect to this incident.
- The AER will issue a compliance bulletin to the market outlining its understanding of the application of non-conformance provisions of clause 3.8.23 of the Rules and the responsibilities of participants to follow dispatch instructions as required by clause 4.9.8(a) of the Rules.
- The AER will consider options to address the use of generator ramp rates for commercial reasons. In general there are two possible approaches. One is to remove or reduce the incentive for generators to reduce the ramp rate for commercial reasons. The second is an administrative requirement for ramp rate bids to reflect actual generator capacity. The AER intends to develop and submit a Rule change proposal late this year or early next year. In considering this issue the AER will assess whether other physical bid parameters may be used for commercial reasons, but to the detriment of power system security management.
- The AER will seek undertakings from NEMMCO with respect to:
  - its procedures for managing market or market systems failures and outage management;
  - regularly reviewing all key constraints; and
  - its obligations with respect to providing information to the market.

2 Introduction

2.1 Scope of the report

This report reviews the operation of the National Electricity Market (NEM) on 30 and 31 October 2005 following the failure of an overhead earthwire on the 330 kV transmission line 76 between Wallerawang and south Sydney in New South Wales. Pursuant to its functions and powers, which are set out in section 2.2 below, the AER has reviewed this incident in order to determine whether registered participants and NEMMCO complied with the Rules.

The report follows a detailed investigation into the events on those days. As part of its investigations the AER sought information from NEMMCO, Delta Electricity, TransGrid and Snowy Hydro.

2.2 AER functions and powers

The enforcement functions and powers of the AER are set out in Part 3 - Division 1, s15 of the National Electricity Law, which provides:

> The AER functions and powers include:
>
> (a) to monitor compliance by Registered participants and other persons with this Law, the Regulations and the Rules; and
>
> (b) to investigate breaches or possible breaches of provisions of this Law, the Regulations or the Rules that are not offence provisions; and
>
> (c) to institute and conduct proceedings:
>
> (i) against relevant participants under section 61 of this Law or section 44AAG of the Trade Practices Act 1974 of the Commonwealth; or
>
> (ii)in respect of Registered participants under section 63 of this Law; or
>
> (iii) against persons under section 68 of this Law; and
>
> (d) to institute and conduct appeals from decisions in proceedings referred to in paragraph (c); and …

The AER is required to perform or exercise the above functions or powers in a manner that will or is likely to contribute to the achievement of the national electricity market objective.

The AER fulfils these functions by monitoring the operation and performance of the national electricity market, conducting special investigations in response to market outcomes and/or specific events and maintaining an ongoing compliance management focus in the market. This includes through specific targeting of aspects of market operation and a rolling program of reviews of market participants' compliance strategies as part of its monitoring and enforcement arrangements.

Clause 8.7.1 of the Rules requires the AER, for the purpose of performing its monitoring functions, to determine whether registered participants and NEMMCO are complying with the Rules. The Rules also require that the monitoring processes:

- are consistent over time;
- do not discriminate unnecessarily between registered participants;
- are cost effective; and
- are published or information relating thereto is available (subject to any confidentiality obligations).

2.3 Description of the event

2.3.1 Initial fault

In central New South Wales, lines 76 and 77 connect the Wallerawang substation with the South Sydney and Ingleburn substations at 330 kV. These lines share the same transmission towers and are protected from lightning strikes by two overhead earthwires. One of these earthwires, the line 76 Optical Powerline Ground Wire (OPGW), contains an optical fibre cable that provides communication services to part of the transmission network.

At approximately 7.30 am on Sunday 30 October 2005, the OPGW failed during a severe storm, probably as a result of a lightning strike. The conductor broke approximately 50m from the tower and fell across line 76 with the following two direct effects:

- line 76 tripped, reclosed, tripped again and locked out; and
- the OPGW ceased performing communication services.

The loss of the OPGW caused a loss of Supervisory Control and Data Acquisition (SCADA[2]) capability at the following locations:

- Wallerawang Power Station – operated by Delta Electricity;
- Mt Piper Power Station – operated by Delta Electricity;
- 330 kV substations at Wallerawang, Wellington and Mt Piper; and
- 132 kV substations at Wallerawang, Orange, Panorama, Beryl, Molong and Parkes.

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[2] SCADA is an acronym for supervisory control and data acquisition, a computer system for gathering and analysing real time data and communicating with remote equipment. SCADA systems are used to monitor and control plant or equipment. A SCADA system gathers information, such as the status of a network element or output from a generating unit, transfers the information back to a central site (either NEMMCO or a TNSP), and displays the information in a logical and organized fashion. A SCADA system can also control remote equipment such as circuit breakers.

This had the effect of preventing monitoring or control of high voltage equipment at these locations. It also prevented monitoring and automatic dispatch of 2300 MW of generating capacity at the two power stations.

TransGrid, identified the location of the broken earthwire at approximately 12.15 pm on 30 October 2005 and immediately sought to remove it so that line 76 could be returned to service. This work, however, was complicated by a number of factors including:

- bad weather conditions; and
- the remote location of the failure. The separation of the OPGW occurred on a 700 metre span of line crossing a deep ravine on the western side of the Blue Mountains approximately 30 kms from Wallerawang.

In addition TransGrid determined that in order to remove the broken OPGW it would be necessary, for safety reasons, to take the adjacent line 77 out of service. In other words a simultaneous outage of both lines 76 and 77 was required. Together the two lines form one of the major supply routes from the western power stations into Sydney.

2.3.2 Impact of the incident on the transmission network

Figure 2 shows the New South Wales 330kV transmission network around Sydney. The lines that were out of service (lines 76 and 77) are shown in black and the locations of the major power stations are depicted as green squares. The figure shows how the combined outage of lines 76 and 77 reduced the ability to transmit power from Mt Piper and Wallerawang to Sydney and increased the loading on lines 35, 36, 8 and 16. The outages also increased the loading on lines 81 and 82 and consequently restricted the output from the Bayswater and Liddell power stations. The increased loadings meant that at times these lines were classified as insecure. These lines are shown in red. The figure also shows the area and power stations affected by the OPGW failure.

Figure 2: Location of the incident

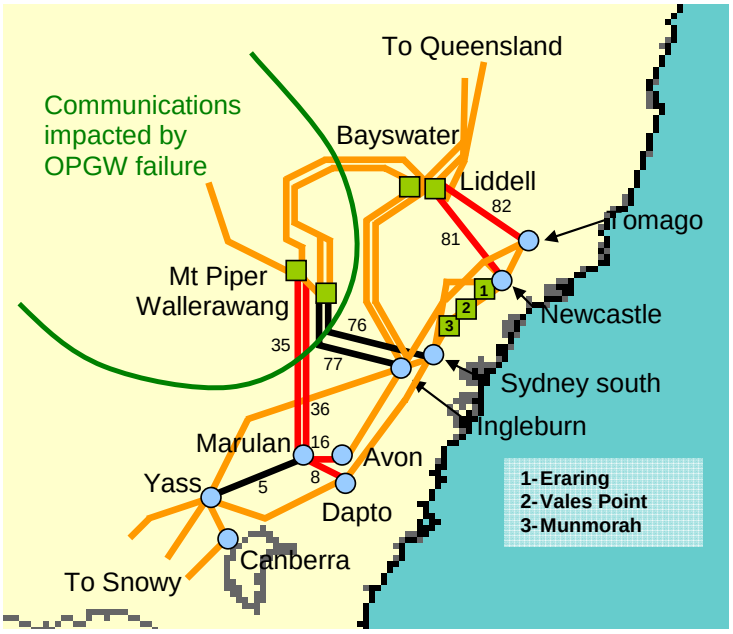

Figure 3 lists the lines affected by the incident and their status.

Figure 3:

Line number	Location	Status
5	Yass to Marulan	Out of service – planned maintenance
8	Marulan to Dapto	Insecure at times
16	Marulan to Avon	Insecure at times
35	Mt Piper to Marulan	Insecure at times
36	Mt Piper to Marulan	Insecure at times[3]
76	Wallerawang to South Sydney	Out of service – fault
77	Wallerawang to Ingleburn	Out of service – to rectify fault
81	Liddell to Newcastle	Insecure at times
82	Liddell to Tomago	Insecure at times

2.3.3 First removal attempt

TransGrid submitted an initial outage request to NEMMCO via the Network Outage Scheduler (NOS) at 1.30 pm on Sunday 30 October in which it advised NEMMCO that it would be necessary to take line 77 out of service in order to remove the OPGW. TransGrid withdrew this outage request at 4.15 pm as the weather conditions deteriorated, and requested an outage of line 77 from the first available time after daybreak on the morning of Monday 31 October. Notice of an outage of line 77 in conjunction with line 76 for Monday morning was issued by NEMMCO at 7.15pm on Sunday.

Later that evening NEMMCO issued a further notice indicating that the outage had been deferred and the constraints were revoked. There were two reasons for NEMMCO's decision:

- first there were insufficient options available to manage post-contingent overloads;[4] and
- second Vales Point unit 6, which would assist with managing security, was due to come on line between 6 am and 7 am on 31 October, but there was uncertainty about whether the time frames would be met.

NEMMCO requested that TransGrid review options to deal with post-contingent overloading as soon as possible to allow the outage to proceed. NEMMCO also advised that direction of Shoalhaven generation should not be considered an option.

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[3] While the constraint managing flow on 35/36 lines violated at times, post-event analysis indicated that the constraint was conservative and post-contingent flows would have been below the 35/36 line rating.

[4] The 76 and 77 lines form one of the major supply routes from the western generators into Sydney. The simultaneous outage of these lines is a significant issue from a security perspective, particularly during stormy weather conditions when the probability of loss of a further line is higher. Additional generation closer to Sydney, for example at Vales Point, assists with the management of security.

2.3.4 Second removal attempt

At 8.50 am on Monday 31 October 2005, TransGrid advised NEMMCO that the loss of SCADA due to the failure of the OPGW was now considered a system emergency[5] and that the line 77 outage needed to go ahead urgently. Furthermore, the AER understands that weather conditions were again deteriorating and that the window in which TransGrid could conduct the necessary works was closing.

At 9.10 am on 31 October 2005, NEMMCO advised TransGrid that (based on further studies and additional arrangements that are described in section 4.2) the line 77 outage could proceed. NEMMCO did not issue a market notice at this time. TransGrid had advised NEMMCO at 11.30 pm the previous night that the recall time would be 30 minutes[6].

At 9.20 am on 31 October 2005, NEMMCO invoked network constraint sets in the market systems to manage the combined outage of lines 76 and 77 and at 9.25 am line 77 was taken out of service. From the dispatch intervals ending 9.20 am onwards, a number of constraints bound (meaning that the market was impacted) and other constraints were violated (meaning that those constraints were unable to maintain security). As a result, the price in New South Wales increased to over $6000/MWh in dispatch interval 9.35 am, reached $10 000/MWh in the 9.55 am dispatch interval, and then remained above $6000/MWh until the 11.00 am dispatch interval.

The same network constraints also led to a combined step reduction of up to 2000 MW on transfer capability into New South Wales from the Queensland and Snowy regions.

Due to the persistence of power system security alarms, at 9.55 am NEMMCO requested TransGrid to recall line 77. Line 77 returned to service almost an hour later, at 10.53 am, with the OPGW still entangled in line 76. The AER understands from NEMMCO that the 30 minute recall time was extended by an additional 30 minutes due to:

- discussions between TransGrid and NEMMCO regarding the imminent return of unit 6 at Vales Point, which, it was believed, would relieve the constraint problem; and
- communication problems between TransGrid and the power stations at Wallerawang and Mt Piper due to landlines (operation telephone systems[7]) being out of service.

At 9.50 am, prior to recalling line 77 and an hour before the return of line 77, NEMMCO revoked several of the violating constraints related to the outage despite the fact that line 77 was still out of service. NEMMCO advised the AER that it took this action because of

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5 This was due to the impacts on several transmission protection systems.

6 In order to safely remove the entangled earth wire, it was necessary to isolate and earth the 77 line transmission circuit, which was on the same tower as the 76 line.

7 Under normal circumstances voice communications between NEMMCO, TransGrid and the power stations is via a dedicated telephone network. This allows direct clearly identified communications between the various control rooms. The loss of the OPGW meant that communications to the power stations were only available via the public telephone network.

concerns that these constraints were not operating effectively and because of the impending recall of line 77. This meant that the market systems did not reflect the actual configuration of the power system at that time. In its report into this incident NEMMCO state that:

> *Revoking of the constraint sets covering outage of the "76 plus 77 lines" and the "77 line on its own" at 09:55 hr did not cause security problems because the constraints associated with outage of the 76 line continued to violate, however, had the constraints in the 76 line outage constraint set ceased violating, system security issues might have arisen because constraints in the "76 plus 77 lines" set were more restrictive.*

2.3.5 Third removal attempt

At 11.58 am, TransGrid resubmitted its line 77 outage request to NEMMCO. NEMMCO granted permission to proceed with the outage of line 77 at 1.35 pm and constraint sets associated with the outage were invoked. The removal of the OPGW was completed at approximately 3.47 pm and line 77 returned to service at 4.20 pm.

During this outage a number of network constraints in New South Wales and Queensland bound, with five constraints violated. The 5-minute dispatch price in New South Wales increased from $33/MWh at 1.55 pm to $10 000/MWh at 2.00 pm. The price remained above $6000/MWh for a number of dispatch intervals until around 3.00 pm when it fell to around $320/MWh. The price in Queensland was also close to the price cap for three dispatch intervals from 2.00 pm.

2.3.6 Completion of repairs

As an interim measure, telecommunications were restored by the temporary installation of an optical fibre cable at ground level. This work was completed by 6.00 pm on 31 October 2005. Line 76 was returned to service at 8.20 am on Tuesday 1 November following spacer repairs.

TransGrid replaced the OPGW on 12 November 2005. On that day, TransGrid arranged a combined outage of lines 76 and 77 and was able to install the replacement OPGW without any noticeable market impact. It should be noted, however, that 12 November was a Saturday with low demands and low Snowy to New South Wales transfers.

2.4 Issues for the AER

Following the AER's review in accordance with 3.13.7, the AER identified a number of issues with respect to the Rules. These include:

- the loss of telecommunications capability;
- power system security;
- generator rates of change;
- conformance with dispatch instructions;
- dispatch and pricing; and
- information to the market.

Each of these issues is discussed in detail in the remainder of the report.

3 The loss of telecommunications capability

3.1 TNSP obligations for power system data communications

Arrangements for the operational control and maintenance of the power system data communications systems, which are critical to the safe operation of the power system, are set out in the Rules. Both TNSP's and NEMMCO have obligations under these provisions.

3.1.1 The Rule provision (4.11.2)

Clause 4.11.2 of the Rules provides as follows:

> 4.11.2 Operational control and indication communication facilities
>
> (a) Each Network Service Provider must provide and maintain, in accordance with the standards referred to in clause 4.11.2(c), the necessary primary and, where nominated by NEMMCO, back-up communications facilities for control, operational metering and indication from the relevant local sites to the appropriate interfacing termination as nominated by NEMMCO.
>
> (b) NEMMCO must provide and maintain the communication facilities between control centres of each Transmission Network Service Provider, on the one hand, and the NEMMCO co-ordinating centre, on the other hand.
>
> (c) NEMMCO must develop, and may amend, standards in consultation with Network Service Providers in accordance with the Rules consultation procedures which must be met by Network Service Providers in providing and maintaining the facilities referred to in clause 4.11.2(a).

3.1.2 Standards governing facilities for telecommunications

The standards governing the provision by NSPs of facilities for telecommunications are outlined in NEMMCO's Standard for Power System Data Communications – Final Determination (PSDCS), which came into effect on 1 January 2004.

Relevant provisions of the PSDCS

Clause 3.1(a) of the PSDCS requires that:

> A *Registered Participant* must design, procure and maintain its *data communications facilities* to reasonably ensure that in any 12 month assessment period:
>
> (i) for at least 95% of *remote monitoring equipment* or *remote control equipment*, the total period of *critical outages* of a *remote monitoring equipment* or *remote control equipment* in a category shown in Column 1 of Table 2 is not greater than the relevant period shown in Column 2 of the table (*interim standard* Column 3)
>
> Clause 3.1(a)(ii) provides that the times set out in Column 3 also apply to the remaining 5% of the equipment.

Table 2 of the PSDCS provides, in part, as follows:

Column 1	**Column 2**	**Column 3**
Category of *remote monitoring equipment* or *remote control equipment*	**Normal standard**	**Interim standard**
remote control equipment	24 hours	48 hours
remote monitoring equipment transmitting or receiving *main dispatch data* for which *NEMMCO* has agreed that it has *substitute values* for that *dispatch data*	12 hours	24 hours

3.1.3 Details of the incident

At approximately 7.30 am on Sunday 30 October 2005, the OPGW was severed during a severe storm and fell across line 76 with the following two direct effects:

- Line 76 tripped, reclosed, tripped again and locked out as a result of the earthwire creating a permanent earth fault; and
- The OPGW ceased performing telecommunication services.

NEMMCO was aware of this outage almost immediately through its own operational systems and verbal advice from TransGrid. In response, NEMMCO invoked constraint set N-SSWW_76 at 7.40 am. Also as a result of the OPGW outage, Delta Electricity advised the AER that it lost all data and operational telephony[8] communications between its western power stations (Mt Piper and Wallerawang) and NEMMCO's control centres.

The loss of the OPGW caused a loss of Supervisory Control and Data Acquisition (SCADA) capability at the following locations:

- Wallerawang Power Station;
- Mt Piper Power Station;
- 330kV Substations at Wallerawang, Wellington and Mt Piper; and
- 132kV Substations at Wallerawang, Orange, Panorama, Beryl, Molong and Parkes.

As a result of the loss of telecommunications:

- TransGrid was unable to remotely operate any of the equipment at the affected substations;

[8] Under normal circumstances voice communications between NEMMCO, TransGrid and the power stations is via a dedicated telephone network. This allows direct clearly identified communications between the various control rooms. The loss of the OPGW meant that communications to the power stations were only available via the public telephone network.

- NEMMCO was unable to remotely monitor power system conditions, including output from the Wallerawang and Mt Piper Power Stations and line flows or alarm operations in the affected parts of the network; and

- the market systems were unable to automatically send dispatch instructions to the Wallerawang and Mt Piper Power Stations via the AGC (Automatic Generation Control) system.

Telecommunications were restored by 6.00 pm on 31 October 2005 when a temporary optical fibre cable was installed at ground level. In total telecommunications between the affected stations was compromised for approximately 34 hours.

Category of the OPGW

The AER understands that the OPGW may fall within either of the categories set out in the table 2 of the PSDCS. NEMMCO has processes to substitute values for the relevant dispatch data. These are detailed in section 3.2.

Interim standard

TransGrid is only required to comply with the interim standard (in Column 3 of Table 2 of the PSDCS) because it has submitted an upgrade plan to NEMMCO in accordance with clause 1.5(a) of the PSDCS. TransGrid informed the AER that this upgrade plan, which involves the upgrade of the relevant parts of TransGrid's facilities, was submitted to NEMMCO on 29 June 2004.

The AER understands from TransGrid that the upgrade date for a number of telecommunications facilities is mid 2008.

Redundancy

At present, TransGrid's communications infrastructure does not provide any redundancy for the OPGW running above line 76.

Clause 3.2 of the PSCDS provides that

> *Data communications facilities* must be arranged to have sufficient redundant elements to be reasonably expected to satisfy the reliability standards set out in clause 3.1 of the *Standards*, taking into account:
>
> (a) the likely failure rate of their elements;
>
> (b) the likely time to repair of their elements; and
>
> (c) the likely need for planned *outages* of their elements.

The standard is "output-based", and not prescriptive in the requirements for redundancy. In any event, TransGrid has committed to upgrade the infrastructure by mid 2008, which the AER understands will be designed to survive the loss of any single telecommunications network element.

Maintenance requirements

Clause 6.1 of the PSDCS provides that:

> A person who is responsible for maintaining *data communications facilities* must:
>
> > (a) promptly repair any failure of *data communications facilities*, taking into account the reliability requirements quantified in Table 2 above;
> >
> > (b) keep *NEMMCO's* control centres informed of progress to repair any failure that is causing a *critical outage; and*
> >
> > (c) consult with *NEMMCO's* control centres regarding the priority of work to correct failures causing or likely to cause a *critical outage*,
>
> with the objective of minimising the impact of *outages* on *central dispatch* and *power system security*.

3.1.4 AER conclusion

The AER concludes that TransGrid complied with the obligations that were imposed upon it under the PSDCS in this instance. More specifically the AER considers that:

- TransGrid acted in accordance with the reliability and maintenance standards published by NEMMCO as required by clause 4.11.2 of the Rules.
- TransGrid made appropriate efforts to promptly repair the failure, and that its actions were consistent with the relevant objectives set out in the PSDCS.

The AER also notes that by mid 2008 TransGrid intends to upgrade the capability of telecommunications facilities to provide redundancy to critical services.

3.2 NEMMCO procedures following loss of SCADA

NEMMCO has developed procedures to ensure the power system can continue to operate in a safe and efficient manner when the data communications system fails until those communication systems can be restored.

3.2.1 NEMMCO procedures

NEMMCO Operating Procedure: "Failure of Market or Market Systems: SO_OP3706" sets out the order in which NEMDE selects SCADA data for processing and provides:

> *When SCADA data fails or if there is partial SCADA system failure and there is no alternative data, NEMDE uses the last dispatch run target as the initial MW for the next dispatch run for scheduled SCADA points. This automatic substitution is adequate for short periods of loss of SCADA data.*

The procedure also states that for a SCADA failure:

> *Wherever possible NDSC will try to arrange for SCADA inputs to be hand-dressed on a five minute cycle to maintain an accurate dispatch.*

3.2.2 Details of the incident

NEMMCO submitted that its actions to manage the loss of SCADA data were consistent with the processes set out in its operating procedures SO_OP3705 (Dispatch) and SO_OP3706 (Failure of Market or Market Systems).

Initial period of SCADA outage

In determining the initial MW output of the generating units at Wallerawang and Mt Piper, NEMMCO initially used the last dispatch run target. NEMMCO adopted this approach from the initial loss of communications at 7.30 am on 30 October until 7.25 am on 31 October. This approach is consistent with operating procedure SO_OP3706 (set out above), for short periods of loss of SCADA data.

Following the loss of communications, Delta Electricity's Wallerawang and Mt Piper operators were unable to see the outputs from the market systems, which meant that the operators at those stations were dispatching units based on information from 3 sources:

- verbal advice from Delta Electricity's Central Coast operators that had access to the dispatch information;
- the NEMMCO back-up bidding facility (used mainly for indicative dispatch targets); and
- verbal advice from NEMMCO.

Delta Electricity initially agreed to rebid its units so that they would be held at their existing outputs. At 10.15 am on 30 October 2005, however, Delta Electricity advised NEMMCO that it would no longer bid units in at a flat output and requested that NEMMCO notify Wallerawang and Mt Piper power stations of their respective targets. From late on Sunday, backup systems were brought on-line at Wallerawang and Mt Piper to provide market systems information to those operators.

Continuing SCADA outage on 31 October

At 7.25 am on 31 October, NEMMCO commenced manual substitution of data based upon verbal advice from local plant operators, in preference to the automatic feeding forward of the last dispatch run target, in order to avoid any inadvertent or spurious SCADA signals from the power stations[9].

[9] NEMMCO was concerned that during the work to repair the OPGW it was possible that the communications facilities could have sent spurious information into the SCADA system, which may have been used in NEMDE.

NEMMCO advised the AER that at 8.45 am, it was contacted by Delta Electricity to advise that Wallerawang had been rebid such that each of its two generating units would be moved up from 340 MW to 400 MW[10]. NEMMCO advised that it then encountered difficulties contacting the Wallerawang power station directly and thus contacted the Delta trader at approximately 9.04 am who advised that the generating units were both generating approximately at 400 MW and would settle at this level. At this time, Wallerawang was generating as much as 90 MW above the NEMDE dispatch targets. The AER understands that the Delta trader informed NEMMCO that these dispatch targets were inconsistent with Wallerawang's dispatch re-offers[11]. At 9.12 am, NEMMCO corrected this discrepancy, to better reflect the actual conditions, by hand dressing[12] the output of both Wallerawang generating units from 340 MW to 400 MW. Delta Electricity was unaware throughout this period of the impending outage of line 77.

The output from the affected power stations

Figure 4, sourced from NEMMCO's report of 5 April 2006 into this incident, shows the output from Wallerawang power station. The blue trace is the actual metered output from the station, which was unavailable via SCADA to NEMMCO at the time because of the telecommunications problems. The yellow trace is the metered output manually substituted (or "hand-dressed") by NEMMCO on advice from Delta Electricity. The red trace is the target from NEMDE.

At the start of the period (between 9.00 am on October 31 and 9.10 am), Wallerawang station's target was being increased by NEMDE from 680 MW (the substituted measured value as known to NEMDE) to 710 MW at its maximum ramp up rate of 30 MW per five minute dispatch interval. The target did not change any further, however, as the hand-dressed value was not being updated.

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10 A rebid was made at around 8.40 am, effective immediately, that resulted in 400 MW of capacity of each Wallerawang unit being offered at negative prices.

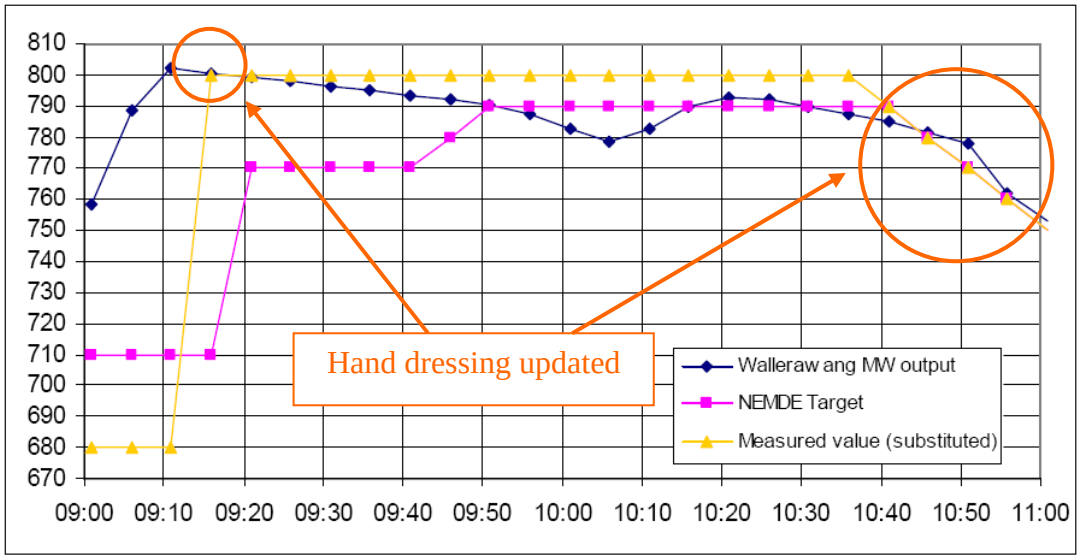
11 This is detailed in section 6.2.

12 The term hand dressing refers to the action by NEMMCO to manually substitute the actual output from the generators into the market systems. This manual action is required when communications from remote locations to the NEMMCO control centres fail, which prevents the actual output from being sent automatically via the SCADA system into the market systems.

At 9.15 am NEMMCO manually updated the hand-dressed value to 800 MW. At 9.20 am the network constraints bound, causing NEMDE to reduce the station output target from 800 MW to 770 MW at its maximum ramp down rate of 30 MW per five minute dispatch interval. Once again the target could not change any further as the hand-dressed value was not being updated. If the station had accurately followed dispatch targets and the substitution for the metered output had been updated regularly, the station would have been driven down at its maximum ramp down rate[13].

At 9.45 am the NEMDE target increased as a result of rebids by Delta Electricity that reduced the maximum ramp down rate, first on Wallerawang unit 7 then on unit 8, to a combined value of 10 MW per dispatch interval (or 1 MW per minute for each unit)[14]. From 10.40 am, the measured value was manually hand-dressed for every dispatch interval[15].

Figure 4: Wallerawang power station output



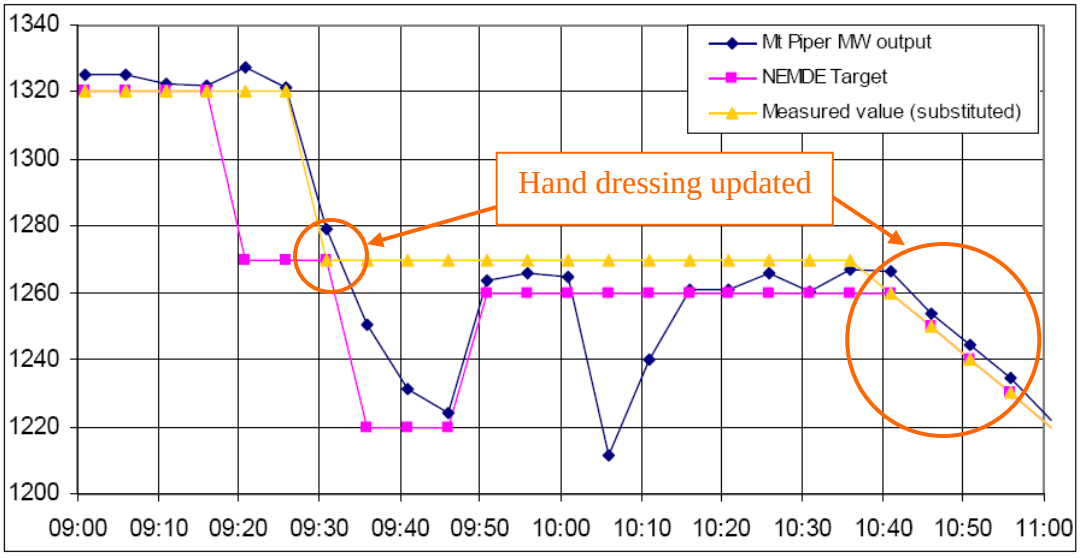
13 The measured value is that measured at the start of a five-minute dispatch interval and the target applies to the end of the dispatch interval. If NEMMCO had hand-dressed the output at 9.20 am to match its target for that interval then the measured value (substituted) would have fallen to 770 MW and the target for 9.25 am would have decreased to 740 MW. Continual hand-dressing by NEMMCO would have seen the yellow line fall instead of being constant at 800 MW. This approach of continual hand-dressing was taken from 10.40 am.

14 As the measured value was static at the hand-dressed value of 800 MW, the target was no longer lower by 30 MW (the ramp rate at 9.40 am), but was reduced by the new ramp rate of 10 MW (that applied from 9.50 am).

15 This process of manually hand-dressing every dispatch interval mimics the automatic approach when SCADA fails which applied from the initial loss of communications at 7.30 am on 30 October until 7.25 am on 31 October.

Figure 5, sourced from NEMMCO's report into this incident, shows the output from Mt Piper power station. This also shows the network constraints at 9.20 am driving the station's output down from 1320 MW to 1270 MW at its maximum ramp down rate of 50 MW per dispatch interval. Again the target did not change further until after the hand-dressed (substituted) value was updated at 9.30 am. The station was then targeted down at its ramp rate (with no further hand-dressing substitutions). At 9.50 am the target increased, again as a result of rebids by Delta Electricity that reduced the ramp down rate of Mt Piper unit 1 and unit 2 to a combined value of 10 MW per dispatch interval (or 1 MW per minute for each unit).

Figure 5: Mt Piper power station output



Comparison of actual generator output with target output

Following the loss of telecommunications and consequent loss of AGC (Automatic Generation Control), plant operators were required to control the output of the units at Wallerawang and Mt Piper manually. This process was made more difficult by the temporary loss of operational telephone communications which also utilise the OPGW facility. These communication systems are the normal systems used by operations personnel.

Delta Electricity took a number of steps to manage the output of generation at Wallerawang and Mt Piper including:

- rebidding output into different price bands in order that NEMDE would continue to dispatch these units with a relatively constant level of output; and
- rebidding to reduce the downward rate of change to 1MW/min in order that any changes in output in a downward direction would be small. Note, however, that rate of change upwards was not varied.

Overall, NEMMCO considered that the Mt Piper and Wallerawang generating units followed their dispatch targets reasonably well over the periods 9.00 am to 11.00 am and 2.00 pm to 4.30 pm on 31 October.

3.2.3 AER conclusion

NEMMCO's decision to halt the automatic process of feeding forward the last dispatch target and resort to hand-dressing, as a result of concerns with spurious SCADA data, appears reasonable.

In order for manual hand dressing of generator output to be effective as a means to manage security and dispatch, it is necessary for NEMMCO to maintain frequent contact with the generating unit in order to confirm that the unit is maintaining or altering its output in accordance with dispatch targets and to feed this output into NEMDE. The process of manually hand-dressing the output of Wallerawang and Mt Piper on the morning of 31 October 2005 could have been more frequent. When combined with the discrepancy between the dispatch targets and output from Wallerawang and Mt Piper, and the reduced ramp rates offered by Delta Electricity, the result was considerably higher output from these units than was required to manage system security. This was despite the fact that one of the critical requirements identified by NEMMCO for allowing this outage to proceed was reduced output at the two power stations.

The failure by NEMMCO to update the output of these stations and therefore drive down the output exacerbated the system security issue. The AER will seek an undertaking from NEMMCO to review its procedures for managing market or market systems failures in this regard, to ensure that under similar emergency situations, the process of substitution is timely, and accurately reflects power system conditions.

NEMMCO's process of hand-dressing was much improved during the later stages of the first outage and for the second outage in the afternoon.

4 Power system security

4.1 NEMMCO obligations

Clause 4.3.1 of the Rules requires that NEMMCO maintain power system security.

The power system security principles are set out in clause 4.2.6 of the Rules. Clause 4.2.6(b) specifically applies to the period following a contingency event or a significant change in power system conditions:

> The *power system security* principles are as follows:
>
> …
>
> (b) Following a *contingency event* (whether or not a *credible contingency event*) or a significant change in *power system* conditions, *NEMMCO* should take all reasonable actions:
>
> > (1) to adjust, wherever possible, the operating conditions with a view to returning the *power system* to a *secure operating state* as soon as it is practical to do so, and, in any event, within thirty minutes[16]

Secure operating state is defined in clause 4.2.4(a) to mean:

> The *power system* is defined to be in a *secure operating state* if, in *NEMMCO*'s reasonable opinion, taking into consideration the appropriate *power system security* principles described in clause 4.2.6:
>
> > (1) the *power system* is in a *satisfactory operating state*; and
> >
> > (2) the *power system* will return to a *satisfactory operating state* following the occurrence of a *single credible contingency event* in accordance with the *power system security and reliability standards*.

Satisfactory operating state is defined in clause 4.2.2(a) to mean that: current, frequency and voltage are within the relevant limits; plant is being operated within ratings; and the power system is stable.

4.2 Details of the incident

Line 77 was taken out of service on two occasions on 31 October 2005. This section will deal with each in turn.

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[16] Sub clause 2 of this provision allows this obligation to be softened based on guidelines issued by the AEMC Reliability Panel, if available. No such guidelines exist.

Outage of line 77 at 9.25 am – 10.55 am

At approximately 9.10 am on 31 October, NEMMCO gave approval to TransGrid for the outage of line 77. NEMMCO submit that this decision was based on the following:

- TransGrid had advised NEMMCO that the loss of telecommunications capability due to the failure of the OPGW was a system emergency due to the loss of SCADA and the impacts on several transmission protection systems;
- as a result of additional studies[17] to those that it had undertaken the previous evening, NEMMCO determined that it should be possible to manage the outage of line 77 on the morning of 31 October; and
- it was possible to manage the outage by
  - — constraining Shoalhaven generation on[18];
  - — reducing output at Mt Piper and Wallerawang Power Stations;
  - — using higher, 15 minute ratings for lines 81 and 82; and
  - — as a last resort, opening line 8 should post contingent overloading occur.

At 9.05 am constraint #SHGEN_E was invoked to constrain the Shoalhaven Power Station on at a level of 240 MW. The constraint #SHGEN_E began violating immediately and remained violated until 9.30 am as Shoalhaven ramped up to its target dispatch level at 10MW/min.

NEMMCO has advised that a decision was made not to reduce the output at Mt Piper and Wallerawang directly but to allow the network constraints to reduce their output, which is NEMMCO's standard practice for managing network outages.

At 9.20 am, NEMMCO invoked a constraint set to manage the outage of line 77, and another covering the outage of line 76 plus line 77. A number of constraints were subsequently violated, for periods of up to 100 minutes. Appendix A provides details of the constraints invoked during this outage and the further outage in the afternoon.

At 9.50 am, NEMMCO revoked two of those invoked constraints because of concerns that these constraints were not operating correctly and the impending recall of line 77.

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17 Those additional studies included an assessment of the impact of the planned outage of the 5 line (between Yass and Marulan) on the outage of the 76 and 77 lines, concluding that those impacts were not material.

18 The constraining on of the Shoalhaven generator should not be confused with a power system direction. A generator may bid itself unavailable for commercial reasons at any time. Shoalhaven did not do this. In the event that a generator is required to be constrained on for power system security reasons and it does bid itself unavailable, NEMMCO has the power to direct that generator. The generator may then seek compensation through the normal market mechanisms.

At 9.55 am, NEMMCO requested TransGrid to recall line 77. Line 77 did not return to service until approximately 10.53 am. The AER understands that the 30 minute recall time was delayed by an additional 30 minutes due to:

- discussions between TransGrid and NEMMCO regarding the imminent return of unit 6 at Vales Point, which, it was believed, would relieve the constraint problem; and

- communication problems between TransGrid and the power stations at Wallerawang and Mt Piper due to the failure of the operational telephone systems .

NEMMCO states in its report that the power system was insecure for about 35 minutes from 9.25 am to 9.59 am.

Outage of line 77 at 2.00 pm – 4.30 pm

At 1.29 pm, NEMMCO invoked a constraint set, covering the outage of line 77, and a further set covering the outage of line 76 plus line 77 effective from 2.00 pm. Notification of these outages first appeared in the market systems from around 1.00 pm. Some of the constraints in these sets had been reformulated following the morning outage.

In the afternoon, additional constraint sets were invoked to ensure the Shoalhaven pumps would be correctly dispatched. The constraint sets were needed to correct an incorrect coefficient sign that was identified in the morning.

Following the outage of line 77, a number of constraint violations occurred. Although the number of constraints that were violated in the afternoon was greater than in the morning, the total amount of violation (measured in MW) was significantly reduced.

NEMMCO states in its report that the power system was insecure for about 20 minutes during the afternoon outage.

Constraint formulation issues

NEMMCO informed the AER that since 31 October it has made a number of alterations to the constraints that were invoked on that day including:

- transferring terms with coefficients of less than 0.07 to the right hand side of the constraint to prevent NEMDE from choosing to violate this constraint in preference to dispatching high priced offers[19];

- re-orienting constraints N>N-76+77A and N>N-76+77E. NEMMCO's practice is to orient constraints toward the reference node of the region in which the constraint applies (ie the Sydney West connection point). In this case, however, a number of constraints were incorrectly oriented toward Snowy. The orientation was based upon

[19] If a coefficient is less than 0.07 then NEMDE can at times violate this constraint regardless of the offer price of the generator to which this coefficient applies. In addition very small coefficients can lead to stability issues – that is large step changes are required in LHS control variables to manage a small change in the RHS limit.

the design of constraints at the start of the market in 1998 which had not been updated; and

- correcting the sign (ie +/-) attaching to the coefficients on the Shoalhaven pumps[20].

NEMMCO's position

NEMMCO informed the AER that the power system was insecure for a period of approximately 35 minutes on the morning of 31 October 2005 and approximately 20 minutes in the afternoon.

With regard to the management of constraints, NEMMCO stated in its report that keeping all of the constraints in its constraint dictionary up to date and consistent with the NEMMCO policy (which is set out in its "Network and FCAS constraint formulation policy") is problematic. NEMMCO has endeavoured to review constraints when they are required for scheduled outages. This practice is not suited to urgent outages such as those that occurred on 31 October. NEMMCO is currently seeking to develop a tool that will allow constraints to be developed online in situations where constraint equations are not available for a particular outage scenario, or where the constraint has been found to be ineffective or overly restrictive.[21]

In its report NEMMCO stated that at the time it allowed the morning outage, it believed that line 77 would be initially operating only with circuit breakers open. This mode of operation allows the line to be rapidly re-instated if needed and thereby minimises the risks of the outage proceeding in the event that conditions change during the outage. As it turned out, NEMMCO did not contact TransGrid until 45 minutes later, by which time the line was already isolated and earthed.

4.3 AER conclusions

NEMMCO granted approval to TransGrid for the outage of line 77 on the morning of 31 October 2005 on the basis of (amongst other things):

- advice from TransGrid that the separation of the OPGW was a system emergency due to the loss of SCADA and the impacts on a number of transmission protection systems; and
- its understanding that the weather conditions were deteriorating at the time; and
- NEMMCO's understanding that it would be able to manage this line outage.

[20] This error in the constraint equation resulted in NEMDE dispatching the Shoalhaven pumps, whilst Shoalhaven was also dispatched as a generator, which is impossible. NEMMCO's report states that this is as a result of NEMDE internally changing the sign for pumping units. This is a quality control issue.

[21] This would being restricted to determining limits based on thermal capabilities.

The loss of communications created significant difficulties in relation to the management of the power system. In the AER's view, these difficulties are likely to have rightly played a major role in both TransGrid's decision to advise NEMMCO that there was a system emergency and NEMMCO's subsequent decision to allow the morning outage to proceed.

During the morning outage, the power system remained insecure for approximately 35 minutes. The AER believes that this period would likely have been shorter but for a number of factors including the following:

- the undesirable interaction and operation of constraints;
- the delay in the recall of line 77;
- the infrequent manual updating of generator output at Mount Piper and Wallerawang power stations into the market systems; and
- the low level of the ramp rates bid in by generators.

The AER believes that this incident highlights the importance of effective constraints to the management of the power system. All reasonable efforts should be made by NEMMCO to ensure their accuracy, including (as foreshadowed in NEMMCO's report into this event) the development of new tools to assist real time power system management. This must not, however, undermine the objective of maintaining transparency to the market, as it is far better to accurately forecast market outcomes (including the impacts of network constraints) in order to facilitate efficient market responses.

The AER is seeking an undertaking from NEMMCO to regularly review and update as required, all key constraints.

Clause 4.2.6 establishes a number of principles to guide NEMMCO with respect to maintaining power system security. NEMMCO uses these principles to ensure its obligations are satisfied by:

- establishing and continually refining its operating systems and procedures;
- a program of continual training for its staff; and
- having the necessary tools to analyse and assess the impacts of emergency situations on the security of the power system.

Given the significant difficulties caused by the loss of communications, the emergency nature of the outage, and the steps taken by NEMMCO prior to the outage and since, to convert and correct constraint accuracy, commence the development of an on-line constraint builder, and a commitment to refine its procedures, the AER believes that NEMMCO processes are consistent with these principles for maintaining power system security.

5 Generator rates of change

5.1 Rule requirements

Clause 3.8.22 provides

> (b) Subject to clauses 3.8.22(c) and 3.8.22A, a *Scheduled Generator* or *Market Participant* may vary its available capacity, daily *energy constraints*, *dispatch inflexibilities* and *ramp rates* of *generating units*, *scheduled network services* and *scheduled loads*, and the *response breakpoints*, *enablement limits* and response limits of *market ancillary services.*

5.2 Details of the incident

During the high priced periods on 31 October, a number of generators utilised the rebidding Rules to alter the rate at which the generators output could be changed in a downward direction. The downward rate of change for: Callide B unit one, Liddell unit four, Yallourn unit one, Pelican Point, Playford and Torrens Island units one, two and three, were all reduced for reasons associated with plant problems.

Network constraints in New South Wales and Queensland at the time were constraining the dispatch of generation. In response to those constraints, the downward rate of change for some of the Delta Electricity, Macquarie Generation and Stanwell Corporation generators were reduced to minimise the commercial impacts of those network constraints on those generators.

Delta Electricity rebidding

Delta Electricity rebid the maximum downward rate of change (referred to in the Rules as a ramp rate) of its generating units at Wallerawang and Mt Piper. Specifically:

- each of the two generating units at Wallerawang were rebid from a maximum downward rate of change of 3 MW/min to 1 MW/min[22] for the dispatch intervals 9.45 am - 11.15 am and 2.10 pm – 5.30 pm on 31 October 2005; and
- each of the two generating units at Mt Piper were rebid from a maximum downward rate of change of 5 MW/min to 1 MW/min for the dispatch intervals 9.45 am - 11.15 am and 2.10 pm – 5.30 pm on 31 October 2005.
- Those rebids did not similarly reduce the allowable upward rate of change, which meant that the generators could be ramped down slowly by the market systems but could be ramped up relatively quickly.
- The reasons given for these rebids were “comms breakdown::change ROC down”, “line constraints::ROC DN change/Band shift”, “Line constraint::ROC DN change” and “Line constraints:: ROC DN change/band shift”.

[22] This is (apart from zero, which is arguably no different from an inflexible bid), the minimum acceptable by the market rebidding systems.

- The AER was subsequently informed by Delta Electricity that the reasons for the rebid were both to facilitate the manual control of the plant and to manage the commercial impact of binding transmission constraints.

- The combination of the loss of SCADA, lack of regular hand-dressing by NEMMCO of unit output into the market systems and rebidding to reduce ramp rates led to a significantly higher output from the Wallerawang and Mt Piper power stations than would otherwise have occurred, and that was a prerequisite for managing the outage of line 77. This is detailed in Section 3.2.2.

Macquarie Generation rebidding

Macquarie Generation rebid the maximum downward rate of change of some its generators at Bayswater and Liddell. Specifically:

- all of its Bayswater units were rebid from a maximum downward rate of change of 3 MW/min to 1 MW/min for dispatch intervals 10.15 am – 4 pm; and

- Liddell units one and three were rebid from a maximum downward rate of change of 2 MW/min to 1 MW/min for dispatch intervals 10.15 am – 4 pm.

The reason given for these rebids was "Constraint Management". At that time an intra regional constraint was reducing the output of these units.

Stanwell Corporation rebidding

Stanwell Corporation rebid the maximum downward rate of change of its generators at Stanwell. Specifically:

- all of its Stanwell units were rebid from a maximum downward rate of change of 2.8 MW/min to 1 MW/min for dispatch intervals 10.50 am – 11 am, 2.20 pm – 3 pm and 3.20 pm – 3.30 pm.

The reason given for these rebids was "Constraint Management". At that time an intra regional constraint was limiting transfers from Central to South Queensland and reducing the output of these units.

NEMMCO position

NEMMCO stated that rebidding by Delta Electricity and other generators in New South Wales made NEMMCO's management of security more difficult and contributed to the continuing security violations encountered on Monday morning while line 77 was out of service. In its report into the incident NEMMCO concluded that:

> *Limited ramp rate capability of a number of generating units in the NSW region contributed to the difficulty encountered in removing the constraint violations. In fact, ramp capability was reduced by some generators rebidding during the outage period making the situation more difficult.*

5.3 AER conclusion

The combination of the loss of SCADA, lack of regular updating of unit output into the market systems and rebidding to reduce ramp rates led to a much lower impact on the Wallerawang and Mt Piper power stations than was forecast and predetermined by NEMMCO to manage system security for the outage of line 77.

The market systems favour generator ramp rate bids over network security. As a result when a generator is faced with a network constraint that requires its output to be reduced, it can utilise the rebidding Rules to reduce its maximum ramp down rate and consequently reduce the commercial impacts on its generating plant. A summary of the effects of rebidding ramp rates is provided in Appendix B.

Delta Electricity's rebid with a reduced downward ramp rate was, in the AER's view, primarily commercially motivated. In this respect, the AER notes that although manual adjustment of its generating units may have caused Delta Electricity some difficulty, Delta Electricity did not reduce the upward ramp rate.

Similarly the rebidding by Macquarie Generation and Stanwell Corporation was intended to mitigate the commercial impacts of intra regional constraints on their generating units.

The AER is concerned that the practice of rebidding reduced ramp rates for commercial reasons jeopardised system security. This is because the market systems are prevented from being able to quickly adjust power flows to respond to issues that emerge in the market. The AER is aware that other physical bid parameters (including frequency control ancillary service trapeziums) have also been used for commercial reasons, with a detrimental impact on power system security management.

This view is consistent with the AER's position in relation to the use of the inflexibility provisions[23], which may have a similar effect (ie to lock in a relatively constant output).

Overall, the AER considers that rebidding a reduced ramp rate in these circumstances by Macquarie Generation and Delta Electricity had the effect of hampering NEMMCO's efforts to maintain power system security.

The AER will consider options to address this issue. In general there are two possible approaches. One is to remove or reduce the incentive for generators to reduce the ramp rate for commercial reasons. The second is an administrative requirement for ramp rate bids to reflect actual generator capacity. The AER intends to develop and submit a Rule change proposal late this year or early next year. In considering this issue the AER will assess whether other physical bid parameters may be used for commercial reasons to the detriment of power system security management.

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[23] Physical operating conditions can prevent generators from increasing or decreasing output. The Rules allow generators to notify of such circumstances using the inflexibility bidding provisions. A generator that declares itself inflexible is treated outside the normal market arrangements and must be dispatched at the volume notified. Bidding inflexible may also afford a commercial advantage to a generator over its competitors. This means it is critical that the inflexibility provisions are used only where abnormal operating conditions exist.

6 Conformance with dispatch instructions

6.1 Rule requirements

Clause 4.9.8(a) of the Rules provides:

> A *Registered Participant* must comply with a *dispatch instruction* given to it by *NEMMCO* unless to do so would, in the *Registered Participant's* reasonable opinion, be a hazard to public safety or materially risk damaging equipment.

Clause 3.8.23 of the Rules provides that:

> (a) If a *scheduled generating unit, scheduled network service* or *scheduled load* fails to respond to a *dispatch instruction* within a tolerable time and accuracy (as determined in *NEMMCO's* reasonable opinion), then:
>
> > (1) the *scheduled generating unit, scheduled network service* or *scheduled load* (as the case may be) is to be declared and identified as non-conforming; and
> >
> > (2) the *scheduled generating unit, scheduled network service* or *scheduled load* (as the case may be) cannot be used as the basis for setting *spot prices*.

NEMMCO must advise a generator that one of its generating units has been declared non-conforming and request a reason for the non-compliance.

6.2 Details of the incident

In its report on the incident, NEMMCO identified a number of generators with materially different output levels compared to the target required by the market systems. Snowy Hydro, for example was 300 MW higher than its target for the 10.05 am dispatch interval. This coincided, however, with a 1000 MW increase in dispatch targets over two dispatch intervals, which was driven by a rebid which increased the availability of capacity priced at around zero by this same amount. This increase led to a rise in the system frequency, which NEMMCO concluded was the cause of a number of Queensland generators to be 250 MW in combination below their targets.

NEMMCO considered that the Mt Piper and Wallerawang generating units followed their dispatch targets reasonably well over the periods 9.00 am to 11.00 am and 2.00 pm to 4.30 pm on 31 October. However, at 9.10 am output from the Wallerawang power station was 90 MW higher than the target.

Delta Electricity advised NEMMCO that these dispatch targets were inconsistent with its expectations[24] based on its rebid at around 8.30 am which shifted capacity from prices of up to $36/MWh into negative prices. This saw the availability at Wallerawang priced

[24] Delta Electricity was in effect "second-guessing" the outcomes from the dispatch process, rather than following targets.

below zero increase from 500 MW to 800 MW. Delta Electricity stated that the reason for this rebid was to facilitate constant output at 400 MW each unit for the remainder of the day, reflecting the effects of the SCADA outages, which meant that the output of the units could only be changed manually. Delta Electricity was unaware of the impending outage of line 77 at this time.

NEMMCO did not declare any of the generating units at Wallerawang or Mt Piper to be non-conforming pursuant to clause 3.8.23 of the Rules.

NEMMCO stated that the failure of generating units to follow dispatch instructions during this incident contributed to the time taken to alleviate the violations that occurred.

6.3 AER conclusions

The AER agrees with NEMMCO's conclusion that the Wallerawang and Mt Piper generating units followed their dispatch targets reasonably well throughout this incident given the difficulties that existed.

The requirement for participants to follow dispatch instructions, as specified in chapter 4 of the Rules, is fundamental to the secure operation of the power system. The non-conformance procedures of chapter 3, on the other hand, are designed to ensure the pricing and dispatch outcomes are realigned when participants fail to respond to a dispatch instruction within a tolerable time and accuracy. NEMMCO is conferred with the power to make decisions in relation to non-conformance in order to realign market dispatch and pricing outcomes.

The AER has explored with NEMMCO the application of the non-conformance provisions of clause 3.8.23 of the Rules and the general responsibilities of participants to follow dispatch instructions outlined in chapter 4.

The AER considers that the obligations established under clause 4.9.8 of the Rules are clear and apply irrespective of the non-conformance procedures developed by NEMMCO in accordance with the Market Rules.

It is acknowledged, however, that the procedures established by NEMMCO for managing non-conformance under clause 3.8.23 of the Rules and the obligation to follow dispatch instructions under clause 4.9.8(a) may have been interpreted by the industry in different ways.

The AER will issue a compliance bulletin to the market in which it will outline its understanding of the requirements imposed by clause 4.9.8(a) of the Rules and the manner in which the AER intends to enforce these provisions. The AER's objective in issuing the compliance bulleting is to clarify its expectations of the obligations on participants.

7 Dispatch and pricing

7.1 Rule requirements

Clause 3.8.1, (Central Dispatch) provides

> (a) *NEMMCO* must operate a *central dispatch* process to *dispatch scheduled generating units, scheduled loads, scheduled network services* and *market ancillary services* in order to balance *power system supply* and demand, using its reasonable endeavours to maintain *power system security* in accordance with Chapter 4 and to maximise the value of *spot market* trading on the basis of *dispatch offers* and *dispatch bids*.
>
> (b) The *central dispatch process should aim to maximise the value of spot market trading i.e. to maximise the value of dispatched load based on dispatch bids less the combined cost of dispatched generation based on generation dispatch offers, dispatched network services based on network dispatch offers, and dispatched market ancillary services based on market ancillary service offers subject to:*
>
> > *(1) dispatch offers, dispatch bids and market ancillary service offers;*
> > *...*
> > *(4) power system security requirements determined as described Chapter 4 and the power system security and reliability standards;*
> > *(5) intra-regional network constraints and intra-regional losses;*
> > *(6) inter-regional network constraints and inter-regional losses;*

Clause 3.9.1 (Principles applicable to spot price determination) provides

> (a) The principles applying to the determination of prices in the *spot market* are as follows:
>
> > (1) a *dispatch price* at a *regional reference node* is determined by the *central dispatch* process for each *dispatch interval*;
> > …
> > (3) *dispatch prices* determine *dispatch* such that a *generating unit* or *load* whose *dispatch bid* or *dispatch offer* at a location is below the *spot price* at that location will normally be *dispatched*;
> > …
> > (5) where the *energy* output of a *Registered Participant* is limited above or below the level at which it would otherwise have been *dispatched* by *NEMMCO* on the basis of its *dispatch offer* or *dispatch bid* due to an *ancillary services direction*, the *Registered Participant's dispatch offer* or *dispatch bid* is taken into account in the determination of *dispatch* but the *dispatch offer* or *dispatch bid* will not be used in the calculation of the *dispatch price* for *energy* in the relevant *dispatch interval*;

Clause 3.9.2 (Determination of spot prices) provides

> (d) The *dispatch price* at a *regional reference node* represents the marginal value of *supply* at that location and time, this being determined as the price of meeting an incremental change in *load* at that location and time in accordance with clause 3.8.1(b).

7.2 Details of the incident

Spot prices in New South Wales were above $5000/MWh for five trading intervals on Monday 31 October, when network constraints designed to manage the network outages failed to maintain power flows on the network at secure levels. Six New South Wales network constraints bound; four of these were violated for a majority of the outage. The five-minute price in New South Wales increased from $20/MWh at 9.30 am to $6280/MWh at 9.35 am. Spot prices peaked at $6724/MWh in New South Wales with five-minute prices driven to almost zero at times, in all other regions. This event saw almost $180 million added to the energy market turnover in New South Wales and Queensland.

As a result of the outage of line 77 on Monday morning, network constraints drove a step reduction of up to 1 000MW on transfer capabilities into New South Wales across the QNI and Snowy interconnectors. Furthermore, significant amounts of generation were dispatched out of merit order. The outage of line 77 was not forecast by NEMMCO in the market systems.

NEMMCO's preliminary operational report into the event, released on 4 November 2005, stated that *"the combined constraint action was not effective"*. In order to restore power system security, NEMMCO recalled the line 77 outage at around 10 am. This was discussed in section 4.2 of this report.

NEMMCO modified the constraints, and at around 2 pm a further outage of line 77 proceeded to continue the repairs. Little prior notice of that outage was provided by NEMMCO to the market. Again, a number of network constraints in New South Wales and Queensland bound as a result and five of these constraints were violated. The five-minute dispatch price in New South Wales increased from $33/MWh at 1.55pm to $10 000/MWh at 2 pm. The price remained above $6 000/MWh for a number of dispatch intervals until around 3pm when it fell to around $320/MWh. The price in Queensland was also close to the price cap for three dispatch intervals from 2 pm.

The New South Wales prices and how those prices were determined by the market systems are detailed in Appendix C.

The line 77 outages which commenced at around 9.30 am and 2 pm, led to step reductions on transfers into New South Wales. There were two periods of reduced capability - from 9.35 am to 11 am and from 2 pm to 4.25 pm. These changes were not forecast. Figure 6 highlights the step reduction in capability for exports from Snowy into New South Wales, with the target flow violating this limit for a substantial period in the morning and a further shorter period in the afternoon.

Figure 6: Snowy export capability and target flow

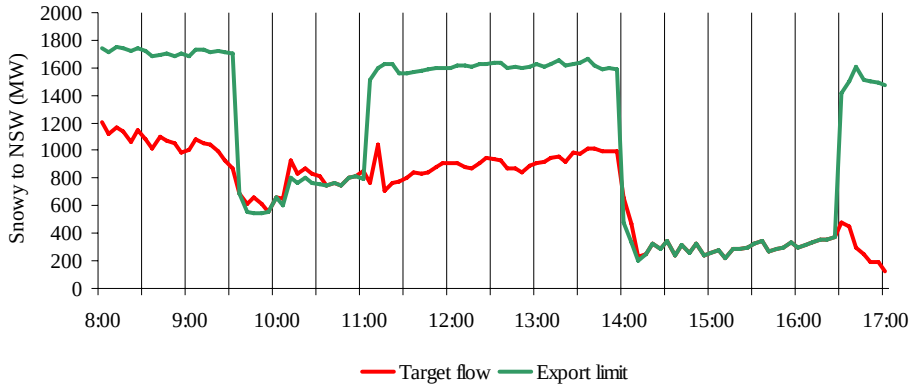
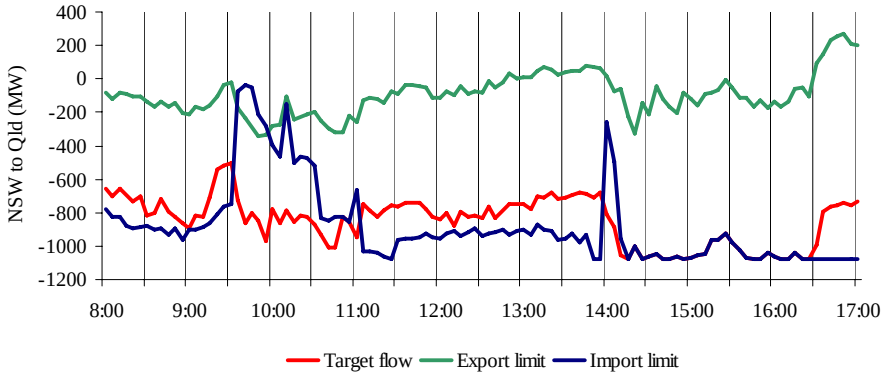


Figure 7 highlights the step changes in capability for flows into New South Wales from Queensland (or imports across QNI). The target flow violated the import limit for most of the morning outage and a further shorter period in the afternoon. Furthermore, the limits on QNI, for the period between 9.35 am and 9.55 am, were infeasible with the export limit lower than the import limit[25].

Figure 7: QNI capability and target flow



7.3 Following the incident

Snowy raised concerns with the AER regarding the accuracy and formulation of constraints to manage the planned outage of line 5 (between Yass and Marulan in southern New South Wales) and the emergency outages of lines 76 and 77.

In addition, pricing outcomes on the day were not at all intuitive. For example the first price shown in Appendix C for the dispatch interval ending 9.35 am was around $6280/MWh. The offers involved in determining that price, however, were less than

[25] At all times the export limit for an interconnector should be greater than the import limit and flows should be between these limits. The limits on QNI, for the period between 9.35am and 9.55am, were infeasible with the export limit falling below the import limit.

$20/MWh. The price for the dispatch interval ending 9.50 am was around $4300/MWh, made up primarily by offers at close to $10 000/MWh from New South Wales generators.

The AER wrote to NEMMCO, questioning:

1. whether in NEMMCO's view, the network constraints invoked to manage the simultaneous outages of lines 76 and 77 in conjunction with the outage of line 5 between Yass and Marulan and other system normal constraints, accurately reflected the capability of the network in order to maximise the value of spot market trade;
2. whether the network constraints invoked overly restricted supply from neighbouring regions; and
3. whether NEMMCO is satisfied that the fully co-optimised network constraints implemented on that day, and the resulting dispatch outcomes, resulted in spot prices that were consistent with the requirements of chapter 3 of the Rules, in particular clause 3.9.7.

With regard to the constraints, NEMMCO in its report into this incident concluded that the constraints that were invoked to manage all of the network outages on the day did not materially restrict supply from neighbouring regions.

NEMMCO also commented that without the use of the fully optimised constraints prices would have been even higher. In its reply to the AER NEMMCO stated:

> *As regards the fully co-optimised constraints implemented on the Monday afternoon, NEMMCO is satisfied that these resulted in spot prices consistent with the requirements of Chapter 3 of the Rules.*
>
> *In particular as regards Clause 3.9.7 the situation on Monday is not unique. The principles that apply were clearly annunciated in the pre-market start report on intra-regional constraints. This document was published under NEM start precondition 9.5 (first published July 1998) and explains how intraregional constraints can affect the price. The outcomes on the Monday afternoon were consistent with the principles set out in this document. The market start pre-condition 9.5 regarding intra-regional constraints was signed off on the basis of this document and hence NEMMCO believes that the principles set out in this document represent a valid interpretation of Clause 3.9.7 which was accepted at time of commencement of the market.*

The AER queried details of the internal processes utilised by NEMMCO to ensure that the price and dispatch outcomes are consistent with the Rules, including constraint formulation and NEMDE certification. In response, NEMMCO stated that

> *There are three broad processes used to ensure that price and dispatch outcomes are consistent with the Rules. These are:*
>
> > *1. Two levels of certification of the NEMDE dispatch engine - the first certifies compliance of the mathematical formulation against the Rules, and the second certifies the software implementation against the mathematical formulation. Both certifications are carried out by an independent auditor with the necessary technical capability to conduct the audit;*
> >
> > *2. Principles and procedures covering constraint formulation and orientation. The general policy is available on the NEMMCO website at http://nemmco.com.au/dispatchandpricing/170-0040.pdf. Constraints updated as part of*

the rollout of fully co-optimised constraints are consistent with this policy. NEMMCO also prepares Constraint Change Reports whenever a constraint is modified.

3. The NEMMCO IT Change Management Procedures, which is available on the NEMMCO website at http://www.nemmco.com.au/registration/360-0013.pdf.

NEMMCO has confirmed that the market auditor reviewed the pricing and dispatch for the day and found they were consistent with the Rules.

7.4 Fully optimised constraints

NEMMCO can manage network security more efficiently by using fully optimised (or option 4) constraints,. Fully optimised constraints reduce the need for conservative safety margins and allow NEMMCO to drive the network closer to its physical capability. They also reduce the need to use discretionary constraints. The use of fully optimised constraints can, however, reduce the predictability of price, imports and generation dispatch outcomes. This is because the interconnector limits published by NEMMCO are the outcomes from the economic trade-off between imports and local generation. This can result in the reported limit being considerably lower than the technical capability, resulting in non-intuitive dispatch. The pricing outcomes on the day show examples where a generator was dispatched even though the price is lower than the offer price of that generator, which is another outcome of the use of fully optimised constraints.

NEMMCO has advised the AER that the program to fully optimise all key network constraints is on track for completion by early 2007.

7.5 AER conclusions

The AER is satisfied that the constraints that were invoked by NEMMCO to manage the network outages on the day did not inappropriately restrict supply from neighbouring regions.

The use of fully optimised constraints leads to efficient market outcomes and greater utilisation of network capability. On 31 October it also led to some pricing and dispatch outcomes that were non intuitive and difficult to predict.

Independent audits of the pricing and dispatch engine (NEMDE) should give a degree of confidence that NEMDE is appropriately optimising dispatch. The market auditor has reviewed and confirmed that the pricing and dispatch for the day were consistent with the Rules. As noted, dispatch may not at all times have been completely optimised because of constraint formulations, and infrequent manual updates into the market systems. The inputs to the dispatch engine (including the accuracy and formulation of constraint equations) also need to be appropriate, which requires accurate procedures and adequate training to ensure precise implementation.

The AER supports NEMMCO's program to fully optimise all key network constraints.

8 Information to the market

8.1 Rule requirements

Clause 3.7A concerns the provision to the market of information concerning planned network outages. Its objective is set out in subclause (a):

> The objective of this clause 3.7A is to provide *Market Participants* with the information on planned *network outages* required so that *Market Participants* are properly informed to enable them to make projections of *market* outcomes, including projections of *settlement residue auction* outcomes, and decisions with respect to *hedge contracts* and other financial risk management tools.

Clauses 3.7A(b) and (c) require TNSPs and NEMMCO, respectively, to publish on a monthly basis information in relation to planned network outages. The clause does not explicitly require NEMMCO to inform the market of 'last minute' network outages.

Clause 3.7.3 of the Rules provides:

> (a) The *short term PASA* must be issued at least daily by *NEMMCO* in accordance with the *timetable*.
>
> …
>
> (c) *NEMMCO* may *publish* additional updated versions of the *short term PASA* in the event of *changes* which, in the judgement of *NEMMCO*, are materially significant and should be communicated to *Scheduled Generators* and *Market Participants*.

(d) The following *short term PASA inputs* are to be prepared by *NEMMCO*:

> …
>
> (3) anticipated *inter-regional network constraints* and *intra-regional network constraints* known to *NEMMCO* at the time.

Clause 3.7.1(d) of the Rules provides:

> *NEMMCO* must use its reasonable endeavours to ensure that it provides to *Scheduled Generators* and *Market Participants* sufficient information to allow *Scheduled Generators* and *Market Participants* to undertake maintenance and *outage* planning without violating *power system security* and to allow the *market* to operate effectively with a minimal amount of intervention by *NEMMCO*.

Clause 3.1.4 (Market design principles) provides:

> (a) This Chapter is intended to give effect to the following market design principles:
>
> (1) minimisation of *NEMMCO* decision-making to allow *Market Participants* the greatest amount of commercial freedom to decide how they will operate in the *market*;
> (2) maximum level of *market* transparency in the interests of achieving a very high degree of *market* efficiency;
> …

8.2 Details of the incident

At approximately 7.15 pm on 30 October, NEMMCO issued market notice 13458 stating that line 77 was scheduled to be taken out of service between 8.30 am and 12.30 pm on 31 October to facilitate repairs. This market notice also set out the constraints that were already operating as a result of the outage of line 76 and the constraint that would be imposed during the outage of line 77.

At approximately 11.28 pm on 30 October, NEMMCO issued market notice 13459 stating that the outage of line 77 would be deferred. This market notice or subsequent notices gave the market no indication of when the outage had been deferred to.

No market notice was issued prior to the outage of line 77 at 9.25 am on 31 October, even though the outage had been approved by NEMMCO at approximately 9.10 am on the same day. Although NEMMCO had contact with Delta Electricity at 8.45 am and at 9.04 am, there was no discussion of the impending outage of line 77. NEMMCO has a policy of not advising individual participants of market information, but rather utilising market notices to advise the whole market.

At approximately 1.35 pm on 31 October, NEMMCO issued market notice 13461. This notice was headed "Inter-Regional Transfer" and stated that due to the imminent outage of line 77 (coincident with the forced outage of line 76) a constraint set would be invoked from 1.35 pm until 7.00 pm. This constraint set was invoked from 1.35 pm. Line 77 was returned to service at 4.20 pm and the constraint was lifted at 4.30 pm. NEMMCO then issued market notice 13465 at approximately 5.14 pm stating that work had been completed and the constraints lifted.

NEMMCO position

NEMMCO informed the AER that following its decision on the morning of 31 October to allow the outage of line 77 to proceed, issuance of a market notice to advise of the change in plans was overlooked due to operational pressures.

Market notice 13459 issued at 11.28 pm on 30 October stated that the outage scheduled for 8.30 am to 12.30 pm the next day, (to address the emergency loss of line 76 and associated communications capabilities) would be deferred. In the event, the outage did in fact go ahead at 9.25 am the next day. NEMMCO advised the AER that this market notice was issued after studies performed by NEMMCO indicated that the outage would be unlikely to proceed. The outage did proceed on the morning of 31 October following TransGrid's declaration that the outage was an emergency.

With regard to the outage of line 77 at 2.00 pm:

- market notice 13461 (issued at 1.35 pm) advised the market that the outage may affect interregional transfers; and

- the outage was forecast in pre-dispatch from the pre-dispatch run published at around 1.00 pm.

8.3 AER conclusion

The AER believes that high quality information is critical to achieving efficiency within the market. In this regard, the AER notes clause 3.1.4(a)(2) of the Rules, which states that one of the market design principles is the maximum level of market transparency in the interests of achieving a very high degree of market efficiency.

The importance of specific information is also made clear in the objectives set out in clause 3.7A(a) of the Rules and the provisions relating to the PASA in clause 3.7.3 of the Rules.

The AER believes that TransGrid did all that was required to keep NEMMCO informed of the unfolding situation and network outage requirements.

The AER believes that the information provided by NEMMCO to the market prior to the outages of line 77 at 9.25 am on 31 October was inadequate.

Circumstances at the time made the case for market notification particularly strong:

- NEMMCO had concerns about the possible consequences of the outage based on its own studies;
- the outages were likely to impact significantly on the power flows around New South Wales; and
- four of the generators identified by NEMMCO as necessary to manage the outage effectively were without SCADA and dispatch targets.

The AER accepts that the circumstances leading up to the outage of line 77 at 9.25 am, and in particular the last minute nature of the approval, may have hindered NEMMCO in its efforts to keep the market informed. Nevertheless, it should have been possible for NEMMCO to issue a market notice prior to the 9.25 am outage that would have kept the market informed of the unfolding emergency outage and assisted the efficient operation of the market.

The AER will seek an undertaking from NEMMCO to review its outage management procedures and training, in light of this incident to ensure that every effort is made to keep the market fully informed of network issues where there is likely to be a material market impact.

Appendix A

Details of the constraints invoked during the two outages on 31 October

Line 77 was taken out of service on two occasions on 31 October 2005. This section details the constraints that were invoked during the two outages.

Outage of line 77 at 9.25 am – 10.55 am

At approximately 9.10 am on 31 October, NEMMCO gave approval to TransGrid for the outage of line 77.

At 9.20 am, NEMMCO invoked constraint sets N-IGWW_77, covering the outage of line 77, and N-X_76_77, covering the outage of line 76 plus line 77. A constraint in the constraint set N-X_76_77 violated immediately (which was before line 77 went out of service because the relevant constraint assumes that the line is actually out of service), and the constraint was violated from 9.20 am to 9.50 am inclusive.

The outage of line 77 occurred at 9.25 am. This status change was reflected in NEMDE from the dispatch interval ending 9.35 am.

Following the outage of line 77 at 9.35 am, a number of constraint violations occurred. These are set out below:

- Constraint N>>N-NIL_1N violated for all dispatch intervals from 9.35 am to 10.45 am.
- Constraint N>N-76__17 violated for all dispatch intervals from 9.35 am to 11.00 am except for DI 10.50 am.
- Constraint N>N-77_17 violated from 9.35 am until 9.50 am.

At 9.50 am, NEMMCO revoked constraints N>N-76+77E and N>N-77__17 because of concerns that these constraints were not operating correctly and the impending recall of line 77. At 9.55 am, NEMMCO requested TransGrid to recall line 77. Line 77 was returned to service at approximately 10.53 am.

NEMMCO states in its report that the power system was insecure for about 35 minutes from 9.25 am to 9.59 am.

Outage of line 77 at 2.00 pm – 4.30 pm

At 1.29 pm, NEMMCO invoked constraint sets N-IGWW_77, covering the outage of line 77, and N-X_76_77, covering the outage of line 76 plus line 77 effective from 2.00 pm. Some of the constraints in these sets had been reformulated following the morning outage. In addition, constraint sets were invoked to ensure the Shoalhaven pumps would not be incorrectly dispatched due to an incorrect coefficient sign that was identified in the morning.

Following the outage of line 77, a number of constraint violations occurred. These are set out below:

- constraint N>>N-NIL_28 violated for dispatch interval 2.00 pm;
- constraint N>N-76__17 violated for dispatch intervals 2.00 pm, 2.05 pm and 2.10 pm;
- constraint N>N-77_17 violated for dispatch intervals 2.00 pm, 2.05 pm and 2.10 pm;
- constraint N>N-76+77A violated for dispatch intervals 2.15 pm, 2.20 pm, 2.40 pm, 2.45 pm, 3.35 pm and 3.55 pm; and
- constraint N>N-WWSS+WWIG_E (which replaced the N>N-76+77E constraint that had been reformulated following the morning outage) violated for dispatch intervals 2.00 pm and 2.05 pm.

Although the number of constraints that were violated in the afternoon was greater than in the morning, the total amount of violation (measured in MW) was significantly reduced.

NEMMCO stated in its report that the power system was insecure for about 20 minutes during the afternoon outage. The critical constraints involved are described in table 3.

Table 3: summary of network constraints violated

Constraint ID	Time constraint was violated (minutes)	Description
N>>N-NIL_1N	75	Manage load on line 82 for trip of line 81 (or vice versa).
N>>N-NIL_28	5	Manage load on line 8 for trip of line 16 (or vice versa).
N>N-76+77A	30	Manage load on line 35 for trip of line 36 (outage of both 76 and 77 lines).[26]
N>N-76+77E	35	Manage load on line 8 for trip of line 16 (outage of both 76 and 77 lines).
N>N-76__17	100	Manage load on line 8 for trip of line 16 (outage of line 76).
N>N-77__17	35	Manage load on line 8 for trip of line 16 (outage of line 77).
N>>N-WWSS+WWIG_E	10	Manage load on line 8 for trip of line 16(outage of both 76 and 77 lines).

Manage line flows	Time line flows were violated (minutes)	Violated constraint ID(s)
line 8 or 16 for loss of the other	100	N>N-76+77E; N>N-76__17; N>N-77__17; N>>N-NIL_1N and N>>N-WWSS+WWIG_E
line 81 or 82 for loss of the other	75	N>>N-NIL_1N
line 35 for loss of line 36	30	N>N-76+77A

[26] While the constraint managing flow on 35/36 lines violated at times, post-event analysis indicated that the constraint was conservative and post-contingent flows would have been below the 35/36 line rating.

Appendix B

The impacts of generator ramp rates on power system security

Ramp rate is the speed at which a generator, load or market network service can change its power output from one level to another. The maximum ramp rate is dependent on the technical characteristics of the equipment and can vary with the prevailing conditions including, for example, the level of dispatch of a generator, the stability of the fuel supply or the duration and speed of movement in one direction. It is normally expressed in MWs per minute.

A market participant must notify NEMMCO of its registered bid and offer data in accordance with schedule 3.1 to the Rules in respect of each of its scheduled loads and scheduled generating units at least six weeks prior to commencing participation in the market. This information includes the normal and maximum ramp rate capability. Market participants must review their registered bid and offer data annually and provide details of any changes to NEMMCO. Registered bid and offer data may be updated by the market participant at any time but may be subject to audit at NEMMCO's request.

In addition to this registration information, a market participant may change its ramp rates used in the dispatch process at any time, through rebidding in accordance with 3.8.22. Moreover, in addition to the registered information and that provided through the bidding and rebidding provisions, each generator transmits through the SCADA[27] system a maximum rate of change capability at any point in time. NEMMCO's dispatch system accepts the lowest of these values when determining the pricing and dispatch outcomes. As a result, a participant currently has the ability to modify the maximum rate of change capability of its plant without submitting the necessary additional information required through the bid or rebidding process. In the 2005-06 financial year, there were discrepancies between the ramp rates of change bid by participants and the actual rates of change they presented to the market through SCADA in respect of 110 of 173 generating units. Forty per cent (or 68 generators), had ramp rates set through SCADA for more than 10 per cent of the time, with 20 generators setting ramp rates through SCADA for more than 90 per cent of the time.

Participants often manipulate the rate of change element of their offer to achieve their commercial objectives. Examples include times where, as a result of a network constraint, the dispatch process attempts to reduce the output of a number of competing generators simultaneously. By minimising the rate at which it moves, a generator is capable of shifting the burden of reducing output to other, possibly cheaper sources. This behaviour can result in less than optimal overall outcomes for the market.

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27 SCADA is an acronym for supervisory control and data acquisition, a computer system for gathering and analysing real time data and communicating with remote equipment. SCADA systems are used to monitor and control plant or equipment. A SCADA system gathers information, such as the status of a network element or output from a generating unit, transfers the information back to a central site (either NEMMCO or a TNSP), and displays the information in a logical and organized fashion. A SCADA system can also control remote equipment such as circuit breakers.

There are examples where, at times of rapidly changing demand, generators have significantly reduced the rate at which they respond compared to the normal levels provided at registration. In some regions, this has resulted in short-term price spikes particularly at times when the network is constrained and the next available capacity to be committed is a standby gas turbine.

Some participants offer, as part of their bid and rebid data, ramp rates of zero. These in effect lead to the dispatch process following generators' own dispatch requirements without consideration of price. A generator can vary its output in the knowledge that the current arrangements to detect compliance with dispatch instructions will not be triggered.

Rebidding with ramp rates of zero is effectively the same as inflexibility, which is allowed where specific technical circumstances are present. A ramp rate of 1MW/min is as close to zero as allowed by NEMMCO's systems and may well be submitted by a unit which is capable of much higher rates.

In all of these examples, a participant is capable of modifying its rate of change parameters, away from normal and reported capabilities. On many occasions this occurs, without the need to rebid and therefore without reason. To address these issues, possible changes to the Rules might:

- require ramp rates of change to be consistent with registered abilities and good industry practice;
- allow rebids to vary those ramp rates of change only in response to abnormal plant conditions or other abnormal operating conditions; and
- prohibit zero ramp rates of change and require SCADA values to conform with bids and offers.

Appendix C

The prices for each 5 minute dispatch interval and how the prices were determined

The following table identifies for each trading interval in which the spot price exceeded $5,000/MWh, every five-minute despatch interval price and the generating units involved in setting the energy price. This information is published by NEMMCO[28]. Also shown is the energy or ancillary service offer price involved in determining the dispatch price together with the quantity and the contribution of that service to the total energy price. Dispatch prices greater than $10,000 are capped. The 30 minute spot price is the time weighted average of the six dispatch interval prices.

Monday 31 October – New South Wales 10am

Time	Dispatch price	Participant	Unit	Service	Offer	Marginal change	Portion
09:35	$6,279.75	Eraring Energy	Humensw	Energy	$0.97	-335.82	-$325.74
		Snowy Hydro	Murray	Energy	$19.50	338.74	$6,605.49
09:40	$432.32	Enertrade	oakey1	Energy	$299.85	1.46	$437.46
		Snowy Hydro	Murray	Energy	$19.50	-0.26	-$5.14
09:45	$6,403.83	Eraring Energy	Humensw	Energy	$0.97	-342.45	-$332.18
		Snowy Hydro	Murray	Energy	$19.50	345.44	$6,736.00
09:50	$4,340.68	CS Energy	swan_b_1	Energy	$29.81	0.69	$20.44
			swan_b_4	Energy	$29.81	0.69	$20.44
		Delta Electricity	mp2	Raise 5 min	$5.00	44.12	$220.61
		Macquarie	bw03	Raise 5 min	$0.40	-46.38	-$18.55
		Generation	bw03	Energy	$9,828.79	46.38	$455,865
			bw04	Raise reg	$0.04	-2.26	-$0.09
			bw04	Raise 5 min	$1.80	2.26	$4.07
			ld01	Raise reg	$0.01	2.26	$0.02
			ld01	Energy	$9,996.83	-45.19	-$451,770
		Eraring Energy	Shpump	Load	$0.00	1.32	$0.00
		Snowy Hydro	Murray	Energy	$19.50	-0.06	-$1.14
09:55	**$10,457.19** ***(capped to $10 000)***	CS Energy	swan_b_1	Raise 5 min	$1.00	-10.70	-$10.70
			swan_b_1	Energy	$98.00	10.70	$1,048.62
			swan_b_1	Raise 60 sec	$0.20	-4.10	-$0.82
			swan_b_1	Raise 6 sec	$0.20	-4.09	-$0.82
		Delta Electricity	mp1	Raise 5 min	$5.00	10.70	$53.50
			mp2	Raise 6 sec	$2.90	4.09	$11.86
		Macquarie	bw02	Raise 60 sec	$1.20	4.10	$4.92
		Generation	ld04	Energy	-$999.16	-9.41	$9,405.91
		Eraring Energy	Shpump	Load	$0.00	-4.23	$0.00
		Snowy Hydro	Murray	Energy	$19.50	-2.84	-$55.29
10:00	$6,605.93	CS Energy	call_b_2	Raise reg	$3.75	0.73	$2.75
		Eraring Energy	er02	Energy	$9,000.00	0.73	$6,599.50
			er02	Raise reg	$0.07	-0.73	-$0.05
		Snowy Hydro	Murray	Energy	$19.50	-0.07	-$1.35
		Tarong	tarong#3	Energy	$13.28	0.38	$5.07
Spot price	**$5 677.08**						

28 NEMMCO first published details on how the price is determined, for every dispatch interval, in June 2004. Documentation of this process can be found at : http://www.nemmco.com.au/dispatchandpricing/140-0036.htm

Monday 31 October – New South Wales 10.30am

Time	Dispatch price	Participant	Unit	Service	Offer	Marginal change	Portion
10:05	$6,663.47	CS Energy	swan_b_3	Raise 5 min	$1.20	-0.38	-$0.46
			swan_b_3	Energy	$98.00	0.38	$37.69
			swan_b_3	Raise 6 sec	$0.01	-0.15	$0.00
			swan_b_3	Raise 60 sec	$0.01	-0.15	$0.00
		Eraring Energy	er02	Raise reg	$0.07	-0.74	-$0.05
			er02	Energy	$9,000.00	0.74	$6,623.58
		Snowy Hydro	Murray	Energy	$0.04	-0.07	$0.00
		Tarong	w/hoe#1	Raise 5 min	$4.00	0.38	$1.54
		Tru Energy (SA)	torrb2	Raise 6 sec	$2.00	0.15	$0.29
			torrb2	Raise 60 sec	$1.00	0.15	$0.15
			torrb3	Raise reg	$1.00	0.74	$0.74
10:10	$6,702.87	International Power	hwps2	Energy	$4.03	-0.06	-$0.25
		Eraring Energy	er02	Raise reg	$0.07	-0.73	-$0.05
			er02	Energy	$9,000.00	0.73	$6,588.12
		Enertrade	gstone1	Raise reg	$1.00	0.73	$0.73
			oakey1	Energy	$299.85	0.38	$114.33
10:15	$6,731.17	LYMMCO	lya3	Energy	$8.13	0.67	$5.47
			lya4	Raise reg	$0.30	0.74	$0.22
			lya4	Energy	$8.11	-0.74	-$5.96
		Eraring Energy	er02	Raise reg	$0.07	-0.74	-$0.05
			er02	Energy	$9,000.00	0.74	$6,616.32
		Enertrade	oakey1	Energy	$299.85	0.38	$115.17
10:20	$6,605.51	International Power	loyyb2	Energy	$8.19	0.67	$5.49
		LYMMCO	lya4	Raise reg	$0.30	0.73	$0.22
			lya4	Energy	$8.11	-0.73	-$5.95
		Eraring Energy	er02	Raise reg	$0.07	-0.73	-$0.05
			er02	Energy	$9,000.00	0.73	$6,601.09
		Tarong	tarong#2	Energy	$12.31	0.38	$4.71
10:25	$6,609.99	International Power	loyyb2	Energy	$8.19	0.67	$5.50
		LYMMCO	lya3	Energy	$8.13	-0.73	-$5.97
			lya3	Raise reg	$0.30	0.73	$0.22
		Eraring Energy	er02	Raise reg	$0.07	-0.73	-$0.05
			er02	Energy	$9,000.00	0.73	$6,605.20
		Tarong	tarong#3	Energy	$13.28	0.38	$5.09
10:30	$6,655.52	CS Energy	swan_b_3	Raise 6 sec	$0.40	-0.15	-$0.06
			swan_b_3	Energy	$98.00	0.38	$37.64
			swan_b_3	Raise 60 sec	$0.40	-0.15	-$0.06
			swan_b_3	Raise 5 min	$1.20	-0.38	-$0.46
		Delta Electricity	mp1	Raise 5 min	$5.00	0.38	$1.92
		LYMMCO	lya1	Raise reg	$0.30	0.74	$0.22
			lya3	Energy	$8.13	-0.06	-$0.51
		Eraring Energy	er02	Raise reg	$0.07	-0.74	-$0.05
			er02	Energy	$9,000.00	0.74	$6,616.46
		Tarong	tarong#3	Raise 60 sec	$0.80	0.15	$0.12
		Tru Energy (SA)	torrb2	Raise 6 sec	$2.00	0.15	$0.29
Spot price	**$6 661.42**						

Monday 31 October – New South Wales 11am

Time	Dispatch price	Participant	Unit	Service	Offer	Marginal change	Portion
10:35	**$16,782.78 *(capped to $10 000)***	CS Energy	swan_b_1	Energy	$549.67	11.31	$6,215.48
			swan_b_1	Raise 5 min	$1.00	-11.31	-$11.31
			swan_b_1	Raise 60 sec	$0.01	-4.33	-$0.04
			swan_b_1	Raise 6 sec	$0.01	-4.32	-$0.04
		LYMMCO	lya1	Energy	$8.12	-2.72	-$22.07
		Macquarie Generation	bw01	Raise 60 sec	$0.80	4.33	$3.46
			bw01	Raise 5 min	$6.80	11.31	$76.89
			bw03	Energy	-$999.79	-5.26	$5,255.87
			bw04	Energy	-$999.79	-5.26	$5,255.87
		Eraring Energy	Shpump	Load	$0.00	-4.90	$0.00
		Tru Energy (SA)	torrb3	Raise 6 sec	$2.00	4.32	$8.65
10:40	$7,808.34	Delta Electricity	mm4	Energy	$9,995.02	0.77	$7,705.04
		LYMMCO	lya3	Energy	$8.13	-0.06	-$0.45
		Enertrade	oakey1	Energy	$299.85	0.35	$103.75
10:45	$7,809.45	Delta Electricity	mm4	Energy	$9,995.02	0.77	$7,706.12
		International Power	loyyb2	Energy	$8.19	-0.06	-$0.45
		Enertrade	oakey1	Energy	$299.85	0.35	$103.78
10:50	$6,605.25	CS Energy	swan_e	Energy	$0.00	0.38	$0.00
		LYMMCO	lya2	Raise reg	$0.30	0.51	$0.15
			lya2	Energy	$8.10	-0.06	-$0.50
			lya2	Raise 60 sec	$0.40	0.03	$0.01
			lya2	Raise 6 sec	$0.50	0.02	$0.01
		Macquarie Generation	bw01	Raise 60 sec	$0.80	-0.03	-$0.02
		Eraring Energy	er01	Raise reg	$0.07	-0.51	-$0.04
			er01	Energy	$9,000.00	0.73	$6,605.67
		Tru Energy (SA)	torrb2	Raise 6 sec	$2.00	-0.02	-$0.04
10:55	$6,622.36	International Power	loyyb2	Energy	$8.25	-0.06	-$0.51
		Eraring Energy	er01	Energy	$9,000.00	0.74	$6,617.80
		Tarong	tarong#1	Energy	$13.18	0.38	$5.06
11:00	$91.44	International Power	loyyb2	Energy	$8.25	-0.24	-$1.98
		Enertrade	oakey1	Energy	$62.62	1.49	$93.42
Spot price	**$6 489.47**						

Monday 31 October – New South Wales 2.30pm

Time	Dispatch price	Participant	Unit	Service	Offer	Marginal change	Portion
14:05	**$18,672.64 *(capped to $10 000)***	Snowy Hydro	Murray	Energy	$19.50	-0.60	-$11.75
		Tarong	w/hoe#1	Energy	$10,000.00	1.87	$18,684
14:10	**$20,055.58 *(capped to $10 000)***	Southern Hydro	wkiewa1	Raise 60 sec	$0.68	0.62	$0.42
			wkiewa1	Raise 6 sec	$1.69	0.62	$1.04
			wkiewa1	Energy	$11.05	-0.62	-$6.82
		Stanwell	stan-1	Raise 6 sec	$2.28	-0.62	-$1.41
		Tarong	w/hoe#1	Energy	$10,000.00	2.01	$20,062
		Tru Energy (SA)	torrb3	Raise 60 sec	$1.00	-0.62	-$0.62
14:15	**$15,972.21 *(capped to $10 000)***	CS Energy	call_b_2	Raise 60 sec	$1.10	0.15	$0.16
		LYMMCO	lya1	Raise 60 sec	$0.40	-0.15	-$0.06
			lya1	Raise 6 sec	$0.50	-0.10	-$0.05
			lya1	Energy	$14.26	0.34	$4.90
		Macquarie Generation	ld04	Energy	-$999.16	-1.03	$1,027.04
		Eraring Energy	er01	Energy	$9,000.00	0.55	$4,980.01
			er02	Energy	$9,000.00	1.11	$9,960.01
		Tru Energy (SA)	torrb3	Raise 6 sec	$2.00	0.10	$0.20
14:20	**$16,007.00 *(capped to $10 000)***	Macquarie Generation	ld04	Energy	-$999.16	-1.03	$1,029.02
		Eraring Energy	er02	Raise reg	$0.07	-1.66	-$0.12
			er02	Energy	$9,000.00	1.66	$14,968
		Snowy Hydro	Murray	Energy	$19.50	0.36	$6.98
		Tarong	tarong#2	Raise reg	$1.40	1.66	$2.33
14:25	$324.09	Delta Electricity	ww8	Energy	-$1,000.00	-0.29	$294.78
		Eraring Energy	er01	Energy	$24.00	0.47	$11.28
			er02	Energy	$24.00	0.47	$11.28
		Snowy Hydro	Murray	Energy	$19.50	0.35	$6.75
14:30	$20.40	DirectLink	n-q-mnsp1	Energy	$20.00	1.49	$29.85
		Snowy Hydro	Murray	Energy	$19.50	-0.48	-$9.45
		Tarong	tnps1	Energy	$0.00	1.60	$0.00
Spot price	**$6 724.08**						

Monday 31 October – New South Wales 3pm

Time	Dispatch price	Participant	Unit	Service	Offer	Marginal change	Portion
14:35	$321.71	Delta Electricity	ww7	Energy	-$1,000.00	-0.15	$150.13
			ww8	Energy	-$1,000.00	-0.14	$144.13
		Eraring Energy	er01	Lower reg	$0.07	0.47	$0.03
			er01	Energy	$24.00	0.47	$11.26
			er02	Lower reg	$0.07	0.47	$0.03
			er02	Energy	$24.00	0.47	$11.26
		Snowy Hydro	Murray	Energy	$19.50	0.35	$6.73
		Tarong	tarong#2	Lower reg	$2.00	-0.94	-$1.88
14:40	$7,880.31	Eraring Energy	er01	Energy	$24.00	-0.07	-$1.70
			er02	Energy	$24.00	-0.07	-$1.70
			Shgen	Energy	$9,900.01	0.80	$7,877.12
		Snowy Hydro	Murray	Energy	$19.50	0.34	$6.59
14:45	$7,866.05	Eraring Energy	er01	Energy	$24.00	-0.07	-$1.70
			er02	Energy	$24.00	-0.07	-$1.70
			Shgen	Energy	$9,900.01	0.79	$7,862.88
		Snowy Hydro	Murray	Energy	$19.50	0.34	$6.57
14:50	$7,872.99	Eraring Energy	er01	Lower reg	$0.07	-0.07	$0.00
			er01	Energy	$24.00	-0.07	-$1.70
			er02	Lower reg	$0.07	-0.07	$0.00
			er02	Energy	$24.00	-0.07	-$1.70
			Shgen	Energy	$9,900.01	0.80	$7,876.05
		Snowy Hydro	Murray	Energy	$0.04	0.34	$0.01
		Tarong	tarong#2	Lower reg	$2.40	0.14	$0.34
14:55	$306.23	Delta Electricity	mp1	Energy	-$1,000.00	-0.14	$143.02
			mp2	Energy	-$1,000.00	-0.14	$143.02
		Eraring Energy	er01	Lower reg	$0.07	0.47	$0.03
			er01	Energy	$24.00	0.47	$11.17
			er02	Lower reg	$0.07	0.47	$0.03
			er02	Energy	$24.00	0.47	$11.17
		Snowy Hydro	Murray	Energy	$0.04	0.34	$0.01
		Stanwell	stan-2	Lower reg	$2.39	-0.93	-$2.22
15:00	$6,888.54	Eraring Energy	Shgen	Energy	$9,900.01	0.70	$6,888.53
		Snowy Hydro	Murray	Energy	$0.04	0.30	$0.01
Spot price	**$5 189.30**						