Market ancillary service prices *above $5000/MW*

1 February 2011
South Australia

AUSTRALIAN ENERGY REGULATOR

Introduction

The AER is required to publish a report where:

- prices for a market ancillary service over a period significantly exceed the relevant spot price for energy; and
- prices for a market ancillary service exceed $5000/MW for a number of trading intervals within that period.[1]

The report must:

- describe the significant factors that contributed to the market ancillary service prices exceeding $5000/MWh;
- identify any linkages between spot prices in the energy market and market ancillary service prices contributing to the occurrence; and
- assess whether rebidding pursuant to clause 3.8.22 contributed to prices exceeding $5000/MWh.

Summary/assessment

On 1 February a planned transmission outage in Victoria reduced the capability of the Heywood interconnector. High energy prices in Victoria drove exports from South Australia into Victoria. These exports, when combined with the transmission outage, led to a requirement for local frequency control ancillary services in South Australia.

AGL is the most significant provider of these frequency control services in South Australia and offered, through a combination of day-ahead offers and rebidding, the majority of its capacity for these services at the price cap. The combination of high energy prices in the eastern states and AGL's high offer prices saw the price for lower frequency control services exceed $5000/MW for seven five-minute dispatch intervals (L60 for five dispatch intervals and L6 for two dispatch intervals[2]). The cost of these services for the seven dispatch intervals, which are paid for by South Australian customers, totalled $441 000. This compares to less than $3000 per day for the same services on a typical day.

[1] This requirement is set out in clause 3.13.7 (e) of the National Electricity Rules.
[2] The "L60" and "L6" services are defined below.

Frequency control ancillary services

Frequency control ancillary services (FCAS) are required to maintain the frequency of the power system within the frequency operating standards. There are two types of FCAS:

- Regulation services, which continuously manage small changes in demand or supply, (changes that cause the frequency to move by only a small amount away from 50 Hz), to correct the frequency. There are regulation services to increase the frequency (raise regulation or RREG) and services to decrease the frequency (lower regulation or LREG).
- Contingency services, which manage large changes in demand or supply that occur relatively rarely and move the frequency by a large amount. There are contingency services to increase the frequency and contingency services to decrease the frequency.

Raise contingency FCAS are required to be available to correct the frequency excursions that have arisen from a credible contingency event[3] that leads to a decrease in frequency. As these contingency events usually involve step reductions in supply, the Electricity Rules stipulate that generators pay for these services.

Lower contingency FCAS are the services required to be available to correct the frequency excursions that arise from a credible contingency event that leads to an increase in frequency. As these contingency events usually involve step reductions in customer demand, the Electricity Rules stipulate that customers pay for these services.

The three lower contingency services are:

- fast services, which arrest a frequency deviation within the first six seconds of a contingent event (L6);
- slow services, which stabilise frequency deviations within sixty seconds of the event (L60); and
- delayed services, which stabilise frequency deviations within five minutes of the event (L5).

Local frequency control ancillary services

On 1 February there was a planned transmission outage of one of the double circuit Moorabool to Sydenham lines in Victoria (close to Melbourne). The outage occurred from 5.05 am to 5.40 pm[4]. This put the system in a situation where, in the event that the remaining Moorabool to Sydenham line failed, the Heywood interconnector would have also failed and there would have been a step change in supply into South Australia equivalent to the flow across the interconnector. If electricity was being exported from South Australia this would have resulted in an oversupply and an increase in frequency. If electricity was being imported into South Australia this would have resulted in an undersupply and a decrease in frequency.

AEMO sets the requirement for FCAS to ensure that the frequency standard (as set by the Reliability Panel) is maintained in the event of step changes in supply that result from credible contingencies, including in this instance the loss of the second Moorabool to Sydenham line (which would have led to the loss of the interconnector). The Reliability Panel terms this as a "separation event".[5]

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[3] Any real power system is subject to shocks, for example the loss of a transmission line or a generator. Those shocks which have a material probability of occurring and/or are likely to have serious consequences are known as "credible contingencies".

[4] Notification was advised through the market systems in December 2010.

[5] A separation event is a credible contingency transmission event that forms an island.

The standard states that in the event of a "separation event" the frequency must be contained within 49 to 51 Hz or a wider band notified to AEMO by a relevant Jurisdictional Coordinator. In the case of South Australia AEMO states:

> *"the Jurisdictional Coordinator for South Australia has notified AEMO that the frequency band for separation of the South Australian power system is 47 to 52 Hz.*
>
> *… The reliability panel has anticipated that under frequency relays will operate at frequency levels in the low end of this range."*

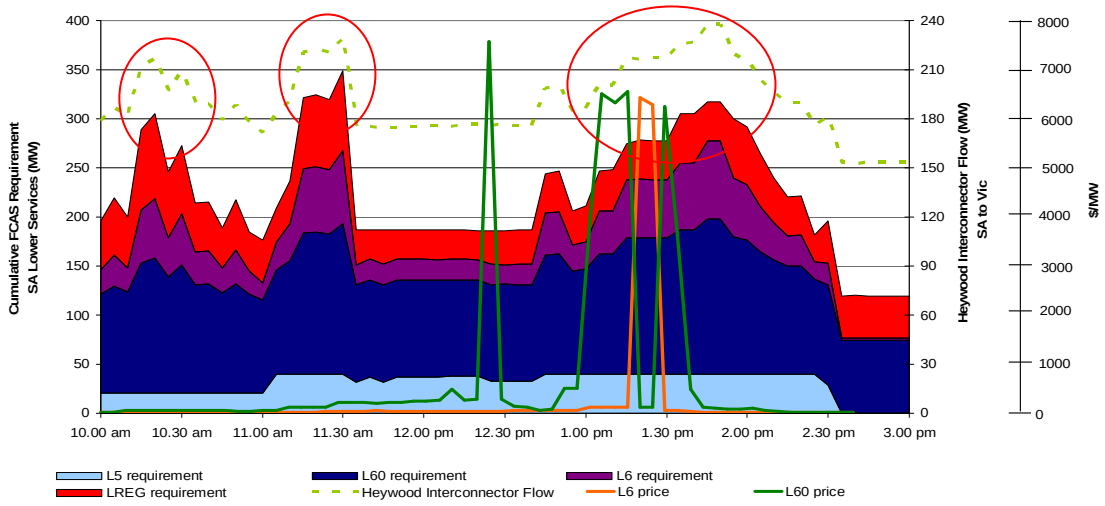
When there is a potential separation event caused by the loss of an interconnector "local frequency control ancillary services" are usually required.

If a region other than South Australia was previously importing and the interconnector fails, then local "raise" services are required to increase the frequency. Typically generators offer "raise" services, by offering to quickly increase output to raise the frequency. Alternatively, if South Australia was previously importing, the need to raise frequency will be remedied through involuntarily interrupting customer loads.

If the region was previously exporting and the interconnector fails, then local "lower" services are required to lower the frequency (typically generators offer to quickly reduce output to lower frequency). In the event of a loss of the Heywood interconnector while exporting from South Australia the resulting oversupply will lead to an increase in frequency in South Australia. In order to manage this, lower contingency FCAS must be sourced from suppliers in South Australia (typically generators). The requirement for this local lower FCAS is proportional to the flow across the interconnector from South Australia to Victoria.

Figure 1 shows the requirement and dispatch prices for local lower FCAS on 1 February and the flow across the Heywood interconnector. It highlights the relationship between exports and the local requirement. In the diagram, the shaded areas are all local requirements for South Australia.

Figure 1: South Australia local lower FCAS requirements, prices and Heywood flow



Local FCAS pricing outcomes

From 10.15 am, exports increased from South Australia into Victoria across the Heywood interconnector. Heywood interconnector flows are represented by the green dotted line in Figure 1, with the increases in exports circled in red. Figure 1 also shows that there was a commensurate increase in the requirement for local lower FCAS in South Australia. In response, the price of L5 and LREG in South Australia increased from around $50/MW at

10.10 am to over $100/MW at 10.15 am and remained above $100/MW before dropping to $90/MW at 11 am.

Figure 1 also highlights another increase in exports at 11.15 pm. This saw the price of L60 increase to around $100/MW at 11.15 am. The energy price in Victoria increased significantly from 12.30 pm, reaching $5332/MWh at 1.30 pm and $5077/MWh at 2 pm[6]. Exports from South Australia into Victoria across the Heywood interconnector increased again from around 12.45 pm (up to 56 MW greater than forecast 4 hours ahead), leading to an increased requirement for local South Australian lower FCAS.

The price of L60 local services in South Australia remained above $100/MW until 12.50 pm, reaching a maximum of $7591/MW at 12.35 pm. The price of L60 climbed above $100/MW at 1.05 pm, and was above $6000/MW from 1.20 pm to 1.30 pm inclusive, before falling to around $100/MW for the following two dispatch intervals. The price then increased again to $6256/MW at 1.45 pm. The total cost of L60 local services for South Australia on the day was $526 000 or 48 per cent of the total FCAS on the mainland for the week.

The price of L6 local services also exceeded $100/MW from 1.15 pm to 1.40 pm inclusive, reaching $6439/MW at 1.35 pm and $6296/MW at 1.40 pm. The total cost of South Australian L6 local services on the day was $76 000. Prices for the L5 and LREG local services increased to $1000/MW for eight dispatch intervals from 1.15 pm to 1.50 pm. The total cost of all local lower services in South Australia on the day (including L60) was $713 000.

As reported in the *Electricity Weekly Market Analysis* report for the week 30 January to 5 February 2011, the total cost of FCAS for the entire mainland for that week was over $1 million. This compares to the total cost of FCAS on the mainland for the previous week of $187 000. The cost of L6 and L60 services in South Australia on the day were the main drivers of the high FCAS cost on the mainland. These services were provided by AGL at its Torrens Island Power Station, Alinta Energy at its Northern Power Station and International Power at its Pelican Point Power Station. For providing these services on the day, AGL received $273 000, Alinta Power received $179 000 and International Power received $149 000. Customers in South Australia are required to pay for these local lower contingency services in proportion to their energy consumption.

Although the price for lower frequency control services exceeded $5000/MW, the South Australia energy price only reached a maximum spot price of $112/MWh at 2.30 pm.

The dispatch process

A planned transmission outage saw one of the Moorabool to Sydenham 500 kV lines out of service from 5.05 am to 5.40 pm. These lines form part of the Heywood interconnector. As discussed above, constraints[7] invoked to manage this outage, combined with higher prices in Victoria at times, led to a requirement for local lower FCAS services in South Australia[8]. The relevant constraint equations set out the "trade-off", that is, the most cost effective combination of exports from South Australia across Heywood and local lower FCAS requirements. For example the equation for constraint F_S++HYML_L60 is:

Local SA L60 dispatch - Heywood target flow to Vic >= -0.03 * SA demand

[6] In accordance with clause 3.13.7 of the Electricity Rules, the AER issued a separate report into these events.
[7] Constraint equations are mathematical expressions used in the National Electricity Market Dispatch Engine (NEMDE) to describe the physical limitations of the power system.
[8] There were a number of other constraints that were invoked as a result of this outage, but these constraints had minimal impact on market outcomes. This is discussed further in Appendix C.

This shows that an increase in exports would need to be matched by an increase in dispatch of local L60 services. This means the export limit would be constrained to the level of the most economical dispatch of local L60 services. Dependant on offer prices, it may be more economical to dispatch higher priced energy offers in other regions instead of increasing exports which will increase the requirement for local L60 services.

The South Australia demand at the time was around 2600 MW. This meant that once the Heywood flow was greater than around 80 MW towards Victoria there was a requirement for local L60 FCAS. The form of this constraint is consistent with AEMO's "*Constraint Formulation Guidelines*" which state:

> *"Where there is a credible risk of separation of 2 regions (either from a plant outage or a reclassification of multiple line loss as a credible contingency) the interconnector flow that is at risk is co-optimised with the FCAS requirements."*

Generator FCAS offers

There are only three power stations registered to provide the L6 and L60 contingency services in South Australia: Torrens Island (owned by AGL); Northern Power Station (owned by Alinta); and Pelican Point Power Station owned by International Power.

Initial offers for the period of high prices

Torrens Island Power Station offered up to:

- 115 MW of L6 (with 35 MW priced at $9000/MW or above and the remainder at the below $500/MW) and
- 250 MW of L60 (150 MW or 60 per cent was priced at $9000/MW or above).

Northern Power Station offered up to:

- 28 MW of L6 (all priced under $50/MW) and
- 44 MW of L60 (all priced under $50/MW).

Pelican Point Power Station offered up to:

- 30 MW of L6 (all priced under $500/MW) and
- 30 MW of L60 (all priced under $500/MW).

Rebids

At 8.42 am, effective from 11.35 am, AGL rebid 100 MW of L60 FCAS at Torrens Island from below $1000/MW (the majority of which was priced below $5/MW) to the price cap and up to 70 MW of L6 FCAS at Torrens Island from $100/MW or lower to the price cap. The reason given was "08:31A unfcast network constraint::fcas/energy risk V>>V_NIL_5".

At 10.56 am, effective from 11.35 am, AGL rebid 30 MW of L60 FCAS from the price cap to below $5/MW. The reason given was "10:01A chg in forecast::PD price decrease Vic >10k". At 12.35 pm, effective from 12.45 pm, AGL rebid 40 MW of L60 FCAS at Torrens Island from the price cap to zero. The reason given was "12:31A chg in dispatch::price increase [Vic][>$8k]". At 1.26 pm, effective from 1.35 pm, AGL rebid 30 MW of L60 FCAS at Torrens Island from the price cap to below $5/MWh. The reason given was "13:20A chg in dispatch::price increase [VIC1/NSW1/QLD1]". These rebids had the affect of reversing the 8.42 am rebid as AGL shifted capacity back down into lower offer prices to ensure dispatch as none of the offers at close to the price cap were dispatched.

At 1.35 pm, effective from 1.45 pm, AGL rebid 10 MW of L60 at Torrens Island from below $5/MW to the price cap and 45 MW of L6 FCAS from the price cap to below $2/MW. The reason given was "13:31A unfcast network constraint::FCAS/energy risk 6sl". At 1.35 pm

and 1.40 pm the price of L6 FCAS was above $6200/MW, once this rebid became effective the price for L6 fell to $40/MW.

There was no other significant rebidding.

Closing offers

Following the rebids by AGL, around 50 per cent of the L6 and L60 offers in South Australia were priced above $12 000/MW. The only participant in South Australia with capacity priced at or above $5000/MW for lower FCAS was AGL. The closing bids for AGL are presented in Appendix B.

At the time of high prices all South Australian L6 and L60 offers priced at up to $101/MW were dispatched. The higher priced offers from AGL were not dispatched because of the "trade-off" between exports and lower FCAS requirements. For example, at 12.35 pm there were 98 MW of local L60 services dispatched, with all dispatched offers priced at below $101/MW. All other remaining L60 offers were from AGL and all were priced at $9000/MW or above. An increase in exports would have created a requirement for these high priced offers from AGL. The "trade-off" was to increase the dispatch of generation in New South Wales at Bayswater unit four (priced at $7502/MWh) instead of increasing exports out of South Australia. This resulted in the price of the local L60 service being set at $7591/MW. Higher exports would have resulted in increased dispatch of FCAS priced at $9000/MW, which was less economic.

The generators involved in setting the price during the high-price period and how that price was determined by the market systems is detailed in Appendix A.

Australian Energy Regulator

June 2011

Appendix A – Price setters for Tuesday 1 February 2011

The following tables identify for the five-minute FCAS dispatch prices above $5000/MW, each price and the generating units involved in setting the price for each of the lower Frequency Control Ancillary Services in South Australia. This information is published by AEMO[9]. Also shown are the offer prices involved in determining the dispatch price together with the quantity of that service and the contribution to the total price. AEMO reports an increase as a negative marginal change in FCAS price setter.

South Australia – lower 60 second FCAS – 1 February

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
12:35	$7591.09	Macquarie Generation	BW04	Energy	$7502.00	-1.02	-$7667.79
		AGL (SA)	TORRA2	Energy	$48.77	0.07	$3.38
		AGL (SA)	TORRA3	Energy	$48.77	0.07	$3.38
		AGL (SA)	TORRB1	Energy	$48.77	0.28	$13.51
		AGL (SA)	TORRB2	Energy	$48.77	0.28	$13.51
		AGL (SA)	TORRB3	Energy	$48.77	0.28	$13.51
		AGL (SA)	TORRB4	Energy	$48.77	0.28	$13.51
		Origin Energy	LADBROK1	Energy	$0.01	-0.12	$0.00
		Origin Energy	LADBROK2	Energy	$0.01	-0.12	$0.00
		AGL (SA)	TORRB4	Lower 5 min	$5.00	1.00	$5.00
		Vic Power Trader	APS	Lower 5 min	$0.00	-1.00	$0.00
		International Power	PPCCGT	Lower 6 sec	$10.69	1.00	$10.69
13:20	$6514.16	Macquarie Generation	BW02	Energy	$7706.00	-0.99	-$7664.39
		AGL (SA)	TORRB1	Energy	$48.77	0.25	$12.27
		AGL (SA)	TORRB2	Energy	$48.77	0.25	$12.27
		AGL (SA)	TORRB3	Energy	$48.77	0.25	$12.27
		AGL (SA)	TORRB4	Energy	$48.77	0.25	$12.27
		International Power	PPCCGT	Lower reg	$1000.69	1.00	$1000.69
		CS Energy	CALL_B_2	Lower reg	$0.01	-1.00	-$0.01
		International Power	PPCCGT	Lower 6 sec	$100.69	1.00	$100.69
13:25	$6345.53	Macquarie Generation	BW03	Energy	$7604.00	-0.99	-$7505.91
		AGL (SA)	TORRB2	Energy	$58.77	0.34	$19.71
		AGL (SA)	TORRB3	Energy	$58.77	0.34	$19.71
		AGL (SA)	TORRB4	Energy	$58.77	0.34	$19.71
		International Power	PPCCGT	Lower reg	$1000.69	1.00	$1000.69
		CS Energy	CALL_B_2	Lower reg	$0.01	-1.00	-$0.01
		International Power	PPCCGT	Lower 6 sec	$100.69	1.00	$100.69
13:30	$6563.32	Macquarie Generation	BW01	Energy	$7808.00	-0.99	-$7713.52
		AGL (SA)	TORRA2	Energy	$48.77	0.06	$2.73
		AGL (SA)	TORRA3	Energy	$48.77	0.06	$2.73
		AGL (SA)	TORRB1	Energy	$48.77	0.22	$10.90
		AGL (SA)	TORRB2	Energy	$48.77	0.22	$10.90
		AGL (SA)	TORRB3	Energy	$48.77	0.22	$10.90
		AGL (SA)	TORRB4	Energy	$48.77	0.22	$10.90
		International Power	PPCCGT	Lower reg	$1000.69	1.00	$1000.69
		CS Energy	CALL_B_2	Lower reg	$0.01	-1.00	-$0.01
		International Power	PPCCGT	Lower 6 sec	$100.69	1.00	$100.69
13:45	$6256.13	Macquarie Generation	BW02	Energy	$7706.00	-0.95	-$7346.13
		AGL (SA)	TORRA2	Energy	$48.77	0.06	$2.73
		AGL (SA)	TORRA3	Energy	$48.77	0.06	$2.73
		AGL (SA)	TORRB1	Energy	$48.77	0.22	$10.91
		AGL (SA)	TORRB2	Energy	$48.77	0.22	$10.91
		AGL (SA)	TORRB3	Energy	$48.77	0.22	$10.91
		AGL (SA)	TORRB4	Energy	$48.77	0.22	$10.91
		International Power	PPCCGT	Lower reg	$1000.69	1.00	$1000.69
		Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00

[9] Details on how the price is determined can be found at www.aemo.com.au

South Australia – lower 6 second FCAS – 1 February

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
13:35	$6439.41	CS Energy	CALL_B_2	Energy	$6857.54	-1.11	-$7589.93
		AGL (SA)	TORRA2	Energy	$48.77	0.06	$2.73
		AGL (SA)	TORRA3	Energy	$48.77	0.06	$2.73
		AGL (SA)	TORRB1	Energy	$48.77	0.22	$10.91
		AGL (SA)	TORRB2	Energy	$48.77	0.22	$10.91
		AGL (SA)	TORRB3	Energy	$48.77	0.22	$10.91
		AGL (SA)	TORRB4	Energy	$48.77	0.22	$10.91
		International Power	PPCCGT	Lower reg	$1000.69	1.00	$1000.69
		International Power	PPCCGT	Lower 60 sec	$100.69	1.00	$100.69
13:40	$6296.04	Macquarie Generation	BW02	Energy	$7706.00	-0.97	-$7446.31
		AGL (SA)	TORRA2	Energy	$48.77	0.06	$2.73
		AGL (SA)	TORRA3	Energy	$48.77	0.06	$2.73
		AGL (SA)	TORRB1	Energy	$48.77	0.22	$10.91
		AGL (SA)	TORRB2	Energy	$48.77	0.22	$10.91
		AGL (SA)	TORRB3	Energy	$48.77	0.22	$10.91
		AGL (SA)	TORRB4	Energy	$48.77	0.22	$10.91
		International Power	PPCCGT	Lower reg	$1000.69	1.00	$1000.69
		International Power	PPCCGT	Lower 60 sec	$100.69	1.00	$100.69

Appendix B – Closing bids

Figures B1 and B2 highlight the L60 and L6 FCAS closing bids for AGL (the only participant in South Australia with capacity priced at or above $5000/MW during the period the price exceeded $5000/MW). It also shows the dispatch of that service for its Torrens Island station and the dispatch price for the related lower services.

Figure B1: AGL (Torrens Island) lower 60 second service closing bid prices, dispatch and dispatch price for 1 February

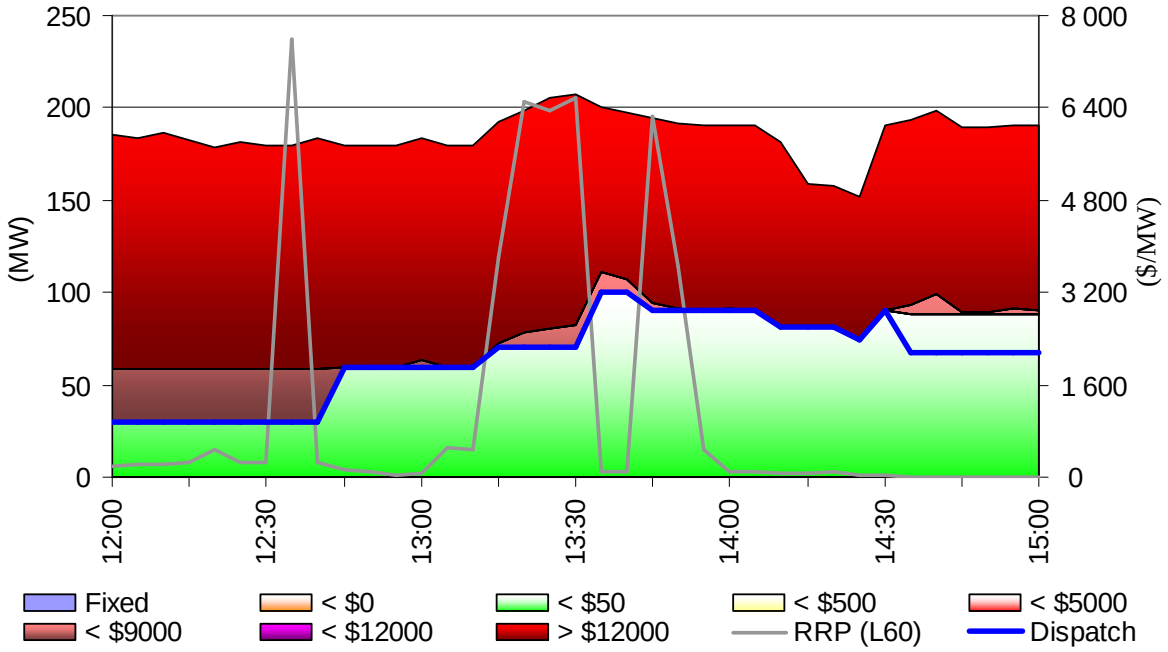
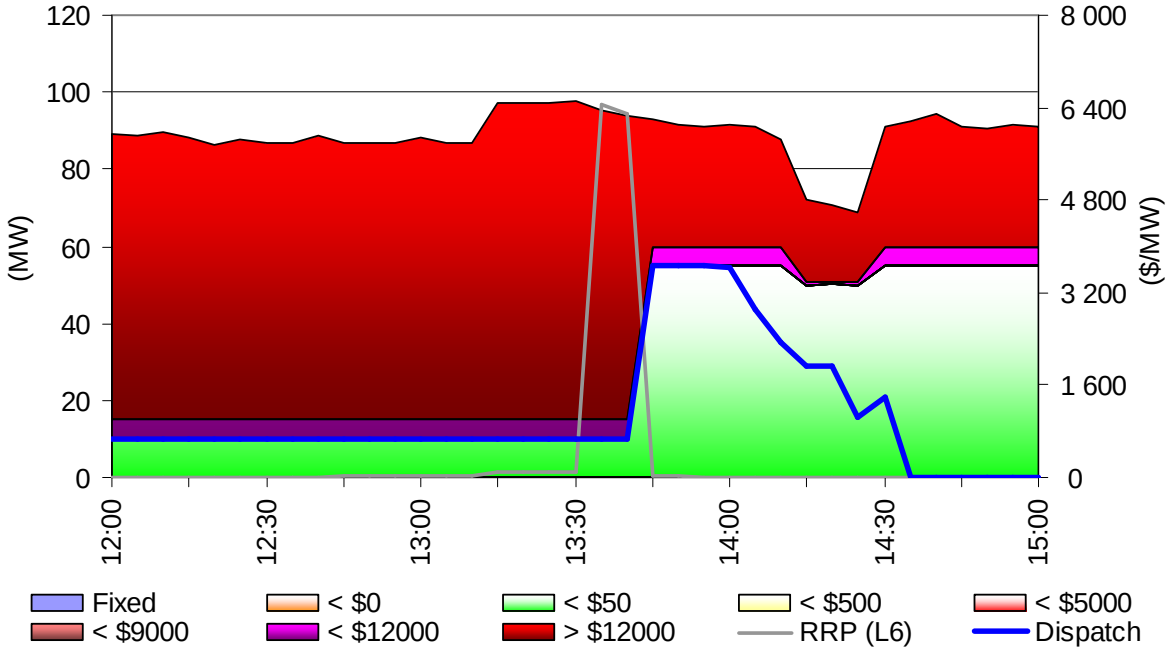


Figure B2: AGL (Torrens Island) lower 6 second service closing bid prices, dispatch and dispatch price for 1 February



Appendix C – FCAS constraints invoked as a result of the Victorian network outages

On 1 February there was a planned transmission outage of one of the double circuit Moorabool to Sydenham lines in Victoria. The Moorabool to Sydenham lines form part of the Heywood interconnector. The APD aluminium smelter is also connected to the Heywood interconnector, close to the SA/Vic border. This means that for the loss of the remaining Moorabool to Sydenham line the Heywood interconnector between South Australia and Victoria would be lost. This would cause a step change in supply into South Australia equivalent to the flow across the interconnector. In the event of the loss of the remaining Moorabool to Sydenham line, the smelter load would also be automatically disconnected[10] and:

- If electricity was being exported from SA this would have resulted in an oversupply and an increase in frequency in SA. As a result of the loss of the smelter load (which is greater than the exports from SA) it would also result in an oversupply and an increase in frequency in the combined Victoria + NSW + Queensland region.
- If electricity was being imported into SA this would have resulted in an undersupply and a decrease in frequency in SA. As a result of the loss the smelter load plus exports to SA it would also result in an oversupply and an increase in frequency in the combined Victoria + NSW + Queensland region.

The planned transmission outage saw one of the Moorabool to Sydenham 500 kV lines out of service from 5.05 am to 5.40 pm on 1 February. The F-V-HYML constraint set was invoked to manage this outage. The constraint equations in this set are:

- F_S++HYML_L5, F_S++HYML_L6, F_S++HYML_L60
    - These constraints determine only the lower contingency (L5, L6 and L60) requirements to manage the impact of loss of the interconnector on SA. Flow across the Heywood interconnector is co-optimised.
    - This group of constraints led to the very high local FCAS prices
- F_QNV+HYML_L5, F_QNV+HYML_L6, F_QNV+HYML_L60, F_QNV+HYML_R5, F_QNV+HYML_R6, F_QNV+HYML_R60
    - These constraints determine lower (L5, L6 and L60) and raise (R5, R6 and R60) contingency requirements to manage the impact of loss of the interconnector (and the smelter) on NSW, Qld and Vic. BassLink is **unable** to transfer FCAS and the BassLink and Heywood interconnectors are co-optimised.
    - This group of constraints at times set the requirement for **lower** contingency FCAS across the NEM. This is because the contingency (loss of the smelter load and flows across the Heywood interconnector) was the largest in the NEM.
    - These constraints did not impact on market outcomes.

[10] In the event of the loss of the remaining Moorabool to Sydenham line, the smelter load would be temporarily connected to the SA region, causing a very large demand/supply imbalance and frequency drop. As a result it would be automatically disconnected from SA by protection equipment (related to the resulting rapid drop in frequency in SA) soon after the loss of the remaining Moorabool to Sydenham line.

- F_ESTN++HYML_L5, F_ESTN++HYML_L6, F_ESTN++HYML_L60, F_ESTN++HYML_R5 , F_ESTN++HYML_R6, F_ESTN++HYML_R60
    - These constraints determine lower and raise contingency requirements to manage the impact of loss of the interconnector on NSW, Qld, Vic and Tas. The Heywood interconnector is co-optimised.
    - These constraints did not impact on market outcomes.
- F_QNV++HYML_L5, F_QNV++HYML_L6, F_QNV++HYML_L60, F_QNV++HYML_R5, F_QNV++HYML_R6, F_QNV++HYML_R60
    - These constraints determine lower and raise contingency requirements to manage the impact of loss of the interconnector on NSW, Qld and Vic. BassLink is able to transfer FCAS. The BassLink and Heywood interconnectors are co-optimised.
    - These constraints did not impact on market outcomes.