Market ancillary service prices above $5000/MW

21 and 22 April 2010
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/MW;
- 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/MW.

Summary/assessment

On 21 and 22 April there was a planned transmission outage in Victoria, which reduced the capability of the Heywood interconnector. High energy prices in Victoria on both days 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.

As a result of AGL's high offer prices, the price for lower frequency control services reached close to the price cap for 94 five-minute dispatch intervals over the two days. The cost of these services, which are paid for by South Australian customers, totalled more than $8 million. This compares to less than $3000 per day for the same services on a typical day.

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).

[1] This requirement is set out in clause 3.13.7 (e) of the National Electricity Rules.

- 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[2] 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 21 and 22 April there were planned transmission outages of one of the double circuit Moorabool to Sydenham lines in Victoria (close to Melbourne). The outages occurred from 7 am to 4.05 pm on 21 April, and from 7 am to 5.20 pm on 22 April[3]. 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".[4]

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.

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[2] 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".

[3] Notification was advised through the market systems around a month before the outages.

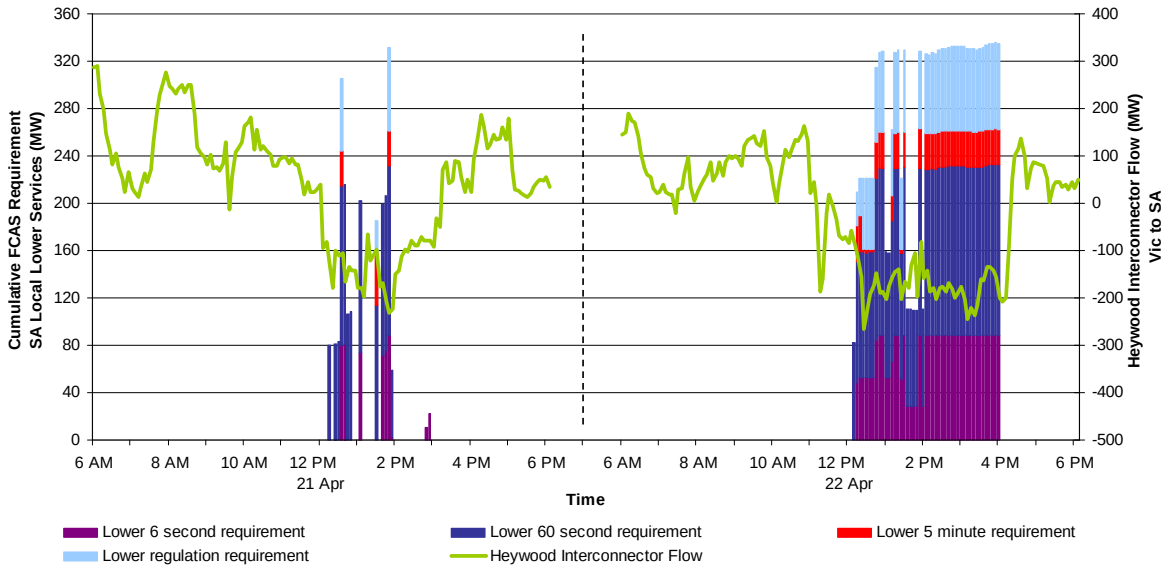
[4] A separation event is a credible contingency transmission event that forms an island.

If the region was previously importing and the interconnector fails, then local "raise" services are required to increase the frequency. Typically generators offer to quickly increase output to raise frequency or, as occurs in South Australia, the 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). So 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 for local lower FCAS on 21 and 22 April and the flow across the Heywood interconnector. It highlights the relationship between exports (negative Heywood flow) and the local requirement.

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



Note that the frequency standard allows for LREG to be substituted for L5

Local FCAS pricing outcomes

On 21 April 2010 from 12.05 pm high energy prices in Victoria led to exports from South Australia across Heywood. This in turn led to a requirement for local South Australian lower FCAS. The prices for the L60 and L6 local services rose to close to the price cap ($10 000/MW) for 16 dispatch intervals in total between 12.30 pm and 1.55 pm. Prices for the L5 and LREG services also increased to this level for two dispatch intervals at 1.35 pm and 1.55 pm.

Similarly, on 22 April 2010 from 12.15 pm high energy prices in Victoria led to exports from South Australia across Heywood[5]. This again led to a requirement for local South Australian lower FCAS. The prices for L60 and L6 local services rose to close to the price cap for a total of 72 dispatch intervals from 12.20 pm to 4.05 pm. Prices for the L5 and LREG services also increased to this level for the 2 pm dispatch interval.

As reported in the *Electricity Weekly Market Analysis* report for the week 18 April 2010 to 24 April 2010, the total cost of FCAS on the mainland for that week was around $9 million. This compares to the total cost of FCAS on the mainland for the previous week of $287 000.

[5] On Thursday 22 April, the Victorian spot price exceeded $5000/MWh on seven occasions. In accordance with clause 3.13.7 of the Electricity Rules, the AER issued a report into this event.

The main contribution to the increase in FCAS cost during the week was the high prices for lower FCAS services in South Australia on 21 and 22 April. The cost for lower FCAS in South Australia over these two days accounted for $8.5 million, or 94 per cent of the total FCAS cost on the mainland for the week. AGL was paid almost $6 million for providing these services from its Torrens Island B Power Station over these two days. Customers in South Australia are required to pay for these local lower services in proportion to their energy consumption.

The price for lower frequency control services reached the price cap for 37 dispatch intervals (L6 service), 51 dispatch intervals (L60), 3 dispatch intervals (L5) and 3 dispatch intervals (LReg) – a total of 94 5-minute dispatch intervals over the two days in question. The South Australia energy price, however, was not greatly affected, reaching a maximum spot price of $3211/MWh at 2 pm on 21 April (driven by two 5-minute prices of $9000/MWh at 1.45 pm and 1.50 pm).

The dispatch process

A planned transmission outage saw one of the Moorabool to Sydenham 500 kV lines out of service from 7 am to 4.05 pm on 21 April, and from 7 am to 5.20 pm on 22 April. These lines form part of the Heywood interconnector. As discussed above, constraints[6] 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[7]. The relevant constraint equations set out the "trade-off" between exports from South Australia across Heywood and increasing local lower FCAS requirements. For example the constraint that determines the L6 requirement (F_S++HYML_L6) is of the form:

Local SA L6 dispatch - Heywood target flow to Vic >= -0.06 * SA demand

The South Australia demand at the time was around 1800 MW. This meant that once the Heywood flow was greater than around 100 MW towards Victoria there was a requirement for local lower FCAS. The form of this constraint is consistent with AEMO's recently published "*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."*

As discussed above, a key driver of the outcomes on 21 and 22 April was the Victorian transmission outages. The AER notes that the AEMC has commenced its "*Transmission Frameworks Review*"[8]. The AER will raise this with the AEMC for consideration as part of their transmission frameworks review.

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[6] Constraint equations are mathematical expressions used in the National Electricity Market Dispatch Engine (NEMDE) to describe the physical limitations of the power system.

[7] 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.

[8] In April 2010, the Ministerial Council on Energy (MCE) directed the AEMC to conduct a review of the arrangements for the provision and utilisation of electricity transmission services in the NEM, with a view to ensuring that the incentives for generation and network investment and operating decisions are effectively aligned to deliver efficient overall outcomes. The AEMC is to review the role of transmission in providing services to the competitive sectors of the NEM, through considering Transmission Investment; Network Operation; Network Charging, Access and Connection; and Management of Network Congestion.

Generator FCAS offers

There are only two power stations registered to provide the L6 and L60 lower contingency services in South Australia – Northern Power Station (owned by Alinta) and Torrens Island A and B (owned by AGL). The Torrens Island B units are the only registered providers of L5.

Initial offers

During the time of high prices Torrens Island Power Station made day-ahead offers of:

- 60 MW of L6 (with 45 MW priced at less than $1/MW and the remainder at the price cap),
- 150 MW of L60 (60 MW priced at less than $5/MW and the remainder at the cap) and
- 150 MW of L5 (30 MW priced at less than $10/MW and the remainder at the cap).

For 21 and 22 April Northern Power Station offered up to:

- 28 MW of L6 (all priced at $40/MW or less) and
- 46 MW of L60 (all priced at $40/MW or less).

Rebids

At 1.37 pm on 21 April, effective from 1.45 pm on 21 April, AGL rebid 45 MW of L6 FCAS at Torrens Island B from below $1/MW to the price cap. The rebid affected the 2 pm to 3.30 pm trading intervals for both 21 April and 22 April, and resulted in all of its capacity for this service being offered at the price cap. The reason given for the rebid was "13:35:A unfcast network constraint: multiple SA1 LHS <=0 (WT=3".

There were no other rebids.

Closing offers

On 21 and 22 April, following the rebids by AGL, around 70 per cent of the L6 offers in South Australia were priced at the cap. In addition around 80 per cent of L5 offers and half of the L60 offers in South Australia were priced at the cap. The combination of high energy prices in Victoria driving exports into that region and the Moorabool to Sydenham line outage, saw these high priced FCAS offers from Torrens Island dispatched and setting the price for these services.

Out of the 94 five-minute dispatch intervals over the two days when the price exceeded $5000/MW, AGL set the price for lower FCAS at Torrens Island B a total of 81 times. At other times the high energy prices in Victoria contributed to the high FCAS price.

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.

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.

Australian Energy Regulator
June 2010

Appendix A – FCAS price setters for 21 and 22 April 2010

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 is the offer prices involved in determining the dispatch price together with the quantity of that service and the contribution to the total price. Unlike for energy the marginal change and contribution are reported as a negative.

South Australia – lower 6 second FCAS – 21 April, 12.40 pm to 1.55 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
12:40	$9999.90	AGL (SA)	TORRB2	Lower 6 sec	$9999.90	-1.00	-$9999.90
12:45	$9999.90	AGL (SA)	TORRB2	Lower 6 sec	$9999.90	-1.00	-$9999.90
12:50	$40.00	Flinders Power	NPS1	Lower 6 sec	$40.00	-1.00	-$40.00
12:55	$40.00	Flinders Power	NPS1	Lower 6 sec	$40.00	-1.00	-$40.00
13:00	$40.00	Flinders Power	NPS1	Lower 6 sec	$40.00	-1.00	-$40.00
13:05	$40.00	Flinders Power	NPS1	Lower 6 sec	$40.00	-1.00	-$40.00
13:10	$9999.90	AGL (SA)	TORRB2	Lower 6 sec	$9999.90	-1.00	-$9999.90
13:15	$0.04	AGL (SA)	TORRB1	Lower 6 sec	$0.04	-1.00	-$0.04
13:20	$0.04	AGL (SA)	TORRB3	Lower 6 sec	$0.04	-1.00	-$0.04
13:25	$0.04	AGL (SA)	TORRB2	Lower 6 sec	$0.04	-1.00	-$0.04
13:30	$0.04	AGL (SA)	TORRB2	Lower 6 sec	$0.04	-1.00	-$0.04
13:35	$40.00	Flinders Power	NPS2	Lower 6 sec	$40.00	-1.00	-$40.00
13:40	$0.50	AGL (SA)	TORRB1	Lower 6 sec	$0.50	-1.00	-$0.50
13:45	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
13:50	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
13:55	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90

South Australia – lower 60 second FCAS – 21 April, 12.30 pm to 12.45 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
12:30	$9517.11	International Power	LOYYB1	Raise 6 sec	$0.88	-2.00	-$1.76
		Hazelwood Power	HWPS4	Energy	$9998.39	-0.95	-$9547.46
		Macquarie Generation	BW03	Lower reg	$1.20	-1.00	-$1.20
		Stanwell	STAN-4	Lower 60 sec	$0.01	-1.00	-$0.01
		Tarong Energy	TARONG#2	Lower 6 sec	$0.00	-1.00	$0.00
		AGL (SA)	TORRA1	Energy	$28.77	1.00	$28.86
		AGL (SA)	TORRA2	Energy	$28.77	1.00	$28.86
		AGL (SA)	TORRB3	Energy	$25.00	-1.00	-$25.00
		AGL (SA)	TORRB3	Lower reg	$0.80	1.00	$0.80
		AGL (SA)	TORRB3	Lower 6 sec	$0.04	1.00	$0.04
		AGL (SA)	TORRB3	Raise 6 sec	$0.04	2.00	$0.08
12:35	$9517.11	CS Energy	SWAN_B_1	Energy	$20.00	-1.01	-$20.12
		Hazelwood Power	HWPS2	Energy	$9998.19	-0.95	-$9544.27
		Stanwell	STAN-1	Energy	$20.26	1.01	$20.39
		Stanwell	STAN-1	Lower reg	$0.99	1.01	$1.00
		Stanwell	STAN-1	Raise reg	$1.99	1.01	$2.00
		Tarong Energy	TARONG#1	Lower 6 sec	$0.00	-1.00	$0.00
		AGL (SA)	TORRB1	Energy	$25.00	1.01	$25.16
		AGL (SA)	TORRB1	Lower reg	$0.80	-1.01	-$0.80
		AGL (SA)	TORRB1	Raise reg	$0.80	-1.01	-$0.80
		AGL (SA)	TORRB3	Lower 6 sec	$0.04	1.00	$0.04
		TRUenergy (Vic)	YWPS1	Lower 60 sec	$0.05	-1.00	-$0.05
12:40	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
12:45	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90

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

South Australia – lower 60 second FCAS – 21 April, 12.50 pm to 1.55 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
12:50	$445.77	Flinders Power	NPS1	Lower reg	$40.00	1.08	$43.27
		Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00
		Delta Electricity	MP1	Lower reg	$1.40	-1.00	-$1.40
		International Power	LOYYB1	Energy	$9.89	-0.05	-$0.53
		Snowy Hydro	MURRAY	Energy	-$1000.00	0.53	-$529.20
		Stanwell	STAN-4	Raise reg	$1.99	0.08	$0.16
		AGL (SA)	TORRB3	Energy	$25.00	0.08	$2.05
		AGL (SA)	TORRB3	Lower reg	$0.80	-0.08	-$0.07
		AGL (SA)	TORRB3	Raise reg	$0.25	-0.08	-$0.02
12:55	$9999.90	AGL (SA)	TORRB1	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:00	$246.34	Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00
		Delta Electricity	MP1	Lower reg	$1.40	-1.00	-$1.40
		Infratil Energy	ANGAS1	Energy	$250.78	1.08	$271.29
		LYMMCO	LYA2	Energy	$8.90	-0.05	-$0.48
		Snowy Hydro	MURRAY	Energy	-$1000.00	0.53	-$529.20
		Stanwell	GSTONE6	Raise 5 min	$2.00	-1.00	-$2.00
		AGL (SA)	TORRB1	Energy	$25.00	-1.00	-$25.00
		AGL (SA)	TORRB1	Lower reg	$0.25	1.00	$0.25
		AGL (SA)	TORRB1	Raise reg	$0.25	1.00	$0.25
13:05	$246.30	Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00
		International Power	LOYYB1	Energy	$9.89	-0.05	-$0.53
		Infratil Energy	ANGAS1	Energy	$250.78	1.08	$271.29
		Snowy Hydro	MURRAY	Energy	-$1000.00	0.53	-$529.20
		Stanwell	GSTONE2	Raise reg	$1.99	-1.00	-$1.99
		Stanwell	GSTONE4	Energy	$20.59	-0.50	-$10.30
		Stanwell	GSTONE4	Lower reg	$0.99	-0.50	-$0.50
		Stanwell	GSTONE6	Energy	$20.59	-0.50	-$10.30
		Stanwell	GSTONE6	Lower reg	$0.99	-0.50	-$0.50
		Stanwell	STAN-1	Energy	$20.26	1.00	$20.26
		AGL (SA)	TORRB1	Energy	$25.00	-1.00	-$25.00
		AGL (SA)	TORRB1	Lower reg	$0.25	1.00	$0.25
		AGL (SA)	TORRB1	Raise reg	$0.25	1.00	$0.25
13:10	$9999.90	AGL (SA)	TORRB1	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:20	$24.33	Delta Electricity	MP2	Lower 5 min	$0.40	-1.00	-$0.40
		Ecogen Energy	NPS	Energy	$280.70	-0.14	-$40.20
		AGL (SA)	TORRB2	Lower 5 min	$5.00	1.00	$5.00
		Origin Energy	URANQ11	Energy	$20.99	0.54	$11.25
13:25	$49.70	Infratil Energy	ANGAS1	Energy	$250.78	-0.27	-$68.56
		Macquarie Generation	BW02	Lower 6 sec	$0.02	-1.00	-$0.02
		Macquarie Generation	BW03	Lower 5 min	$0.40	-1.00	-$0.40
		AGL (SA)	TORRB1	Lower 5 min	$5.00	1.00	$5.00
		AGL (SA)	TORRB2	Lower 6 sec	$0.04	1.00	$0.04
		Origin Energy	URANQ11	Energy	$20.99	0.68	$14.25
13:30	$2962.36	Delta Electricity	MP2	Lower 5 min	$0.40	-1.00	-$0.40
		Ecogen Energy	NPS	Energy	$9100.70	-0.33	-$2978.66
		Macquarie Generation	BW03	Lower 6 sec	$0.03	-1.00	-$0.03
		TRUenergy	TALWA1	Energy	$21.74	0.53	$11.48
		AGL (SA)	TORRB2	Lower 5 min	$5.00	1.00	$5.00
		AGL (SA)	TORRB2	Lower 6 sec	$0.04	1.00	$0.04
13:35	$9999.90	AGL (SA)	TORRB1	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:40	$444.10	Flinders Power	NPS1	Energy	$11.22	-0.54	-$6.10
		Flinders Power	NPS1	Lower reg	$40.00	0.27	$10.88
		Flinders Power	NPS1	Lower 60 sec	$40.00	0.50	$20.02
		Flinders Power	NPS2	Energy	$11.37	0.49	$5.51
		Flinders Power	NPS2	Lower reg	$40.00	0.49	$19.40
		Flinders Power	NPS2	Lower 60 sec	$40.00	-0.74	-$29.74
		Delta Electricity	MP2	Lower reg	$1.40	-0.76	-$1.06
		Snowy Hydro	MURRAY	Energy	-$1000.00	0.46	-$463.40
		AGL (SA)	TORRB1	Lower 6 sec	$0.50	0.76	$0.38
13:45	$9999.90	AGL (SA)	TORRB1	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:50	$9999.90	AGL (SA)	TORRB1	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:55	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90

South Australia – lower 5 minute FCAS – 21 April, 1.35 pm and 1.55 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
13:35	$9999.90	AGL (SA)	TORRB1	Lower 5 min	$9999.90	-1.00	-$9999.90
13:55	$9701.47	Synergen Power	MINTARO	Energy	$299.10	1.00	$299.10
		AGL (SA)	TORRB3	Energy	$9999.77	-1.00	-$9999.77
		AGL (SA)	TORRB3	Lower reg	$0.80	-1.00	-$0.80

South Australia – lower regulation FCAS – 21 April, 1.35 pm and 1.55 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
13:35	$10001.02*	Delta Electricity	MP2	Lower reg	$1.40	-1.00	-$1.40
		International Power	LOYYB2	Lower 5 min	$0.28	1.00	$0.28
		AGL (SA)	TORRB1	Lower 5 min	$9999.90	-1.00	-$9999.90
13:55	$9701.47	Synergen Power	MINTARO	Energy	$299.10	1.00	$299.10
		AGL (SA)	TORRB3	Energy	$9999.77	-1.00	-$9999.77
		AGL (SA)	TORRB3	Lower reg	$0.80	-1.00	-$0.80

*** capped at $10 000/MW**

South Australia – lower 6 second FCAS – 22 April, 12.50 pm to 2.55 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
12:50	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
12:55	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
13:00	$9999.90	AGL (SA)	TORRB1	Lower 6 sec	$9999.90	-1.00	-$9999.90
13:05	$40.00	Flinders Power	NPS1	Lower 6 sec	$40.00	-1.00	-$40.00
13:10	$40.00	Flinders Power	NPS1	Lower 6 sec	$40.00	-1.00	-$40.00
13:15	$40.00	Flinders Power	NPS2	Lower 6 sec	$40.00	-1.00	-$40.00
13:20	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
13:25	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
13:30	$40.00	Flinders Power	NPS1	Lower 6 sec	$40.00	-1.00	-$40.00
13:35	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
13:40	$241.40	Flinders Power	NPS1	Energy	$11.22	0.07	$0.73
		Flinders Power	NPS1	Lower 60 sec	$40.00	1.00	$40.00
		LYMMCO	LYA3	Energy	$9.30	0.10	$0.88
		LYMMCO	LYA3	Raise reg	$0.90	-0.10	-$0.09
		Snowy Hydro	MURRAY	Energy	-$1000.00	0.28	-$283.00
		Stanwell	GSTONE6	Raise reg	$0.94	0.10	$0.09
13:45	$241.38	Flinders Power	NPS2	Energy	$11.37	0.06	$0.74
		Flinders Power	NPS2	Lower 60 sec	$40.00	1.00	$40.00
		LYMMCO	LYA4	Energy	$9.40	0.09	$0.89
		Snowy Hydro	MURRAY	Energy	-$1000.00	0.28	-$283.00
13:50	$241.40	Flinders Power	NPS1	Energy	$11.22	0.07	$0.73
		Flinders Power	NPS1	Lower 60 sec	$40.00	1.00	$40.00
		LYMMCO	LYA3	Energy	$9.30	0.10	$0.89
		Snowy Hydro	MURRAY	Energy	-$1000.00	0.28	-$283.00
13:55	$366.77	Flinders Power	NPS2	Lower 60 sec	$40.00	1.00	$40.00
		Delta Electricity	MP1	Lower reg	$1.40	-0.41	-$0.57
		Delta Electricity	MP2	Lower 5 min	$0.40	-0.59	-$0.24
		Snowy Hydro	MURRAY	Energy	-$1000.00	0.40	-$397.10
		Stanwell	STAN-4	Raise reg	$0.94	-0.41	-$0.38
		AGL (SA)	TORRB1	Energy	$28.77	-0.41	-$11.68
		AGL (SA)	TORRB1	Lower reg	$0.25	0.41	$0.10
		AGL (SA)	TORRB1	Raise reg	$0.25	0.41	$0.10
		AGL (SA)	TORRB2	Lower 5 min	$5.00	0.59	$2.97
14:00	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
14:05	$239.88	Flinders Power	NPS2	Energy	$11.37	0.06	$0.66
		Flinders Power	NPS2	Lower 60 sec	$40.00	1.00	$40.00
		Snowy Hydro	MURRAY	Energy	-$1000.00	0.28	-$280.50
14:10	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
14:15	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
14:20	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
14:25	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
14:30	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
14:35	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
14:40	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
14:45	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
14:50	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
14:55	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90

South Australia – lower 6 second FCAS – 22 April 3 pm to 4.05 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
15:00	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
15:05	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
15:10	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
15:15	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
15:20	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
15:25	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
15:30	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
15:35	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
15:40	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
15:45	$9999.90	AGL (SA)	TORRB2	Lower 6 sec	$9999.90	-1.00	-$9999.90
15:50	$9999.90	AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
15:55	$9999.90	AGL (SA)	TORRA1	Energy	$28.77	-0.13	-$3.60
		AGL (SA)	TORRA2	Energy	$28.77	-0.13	-$3.60
		AGL (SA)	TORRB2	Energy	$28.77	-0.25	-$7.19
		AGL (SA)	TORRB3	Energy	$28.77	0.50	$14.39
		AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
16:00	$9999.90	AGL (SA)	TORRA2	Energy	$28.77	-0.50	-$14.39
		AGL (SA)	TORRB3	Energy	$28.77	0.50	$14.39
		AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90
16:05	$9999.90	AGL (SA)	TORRA2	Energy	$28.77	-0.50	-$14.39
		AGL (SA)	TORRB3	Energy	$28.77	0.50	$14.39
		AGL (SA)	TORRB3	Lower 6 sec	$9999.90	-1.00	-$9999.90

South Australia – lower 60 second FCAS – 22 April, 12.20 pm to 12.40 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
12:20	$9421.40	Origin Energy	LADBROK1	Energy	$0.01	0.00	$0.00
		Origin Energy	QPS1	Energy	$0.01	0.00	$0.00
		Origin Energy	QPS5	Energy	$0.01	0.00	$0.00
		Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00
		Delta Electricity	MP1	Lower reg	$1.40	-1.00	-$1.40
		International Power	LOYYB2	Energy	$9998.89	-0.95	-$9488.95
		AGL (SA)	TORRB2	Energy	$28.77	1.00	$28.77
		AGL (SA)	TORRB2	Lower reg	$0.25	1.00	$0.25
12:25	$9446.28	Flinders Power	NPS1	Energy	$11.22	1.00	$11.22
		Flinders Power	NPS1	Lower reg	$0.00	1.00	$0.00
		Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00
		Delta Electricity	MP1	Lower reg	$1.40	-1.00	-$1.40
		LYMMCO	LYA3	Energy	$9999.30	-0.95	-$9496.34
		LYMMCO	LYA3	Raise reg	$0.90	0.95	$0.85
		Stanwell	STAN-3	Raise reg	$0.94	-0.95	-$0.89
		AGL (SA)	TORRA1	Energy	$0.00	0.00	$0.00
		AGL (SA)	TORRA2	Energy	$0.00	0.00	$0.00
12:30	$9451.12	Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00
		Delta Electricity	MP2	Lower 5 min	$0.40	-1.00	-$0.40
		LYMMCO	LYA2	Energy	$9998.90	-0.95	-$9495.96
		AGL (SA)	TORRA1	Energy	$0.00	0.50	$0.00
		AGL (SA)	TORRA2	Energy	$0.00	0.50	$0.00
		AGL (SA)	TORRB1	Lower 5 min	$5.00	1.00	$5.00
12:35	$9456.88	Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00
		Delta Electricity	MP2	Lower 5 min	$0.40	-1.00	-$0.40
		Ecogen Energy	NPS	Energy	$9997.70	-0.95	-$9501.81
		AGL (SA)	TORRA1	Energy	$0.00	0.25	$0.00
		AGL (SA)	TORRA2	Energy	$0.00	0.25	$0.00
		AGL (SA)	TORRB1	Energy	$0.00	0.50	$0.00
		AGL (SA)	TORRB1	Lower 5 min	$5.00	1.00	$5.00
12:40	$9455.32	Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00
		Ecogen Energy	NPS	Energy	$9997.70	-0.95	-$9499.81
		Macquarie Generation	BW03	Lower 5 min	$0.40	-1.00	-$0.40
		AGL (SA)	TORRA1	Energy	$0.00	0.17	$0.00
		AGL (SA)	TORRA2	Energy	$0.00	0.17	$0.00
		AGL (SA)	TORRB1	Energy	$0.00	0.34	$0.00
		AGL (SA)	TORRB1	Lower 5 min	$5.00	1.00	$5.00
		AGL (SA)	TORRB3	Energy	$0.00	0.34	$0.00

South Australia – lower 60 second FCAS – 22 April, 12.45 pm to 4.05 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
12:45	$9454.31	Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00
		Delta Electricity	MP2	Lower 5 min	$0.40	-1.00	-$0.40
		Hazelwood Power	HWPS2	Energy	$9998.19	-0.95	-$9499.28
		AGL (SA)	TORRA1	Energy	$0.00	0.17	$0.00
		AGL (SA)	TORRA2	Energy	$0.00	0.17	$0.00
		AGL (SA)	TORRB1	Energy	$0.00	0.34	$0.00
		AGL (SA)	TORRB1	Lower 5 min	$5.00	1.00	$5.00
		AGL (SA)	TORRB3	Energy	$0.00	0.34	$0.00
12:50	$9999.90	AGL (SA)	TORRB1	Lower 60 sec	$9999.90	-1.00	-$9999.90
12:55	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:00	$9999.90	AGL (SA)	TORRB3	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:05	$9446.45	Flinders Power	NPS1	Energy	$11.22	1.01	$11.30
		Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00
		Hazelwood Power	HWPS2	Energy	$9998.19	-0.95	-$9498.28
		Macquarie Generation	BW01	Lower reg	$0.40	-1.00	-$0.40
		AGL (SA)	TORRB1	Lower reg	$0.80	1.00	$0.80
13:10	$9443.30	Flinders Power	NPS1	Lower 6 sec	$40.00	1.00	$40.00
		Flinders Power	NPS2	Energy	$11.37	1.01	$11.45
		Delta Electricity	MP2	Lower 5 min	$0.40	-1.00	-$0.40
		International Power	LOYYB2	Energy	$9998.89	-0.95	-$9498.95
		AGL (SA)	TORRB1	Lower 5 min	$5.00	1.00	$5.00
13:15	$9999.90	AGL (SA)	TORRB1	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:20	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:25	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:30	$9999.90	AGL (SA)	TORRB1	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:35	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
13:40	$40.00	Flinders Power	NPS1	Lower 60 sec	$40.00	-1.00	-$40.00
13:45	$40.00	Flinders Power	NPS2	Lower 60 sec	$40.00	-1.00	-$40.00
13:50	$40.00	Flinders Power	NPS1	Lower 60 sec	$40.00	-1.00	-$40.00
13:55	$40.00	Flinders Power	NPS2	Lower 60 sec	$40.00	-1.00	-$40.00
14:00	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
14:05	$40.00	Flinders Power	NPS2	Lower 60 sec	$40.00	-1.00	-$40.00
14:10	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
14:15	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
14:20	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
14:25	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
14:30	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
14:35	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
14:40	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
14:45	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
14:50	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
14:55	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:00	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:05	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:10	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:15	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:20	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:25	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:30	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:35	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:40	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:45	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:50	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
15:55	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
16:00	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90
16:05	$9999.90	AGL (SA)	TORRB2	Lower 60 sec	$9999.90	-1.00	-$9999.90

South Australia – lower 5 minute FCAS – 22 April, 2.00 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
14:00	$9999.90	AGL (SA)	TORRB1	Lower 5 min	$9999.90	-1.00	-$9999.90

South Australia – lower regulation FCAS – 22 April, 2.00 pm

Time	Dispatch price	Participant	Unit	Service	Offer price	Marginal change	Contribution
14:00	$9999.90	AGL (SA)	TORRB1	Lower 5 min	$9999.90	-1.00	-$9999.90

Appendix B – Closing bids

Figures B1 – B8 highlight the 5-minute lower 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 B station and the dispatch price for the related lower services.

Figure B1: Torrens Island B lower 60 second service closing bid prices, dispatch and dispatch price for 21 April

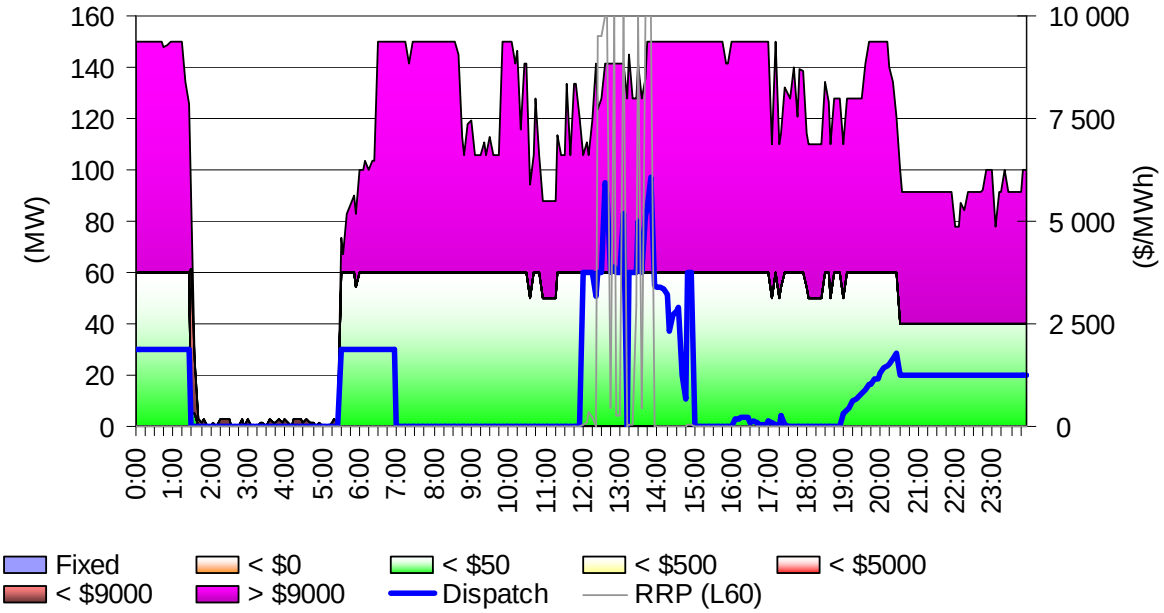


Figure B2: Torrens Island B lower 6 second service closing bid prices, dispatch and dispatch price for 21 April

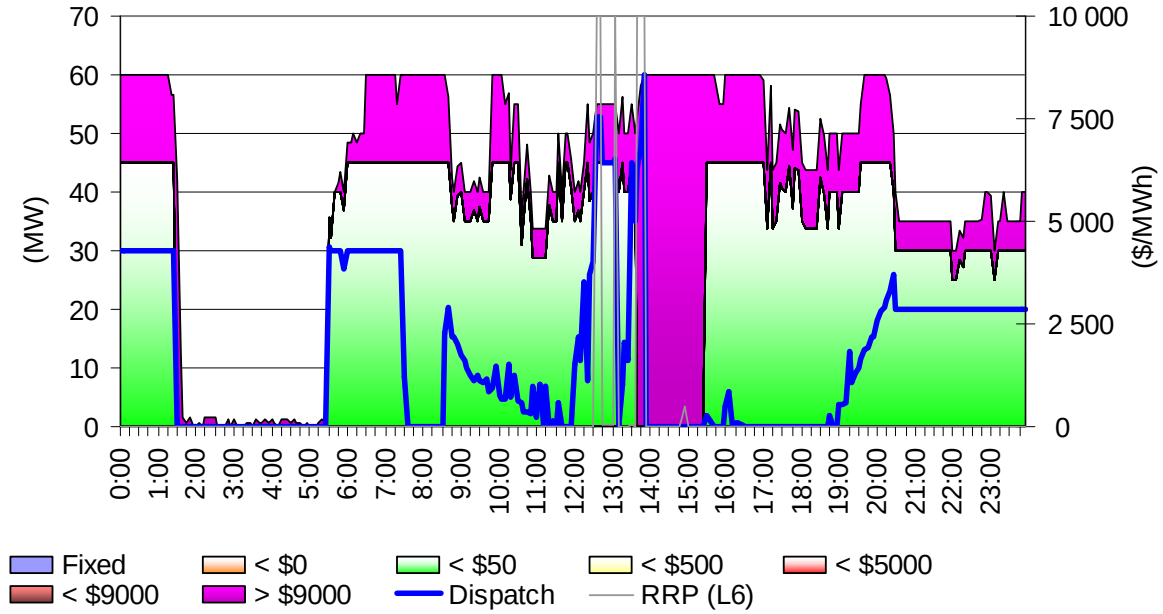


Figure B3: Torrens Island B lower 5 minute service closing bid prices, dispatch and dispatch price for 21 April

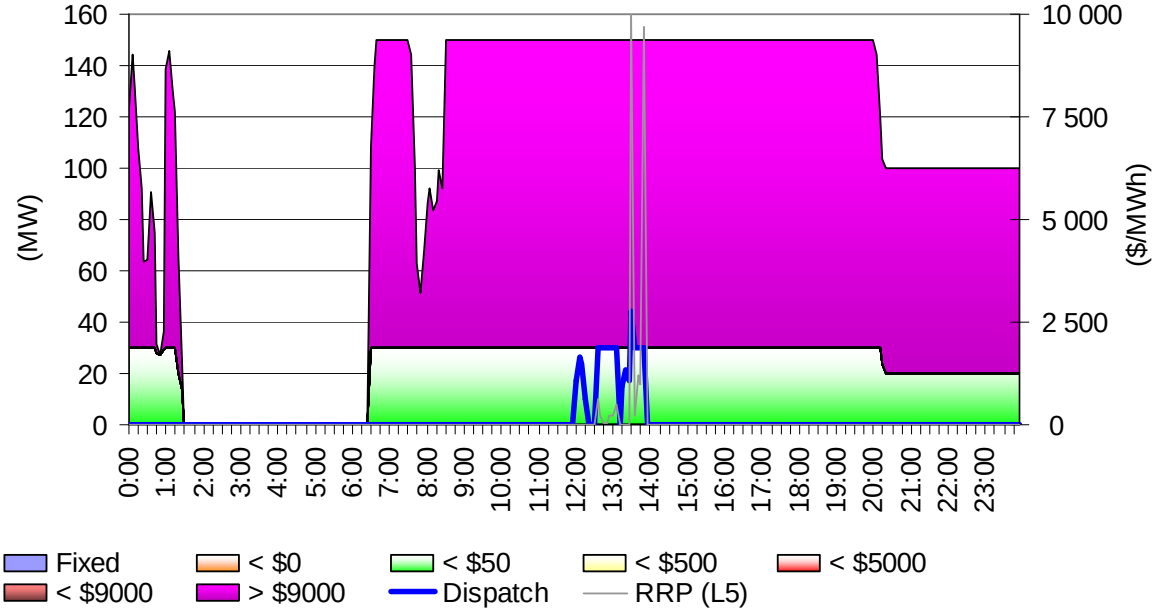


Figure B4: Torrens Island B lower regulation service closing bid prices, dispatch and dispatch price for 21 April

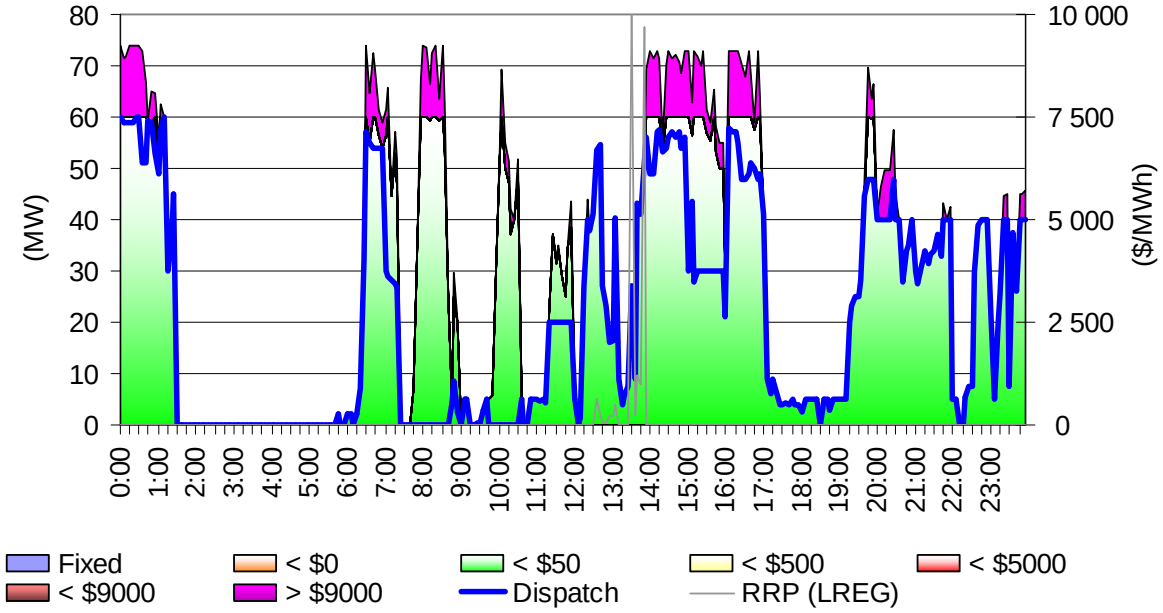


Figure B5: Torrens Island B lower 60 second service closing bid prices, dispatch and dispatch price for 22 April

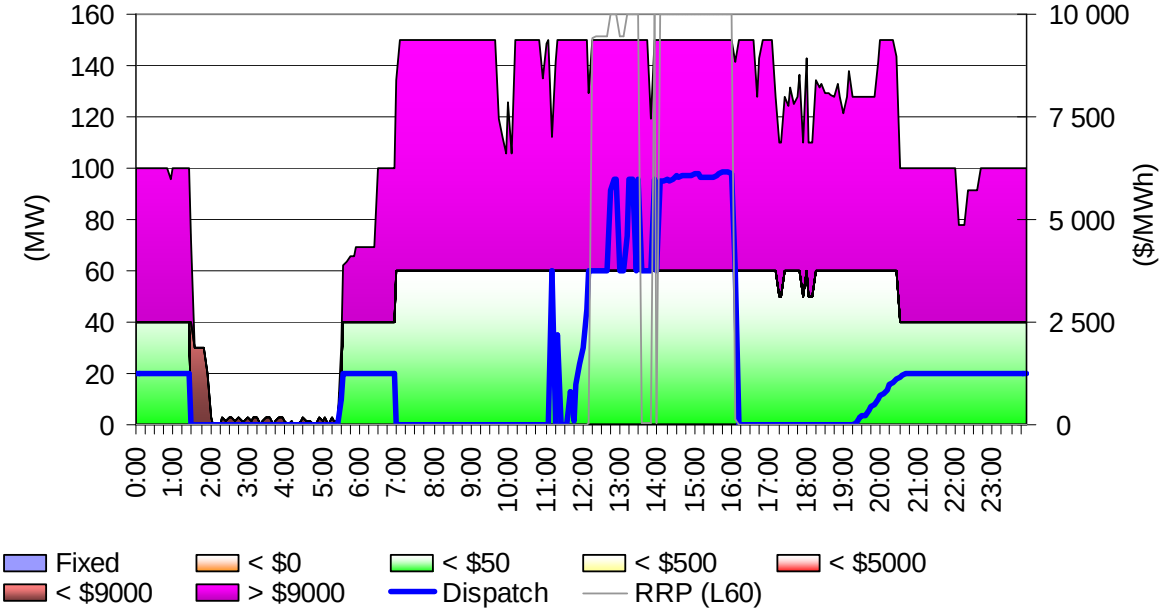


Figure B6: Torrens Island B lower 6 second service closing bid prices, dispatch and dispatch price for 22 April

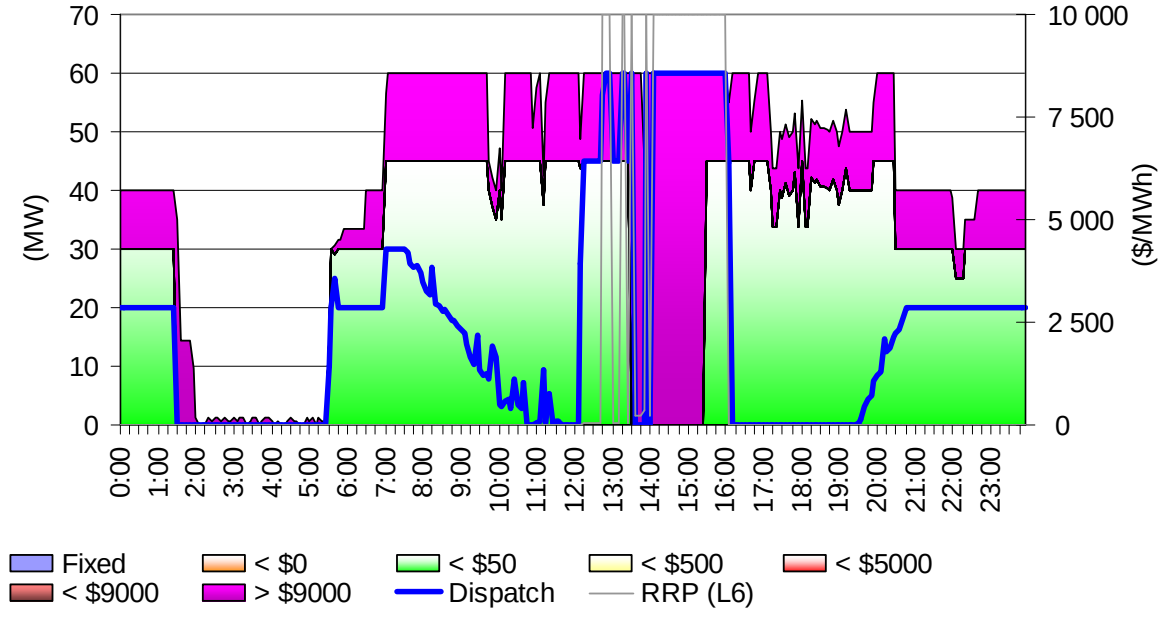


Figure B7: Torrens Island B lower 5 minute service closing bid prices, dispatch and dispatch price for 22 April

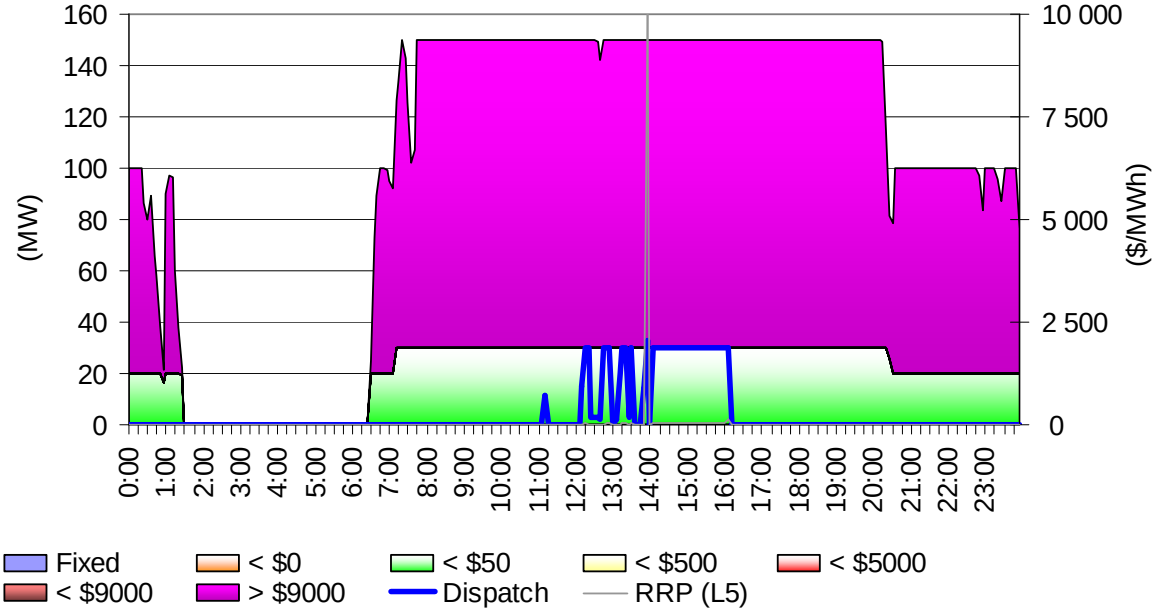
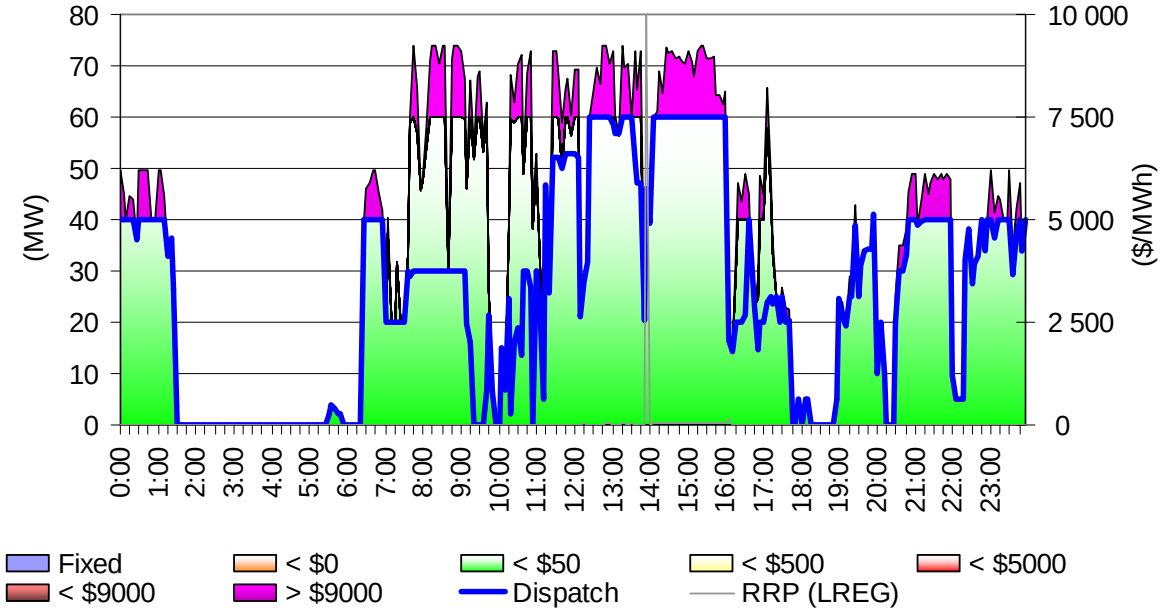


Figure B8: Torrens Island B lower regulation service closing bid prices, dispatch and dispatch price for 22 April



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

On 21 and 22 April 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 addition the large smelter load would be temporarily connected to the SA region but 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. Note that the smelter load is much greater than the allowable flows across the Heywood interconnection when there is a circuit out of service. In the event of the loss of the remaining Moorabool to Sydenham line, the smelter load would be automatically disconnected 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 less than 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 7 am to 4.05 pm on 21 April, and from 7 am to 5.20 pm on 22 April. The F-V-MLSY 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. The Heywood interconnector is co-optimised.
    - This group of constraints led to the very high local FCAS prices (at times at the cap) in South Australia.
- 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 on NSW, Qld and Vic. BassLink is **unable** to transfer FCAS (note that BassLink was out of service on these days). 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. Prices at all times, however, were less than $5/MW.
- 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.