SCHEDULING ERROR REPORT

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AEMO

AUSTRALIAN ENERGY MARKET OPERATOR
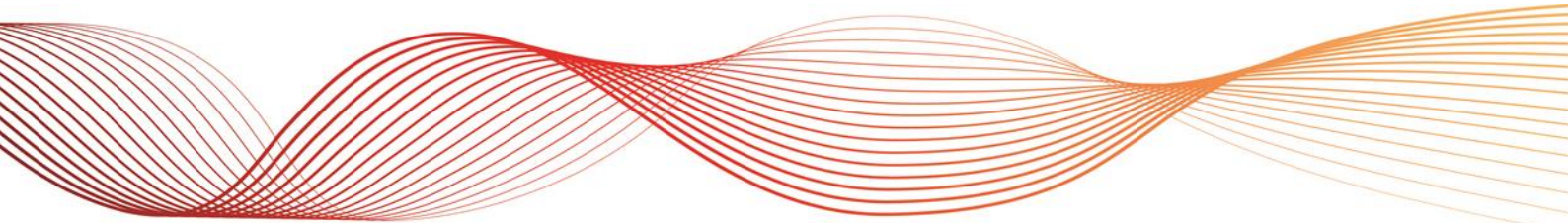
IMPORTANT NOTICE

Purpose

AEMO has prepared this report using information available as at January 2018, unless otherwise specified.

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1. SUMMARY

On 12 November 2017, AEMO identified in accordance with clause 3.9.2B of the National Electricity Rules (NER), the dispatch interval (DI) ending 0535 hrs as subject to review under its automated procedures for identifying manifestly incorrect inputs (MII). The subsequent three DIs ending 0540 hrs, 0545 hrs and 0550 hrs were also automatically marked for review, according to standard procedure.

Initial investigation into the event found no evidence of a MII, resulting in the 5-minute dispatch prices being accepted for DI ending 0535 hrs as well as the subsequent three DIs ending 0540 hrs, 0545 hrs and 0550 hrs.

Following its investigation of the event, AEMO now considers that:

- Its determination that DIs ending 0535 hrs to 0550 hrs were not affected by MII was incorrect.
- A scheduling error occurred for DIs ending 0535 hrs to 0600 hrs due to the invocation of an incorrect constraint set.

A total of 158.71 MWh of generation was constrained-off across all regions in the NEM due to the invocation of an incorrect constraint set.

2. EVENT DETAILS

All times referenced in this report are market time (AEST).

The Hazelwood – South Morang No.2 500 kV transmission line was de-energised for voltage control at 0105 hrs on 12 November 2017 by invoking the constraint set V-HWSM. On the same day at 0507 hrs, Alcoa Portland (APD) Potline 1 and its associated Portland No.1 220 kV bus and transformers tripped. At 0524 hrs, APD Potline 2 and its associated transformer also tripped. The trip of both Potlines caused a loss of approximately 380 MW of load in Victoria and high voltage on the Hazelwood – Rowville 500 kV transmission line. As a result, the Hazelwood – Rowville 500 kV transmission line was taken out of service at 0530 hrs to manage high voltage by invoking the constraint set V-X_HWSM_ROSM.

For DI ending 0535 hrs, the energy price in South Australia and Victoria decreased from $54.56/MWh and $57.56/MWh, respectively to the Market Floor Price (MFP) of -$1,000/MWh. The energy price in New South Wales increased to $240.65/MWh from $60.00/MWh. The V-SA (Heywood) interconnector flow, which was flowing towards Victoria with a target of 234 MW, reversed towards South Australia with a target flow of 258 MW. The V-S-MNSP1 (Murraylink) interconnector flow, which was flowing towards Victoria, increased to 118 MW from 36 MW. The VIC1-NSW1 interconnector flow, which was flowing towards New South Wales with a target of 198 MW, reversed towards Victoria with a target flow of 240 MW. The binding Heywood, Murraylink and VIC1-NSW1 export constraint equation was V::N_X_HWSM_ROSM_V2 (refer to *Appendix A*) which is contained within the constraint set V-X_HWSM_ROSM. The change in energy price in Victoria and South Australia, and target Heywood flow for DI ending 0535 hrs was automatically flagged as subject to review as a potential MII.

The subsequent three DIs ending 0540 hrs, 0545 hrs and 0550 hrs were automatically marked for review. At 0600 hrs, the constraint set V-X_HWSM_ROSM was revoked and subsequently, the constraint set V-X_HWSM_HWRO3 was invoked.

Table 1 displays the Energy Regional Original Prices (ROP) for Victoria, South Australia and New South Wales regions, and target Heywood, Murraylink and VIC1-NSW1 interconnector flows for the previous DI (0530 hrs), and all DIs during the invocation of the constraint set V-X_HWSM_ROSM (DIs ending 0535 hrs to 0600 hrs)

The frequency control ancillary services (FCAS) prices were not materially impacted although contingency Raise 6 second and Lower Regulation services were slightly elevated.

Table 1. Regional ROP and interconnector target flows on 12 November 2017

		DI ending (hrs)						
		0530	0535	0540	0545	0550	0555	0600
Energy ROP ($/MWh)	NSW	60	240.65	183.14	29.88	59.97	74.95	69.69
	SA	54.56	-1000	-405.68	-80	40.22	68.92	67.46
	VIC	57.56	-2300.98[1]	-1000	-199.83	16.15	64.1	66.29
Interconnector Target Flow (MW)	V-SA	-234	258	74	-33	-3	-143	-136
	V-S-MNSP1	-36	-118	-158	-143	-146	-67	-45
	VIC1-NSW1	198	-241	-230	-208	-148	-166	-229

3. MARKET IMPACT

The invocation of the constraint set V-X_HWSM_ROSM at DI ending 0535 hrs significantly impacted the energy price in South Australia and Victoria, as shown in Table 1. There was a slight elevation in energy prices in New South Wales including mainland FCAS Raise 6 second and Lower Regulation services. Prices in other regions were not materially affected.

The step change in South Australian and Victorian energy price and Heywood Interconnector flow exceeded the relevant thresholds and as a result, DI ending 0535 hrs was automatically triggered as "subject to review".

Market Notice (MN 59872) was automatically issued to inform the market of the non-firm prices for DI ending 0535 hrs. Whilst investigations were carried out, subsequent Market Notices (MN 59873–59875) were automatically issued within the next 15 minutes notifying the non-firm prices for DIs ending 0540 hrs, 0545 hrs and 0550 hrs.

At 0546 hrs, AEMO's initial investigation identified that the dispatch outcome for DI ending 0535 hrs and the subsequent DIs ending 0540 hrs, 0545 hrs and 0550 hrs were not affected by any MII. Hence, the prices were accepted and Market Notices (MN 59876–59879) were automatically issued to inform the market of the unchanged (firm) prices.

At 0600 hrs, further investigations revealed that DIs ending between 0535 hrs and 0550 hrs were affected by MII due to the invocation of the incorrect constraint set V-X_HWSM_ROSM. As a result, the incorrect constraint set was revoked and the correct constraint set V-X_HWSM_HWRO3 was invoked for DI ending 0605 hrs. This correct constraint set was revoked for DI ending 0635 hrs when the Hazelwood – Rowville 500 kV line returned to service at 0630 hrs. No further changes to the reviewed dispatch prices are allowed once the prices are firm.

To assess the market impact of this event, AEMO did a simulated re-run of the NEMDE files for DIs ending between 0535 hrs and 0600 hrs on 12 November 2017. The incorrect constraint set V-X_HWSM_ROSM was replaced with the correct constraint set V-X_HWSM_HWRO3. A total of 158.71 MWh of generation was constrained-off across all regions in the NEM due to the invocation of the incorrect constraint set.

4. SCHEDULING ERROR

Under NER clause 3.8.24(a)(2), a scheduling error occurred for DIs ending between 0535 hrs and 0600 hrs on 12 November 2017 due to the invocation of an incorrect constraint set.

Under NER clause 3.16.2(a), Market Participants affected by a scheduling error may apply to a dispute resolution panel established under NER clause 8.2.6A for a determination on whether they are entitled to compensation.

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[1]This ROP was capped at the Market Floor Price of -$1,000.00/MWh.

5.   CORRECTIVE ACTION

In this event, the peer review process that is part of AEMO's standard operating practice was not effective in preventing an incorrect constraint set being invoked. To reduce the risk of incorrect constraint sets being invoked in the future, the peer review process and the process of identifying and assessing MIIs and pricing revisions will be reviewed and any improvements incorporated as part of the Skills Maintenance and Simulator training.

6.   CONCLUSION

A scheduling error occurred for DIs ending 0535 hrs to 0600 hrs on 12 November 2017 under NER clause 3.8.24(a)(3) because AEMO invoked an incorrect constraint set.

APPENDIX A. CONSTRAINT FORMULATION FOR V::N_X_HWSM_ROSM_V2

Constraint type: LHS<=RHS
Effective date: 26/05/2017
Author: TLIU
Version No: 1
Weight: 35
Constraint active in: Dispatch and DS PASA, Predispatch and PD PASA, ST PASA
5 Min Predispatch RHS: Predispatch
Active in PASA for: LRC & LOR

Constraint description: Out=Hazelwood-South Morang & Rowville-South Morang 500kV lines, prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line, VIC accelerates, Yallourn W G1 on 500 kV.
Impact: Victorian Generation + Interconnectors
Source: AEMO
Limit type: Transient Stability
Reason: Prevent transient instability for fault and trip of a HWTS-SMTS 500 kV line in VIC
Modifications: New
Additional Notes: AEMO limit advice 05/05/17. CCR3408

LHS=

-0.6256 x Murray hydro (14 aggregated units) (ENERGY)
-0.5743 x Ararat wind farm (ENERGY)
-0.8664 x Laverton North GT Unit 1 (ENERGY)
-0.8664 x Laverton North GT Unit 2 (ENERGY)
-0.9146 x Dartmouth hydro (ENERGY)
-0.5743 x Mt Mercer wind farm (ENERGY)
-0.9146 x McKay Creek (units 1-6) plus Bogong hydro (units 1-2) aggregate (ENERGY)
-0.5743 x Bald Hill Wind Farm (ENERGY)
-0.8664 x Newport GT (ENERGY)
-0.5743 x Oaklands Hill wind farm (ENERGY)
-0.5743 x Macarthur wind farm (ENERGY)
-0.8664 x Somerton GT (4 aggregated units) (ENERGY)
-0.9146 x West Kiewa hydro (units 1 & 2 aggregated) (ENERGY)
-0.9146 x West Kiewa hydro (units 3 & 4 aggregated) (ENERGY)
-0.3122 x Yallourn W unit 2 (ENERGY)
-0.3122 x Yallourn W unit 3 (ENERGY)
-0.3122 x Yallourn W unit 4 (ENERGY)
-0.374 x MW flow north on the Basslink DC Interconnector
 + MW flow west on the Murraylink DC Interconnector
0.4426 x MW flow west on the Vic-SA AC interconnector
0.8453 x MW flow north on the Vic to NSW AC Interconnector

RHS

Default RHS value= 350

Dispatch RHS=
0.8453 x **(** -0.000996 x **(** [MW flow west on the Vic-SA AC interconnector]**)** ^{2}
+ 6.56 x [Inertia of Generators connected to 500 kV network : Loy Yang A&B, Hazelwood, Jeeralang and Morwell PS]
+ 16.45 x [Inertia of Eildon PS Unit 1 & 2]
+ 12.06 x [Total Inertia of in-service Mortlake PS generators]
+ 11.52 x [Inertia of Generators connected to 220 kV network : Yallourn W PS]
+ 1.082 x [Clover PS (SCADA)]
- 0.3907 x [*Generic Equation:* X-V_STATGRDN_STAB_DS]
+ 0.0938 x **((** -1 x [Summated MW loading into APD measured at APD 500kV bus]
+ Portland wind farm MW]**))**
+ 0.6794 x [Mortons Lane Wind Farm MW]
+ 0.6794 x [Portland wind farm MW]
+ 0.6794 x [Waubra wind farm MW]
+ 0.6794 x [SCADA MW for Yambuk wind farm]

+ 0.6794 x [MW summation of the Challicum wind farm output]
- 0.6293 x [Sum of VIC generation plus imports including non-scheduled wind generation]
+ 1328 {Intercept}
- 97 {Confidence Interval}
- 50 {Operating Margin}
- 350 {PO44_offset}**)**
+ 10000 x [Yallourn unit 1 status (=1 in 220kV mode, =0 otherwise)]

Predispatch RHS=
0.8453 x **(** -0.000996 x **(** [MW flow west on the Vic-SA AC interconnector]**)** ^{2}
+ 6.56 x [*Generic Equation:* X-VIC_500_INERT_PD]
+ 16.45 x [*Generic Equation:* X-EILDON_INERT_PD]
+ 12.06 x [*Generic Equation:* X-MOPS_INERT_PD]
+ 11.52 x [*Generic Equation:* X-VIC_220_INERT_PD]
+ 1.082 x [Clover PS (SCADA)]
- 0.3907 x [*Generic Equation:* X-V_STATGRDN_STAB_PD]
+ 0.0938 x [*Generic Equation:* X-V_APPD]
- 0.6794 x [Mortons Lane Wind Farm]
- 0.6794 x [Portland Wind Farm - MW forecast is negative]
- 0.6794 x [Waubra Wind Farm - MW forecast is negative]
- 0.6794 x [Yambuk Wind Farm - MW forecast is negative]
- 0.6794 x [Challicum Hills Wind Farm - MW forecast is negative]
- 0.6293 x [*Generic Equation:* X-VIC_OPER_DEM_PD]
+ 1328 {Intercept}
- 97 {Confidence Interval}
- 50 {Operating Margin}
- 350 {PO44_offset}**)**
+ 10000 x [Yallourn unit 1 status (=1 in 220kV mode, =0 otherwise)]

DS, PD and ST PASA RHS=
0.8453 x **(** 6.56 x [*Generic Equation:* X-VIC_500_INERT_ST]
+ 16.45 x [*Generic Equation:* X-EILDON_INERT_PD]
+ 12.06 x [*Generic Equation:* X-MOPS_INERT_PD]
+ 11.52 x [*Generic Equation:* X-VIC_220_INERT_ST]
+ 0 {CLOVER_GEN}
- 0.3907 x [*Generic Equation:* X-V_NSST]
+ 0.0938 x [*Generic Equation:* X-V_APST]
- 0.6794 x [Mortons Lane Wind Farm]
- 0.6794 x [Portland Wind Farm - MW forecast is negative]
- 0.6794 x [Waubra Wind Farm - MW forecast is negative]
- 0.6794 x [Yambuk Wind Farm - MW forecast is negative]
- 0.6794 x [Challicum Hills Wind Farm - MW forecast is negative]
- 0.6293 x [*Generic Equation:* X-VIC_OPER_DEM_PD]
+ 1328 {Intercept}
- 97 {Confidence Interval}
- 50 {Operating Margin}
- 350 {PO44_offset}**)**

Equation: X-EILDON_INERT_PD

if
 Eildon hydro unit 1 **<= 0**
then
 0
else
 3
+ **if**
 Eildon hydro unit 2 **<= 0**
then
 0
else
 3

Equation: X-MOPS_INERT_PD

if
 Mortlake GT unit 1 **<= 0**
then

 0
else
 21.079
+ **if**
 Mortlake GT unit 2 **<= 0**
then
 0
else
 21.079

Equation: X-V_APPD

((-1 x [Summated MW loading into APD measured at APD 500kV bus]
+ Portland wind farm MW
- 325 {Avg_APD_MW_LOAD}**))**
x **((** 0.05 x **(((** 1st Period of Predispatch
+ 2nd Period of Predispatch
+ 3rd Period of Predispatch
+ 4th Period of Predispatch
+ 5th Period of Predispatch
+ 6th Period of Predispatch
+ 7th Period of Predispatch
+ 8th Period of Predispatch
+ 9th Period of Predispatch
+ 10th Period of Predispatch
+ 11th Period of Predispatch
+ 12th Period of Predispatch
+ 13th Period of Predispatch
+ 14th Period of Predispatch
+ 15th Period of Predispatch
+ 16th Period of Predispatch
+ 17th Period of Predispatch
+ 18th Period of Predispatch
+ 19th Period of Predispatch
+ 20th Period of Predispatch**))**
x **(** 1 {Periods_Scal_Factor}**))))**
+ **(** 325 {Avg_APD_MW_LOAD}**)**

Equation: X-V_APST

325 {Avg_APD_MW_LOAD}

Equation: X-V_NSST

0.38 x [Zone: Stategrid]

Equation: X-V_STATGRDN_STAB_DS

MW Load at Bendigo
- Fosterville 11kV substation loads
+ MW Load at Glenrowan
+ MW Load at Kerang
+ MW Load at Mount Beauty. Includes output of Clover Power Station
+ MW Load at Red Cliffs
- MW Load at Shepparton
- MW Load at Wemen
+ Total 66 kV & 22 kV MW load at Wodonga. Includes output of Hume Power Station on VIC side

Equation: X-V_STATGRDN_STAB_PD

((0.7 x **((** -1 x [Zone: Stategrid]**)**
x **(** 1 {Avg_SGRID_N_Ratio}**))**
+ MW Load at Bendigo
- Fosterville 11kV substation loads
+ MW Load at Glenrowan
+ MW Load at Kerang
+ MW Load at Mount Beauty. Includes output of Clover Power Station
+ MW Load at Red Cliffs

- MW Load at Shepparton
- MW Load at Wemen
+ Total 66 kV & 22 kV MW load at Wodonga. Includes output of Hume Power Station on VIC side**))**
x **((** 0.05 x **(((** 1st Period of Predispatch
+ 2nd Period of Predispatch
+ 3rd Period of Predispatch
+ 4th Period of Predispatch
+ 5th Period of Predispatch
+ 6th Period of Predispatch
+ 7th Period of Predispatch
+ 8th Period of Predispatch
+ 9th Period of Predispatch
+ 10th Period of Predispatch
+ 11th Period of Predispatch
+ 12th Period of Predispatch
+ 13th Period of Predispatch
+ 14th Period of Predispatch
+ 15th Period of Predispatch
+ 16th Period of Predispatch
+ 17th Period of Predispatch
+ 18th Period of Predispatch
+ 19th Period of Predispatch
+ 20th Period of Predispatch**))**
x **(** 1 {Periods_Scal_Factor}**)))**
+ **(** 0.7 x **((** Zone: Stategrid**)**
x **(** 1 {Avg_SGRID_N_Ratio}**)))**

Equation: X-VIC_220_INERT_PD

if
 Yallourn W unit 2 **<= 0**
then
 0
else
 12.76
+ **if**
 Yallourn W unit 3 **<= 0**
then
 0
else
 12.172
+ **if**
 Yallourn W unit 4 **<= 0**
then
 0
else
 13.23
+ **if**
 -1 {YWG1_Offset}
 + **if**
  Yallourn W unit 1 **<= 0**
 then
  0
 else
  1
 + Yallourn unit 1 status (=1 in 220kV mode, =0 otherwise) **<= 0**
then
 0
else
 12.76

Equation: X-VIC_220_INERT_ST

if
 Yallourn W unit 2 **<= 0**
then
 0
else

 12.76
+ **if**
 Yallourn W unit 3 **<= 0**
then
 0
else
 12.172
+ **if**
 Yallourn W unit 4 **<= 0**
then
 0
else
 13.23
+ **if**
 -1 {YWG1_Offset}
 + **if**
  Yallourn W unit 1 **<= 0**
 then
  0
 else
  1
 + 1 {YWPS1_220_ON} **<= 0**
then
 0
else
 12.76

Equation: X-VIC_500_INERT_PD

if
 Loy Yang A unit 1 **<= 0**
then
 0
else
 19.68
+ **if**
 Loy Yang A unit 2 **<= 0**
then
 0
else
 27.52
+ **if**
 Loy Yang A unit 3 **<= 0**
then
 0
else
 19.68
+ **if**
 Loy Yang A unit 4 **<= 0**
then
 0
else
 22.524
+ **if**
 Loy Yang B unit 1 **<= 0**
then
 0
else
 16.576
+ **if**
 Loy Yang B unit 2 **<= 0**
then
 0
else
 16.576
+ **if**
 Jeeralang A GT unit 1
 - 2 {Min_Level} **<= 0**

---

then
  0
else
  5.44
+ **if**
  Jeeralang A GT unit 2
  - 2 {Min_Level} **<= 0**
then
  0
else
  5.44
+ **if**
  Jeeralang A GT unit 3
  - 2 {Min_Level} **<= 0**
then
  0
else
  5.44
+ **if**
  Jeeralang A GT unit 4
  - 2 {Min_Level} **<= 0**
then
  0
else
  5.44
+ **if**
  Jeeralang B GT unit 1
  - 2 {Min_Level} **<= 0**
then
  0
else
  8.9
+ **if**
  Jeeralang B GT unit 2
  - 2 {Min_Level} **<= 0**
then
  0
else
  8.9
+ **if**
  Jeeralang B GT unit 3
  - 2 {Min_Level} **<= 0**
then
  0
else
  8.9
+ **if**
  Bairnsdale GT unit 1 **<= 0**
then
  0
else
  0.96
+ **if**
  Bairnsdale GT unit 2 **<= 0**
then
  0
else
  0.96
+ **if**
  Valley Power GT Unit 1 **<= 0**
then
  0
else
  1.89
+ **if**
  Valley Power GT Unit 2 **<= 0**
then
  0

else
 1.89
+ **if**
 Valley Power GT Unit 3 **<= 0**
then
 0
else
 1.89
+ **if**
 Valley Power GT Unit 4 **<= 0**
then
 0
else
 2.5
+ **if**
 Valley Power GT Unit 5 **<= 0**
then
 0
else
 2.5
+ **if**
 Valley Power GT Unit 6 **<= 0**
then
 0
else
 2.5
+ **if**
 -1 {YWG1_Offset}
 + **if**
  Yallourn W unit 1 **<= 0**
  then
   0
  else
   1
 + Yallourn unit 1 status (=1 in 500kV mode, =0 otherwise) **<= 0**
then
 0
else
 12.76

Equation: X-VIC_500_INERT_ST

if
 Loy Yang A unit 1 **<= 0**
then
 0
else
 19.68
+ **if**
 Loy Yang A unit 2 **<= 0**
then
 0
else
 27.52
+ **if**
 Loy Yang A unit 3 **<= 0**
then
 0
else
 19.68
+ **if**
 Loy Yang A unit 4 **<= 0**
then
 0
else
 22.524
+ **if**
 Loy Yang B unit 1 **<= 0**

then
 0
else
 16.576
+ **if**
 Loy Yang B unit 2 **<= 0**
then
 0
else
 16.576
+ **if**
 Jeeralang A GT unit 1
 - 2 {Min_Level} **<= 0**
then
 0
else
 5.44
+ **if**
 Jeeralang A GT unit 2
 - 2 {Min_Level} **<= 0**
then
 0
else
 5.44
+ **if**
 Jeeralang A GT unit 3
 - 2 {Min_Level} **<= 0**
then
 0
else
 5.44
+ **if**
 Jeeralang A GT unit 4
 - 2 {Min_Level} **<= 0**
then
 0
else
 5.44
+ **if**
 Jeeralang B GT unit 1
 - 2 {Min_Level} **<= 0**
then
 0
else
 8.9
+ **if**
 Jeeralang B GT unit 2
 - 2 {Min_Level} **<= 0**
then
 0
else
 8.9
+ **if**
 Jeeralang B GT unit 3
 - 2 {Min_Level} **<= 0**
then
 0
else
 8.9
+ **if**
 Bairnsdale GT unit 1 **<= 0**
then
 0
else
 0.96
+ **if**
 Bairnsdale GT unit 2 **<= 0**
then

```
  0
else
  0.96
+ if
  Valley Power GT Unit 1 <= 0
then
  0
else
  1.89
+ if
  Valley Power GT Unit 2 <= 0
then
  0
else
  1.89
+ if
  Valley Power GT Unit 3 <= 0
then
  0
else
  1.89
+ if
  Valley Power GT Unit 4 <= 0
then
  0
else
  2.5
+ if
  Valley Power GT Unit 5 <= 0
then
  0
else
  2.5
+ if
  Valley Power GT Unit 6 <= 0
then
  0
else
  2.5
```

Equation: X-VIC_OPER_DEM_PD

Victoria region demand
- Waubra Wind Farm - MW forecast is negative
- Portland Wind Farm - MW forecast is negative
- Challicum Hills Wind Farm - MW forecast is negative
- Yambuk Wind Farm - MW forecast is negative
- Mortons Lane Wind Farm

ABBREVIATIONS

Abbreviation	Expanded name
AEMO	Australian Energy Market Operator
DI	Dispatch Interval
FCAS	Frequency Control Ancillary Service
LHS	Left-Hand-Side
MII	Manifestly Incorrect Input
MN	Market Notice
MFP	Market Floor Price
MPC	Market Price Cap
MW	Megawatt
MWH	Megawatt Hour
NEM	National Electricity Market
NEMDE	National Electricity Market Dispatch Engine
NER	National Electricity Rules
RHS	Right-Hand-Side
RRP	Regional Reference Price