POWER SYSTEM INSECURE IN VICTORIA ON 23 MAY 2016

AN AEMO POWER SYSTEM OPERATING INCIDENT REPORT FOR THE NATIONAL ELECTRICITY MARKET

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AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

INCIDENT CLASSIFICATIONS

Classification	Detail
Time and date of incident	0023 hrs to 0107 hrs on Monday, 23 May 2016
Region of incident	Victoria
Affected regions	Victoria
Event type	Power system not in a secure operating state
Generation Impact	No generator was disconnected or limited as a result of this incident
Customer Load Impact	No customer load was disconnected as a result of this incident
Associated reports	Electricity Pricing Event Report – Monday, 23 May 2016

ABBREVIATIONS

Abbreviation	Term
AEMO	Australian Energy Market Operator
APD	Alcoa Portland
EMS	Energy Management System
F2 Transformer	South Morang F2 500/330 kV transformer
CB	Circuit breaker
DI	Dispatch interval
HYTS	Heywood Terminal Station
kV	Kilovolt
MOPS	Mortlake Power Station
MVA	Mega Volt Amp
MW	Megawatt
NER	National Electricity Rules
CA	Contingency analysis
SMTS	South Morang Terminal Station
TOA	Temporary operating advice
TRTS	Tarrone Terminal Station

IMPORTANT NOTICE

Purpose

AEMO has prepared this report in accordance with clause 4.8.15(c) of the National Electricity Rules, using information available as at the date of publication, unless otherwise specified.

Disclaimer

AEMO has made every effort to ensure the quality of the information in this report but cannot guarantee its accuracy or completeness. Any views expressed in this report are those of AEMO unless otherwise stated, and may be based on information given to AEMO by other persons.

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1. OVERVIEW

This is a report of a reviewable operating incident[1] that occurred on Monday, 23 May 2016 where the power system in Victoria was not in a secure operating state for 35 minutes.

There was no loss of generation or customer supply as a result of this incident.

The power system was in a satisfactory operating state, but not secure operating state, during this incident because the South Morang (SMTS) F2 500/330 kV transformer would have been overloaded if either of the following credible contingency events occurred:

- Trip of the Tarrone – Heywood – Alcoa Portland No. 1 (TRTS-HYTS-APD1) 500 kV transmission lines and the Alcoa Portland (APD) Potlines.[2]
- Trip of the Mortlake – Heywood – Alcoa Portland No. 2 (MOPS-HYTS-APD2) 500 kV transmission lines and the Alcoa Portland (APD) Potlines.[3]

As a reviewable operating incident, AEMO is required to assess power system security over the course of the incident, and assess the adequacy of the provision and response of facilities and services and the appropriateness of actions taken to restore or maintain power system security.[4]

AEMO has concluded that:

1. AEMO did not have procedures in place to manage changes to the F2 transformer rating.
    - AEMO has amended its procedures in relation to changes to the F2 transformer rating.
2. The power system was not in a secure operating state for 35 minutes.
3. The delay in restoring the power system to a secure operating state was caused by AEMO failing to respond to the potential overloading of the F2 transformer in a timely manner.
4. AEMO incorrectly used the Constraint Automation tool to develop a constraint set to restore the power system to a secure operating state.
    - This functionality has since been removed from the Constraint Automation tool.

This report is prepared in accordance with clause 4.8.15(c) of the National Electricity Rules (NER). It is based on information from AEMO's Energy and Market Management Systems.

Australian Eastern Standard Time is used in this report.

2. THE INCIDENT

On Sunday, 22 May 2016 at 2354 hrs an unplanned outage of the APD No.1 Potline occurred, causing the SMTS F2 500/330 kV transformer (F2 transformer) loading to increase to 1116 MVA at 2358 hrs.

At 0002 hrs on 23 May, AusNet Transmission Group Pty Ltd (AusNet Services[5]) advised AEMO that as the loading on the F2 transformer had exceeded the 1000 MVA normal rating for greater than 30 minutes in the previous 24 hours, its loading should not exceed 1000 MVA for the next 24 hrs. See Appendix B for an explanation of the F2 transformer ratings. This advice was consistent with previous advice provided by AusNet Services to AEMO. Based on this advice, AEMO amended the transformer's short-term ratings to 1000 MVA in the dispatch interval (DI) ending 0010 hrs.

The APD No.1 Potline returned to service at 0010 hrs on 23 May 2016

[1] See NER clause 4.8.15 and the AEMC Reliability Panel Guidelines for Identifying Reviewable Operating Incidents.
[2] The simultaneous trip of the APD Potlines and the TRTS-HYTS-APD1 500 kV line was reclassified as credible on 4 March 2014. See Market Notice 45245.
[3] The simultaneous trip of the APD Potlines and the MOPS-HYTS-APD2 500 kV line was reclassified as credible on 7 Jan 2014. See Market Notice 44444.
[4] See NER clause 4.8.15(b).
[5] As owner and operator of the SMTS F2 transformer.

At 0023 hrs on 23 May 2016, AEMO's contingency analysis (CA) tool indicated violations, where the F2 transformer would have been overloaded if either of the following credible contingencies occurred:

- Trip of the TRTS-HYTS-ADP1 500 kV transmission line and the APD Potlines.
- Trip of the MOPS-HYTS-APD2 500 kV transmission line and the APD Potlines.

These violations indicated that the F2 transformer's post-contingent loading would be greater than its amended maximum allowable loading of 1000 MVA. Similar violations occurred for both contingencies. The magnitude of the CA violations for the trip of the TRTS-HYTS-APD1 500 kV transmission line and APD Potlines are given in table 1.

Table 1 Potential post-contingent loading on the SMTS F2 transformer for the trip of the TRTS- HYTS-APD1 500 kV transmission line and APD Potlines

Dispatch interval ending	Post Contingent Loading (MVA)	Post Contingent Loading (% of transformer rating – 1000 MVA)
23/05/2016 00:20	940	94%
23/05/2016 00:25	1021	102%
23/05/2016 00:30	1049	105%
23/05/2016 00:35	1057	106%
23/05/2016 00:40	1107	111%
23/05/2016 00:45	1115	112%
23/05/2016 00:50	1122	112%
23/05/2016 00:55	1110	111%
23/05/2016 01:00	1130	113%
23/05/2016 01:10	1097	110%
23/05/2016 01:15	975	98%

AEMO invoked constraint set CA_SPS_46545836 at 0110 hrs and the power system returned to a secure operating state at 0111 hrs.

3. POWER SYSTEM SECURITY

AEMO is responsible for power system security in the NEM[6]. This means AEMO is required to operate the power system in a secure operating state and return the power system to a secure operating state following a credible contingency event.[7] This section assesses how AEMO managed power system security over the course of the incident.[8]

Although the alarm in relation to the potential overloading of the F2 transformer sounded in AEMO's control room at 0023 hrs on 23 May 2016, AEMO did not take action to address this issue within 30 minutes[9], as staff were involved with the management of an unrelated issue. At around 0100 hrs, AEMO considered what options were available to restore power system security.

[6] NER Clause 4.3.1.

[7] AEMO is responsible for power system security in the NEM and is required to operate the power system in a secure operating state (NER Clause 4.2.4 (a)). AEMO must thereby ensure that the power system is maintained in, or returned to, a secure operating state following a contingency event.

[8] AEMO is required to take reasonable actions to return the power system to a secure state within thirty minutes following a contingency event - NER Clause 4.2.6 (b).

[9] AEMO is required to take reasonable actions to return the power system to a secure state within thirty minutes following a contingency event - NER Clause 4.2.6 (b).

3.1 Thermal Ratings

AEMO considered amending the normal rating on the F2 transformer to a value lower than 1000 MVA, as this had been done on previous occasions,[10] but this is not a standard or documented process for managing power system security, hence AEMO decided not to follow this process.

3.2 Constraint Sets

There were no existing constraint sets available to manage loading on the F2 transformer for the trip of either the TRTS-HYTS-APD1 500 kV transmission line and the APD Potlines, or the MOPS-HYTS-APD2 500 kV transmission line and the APD Potlines. Under normal conditions, where the short-term rating of 1200 MVA[11] is available, these contingencies would be unlikely to cause a potential overload on the F2 transformer.

AEMO, therefore, used its Constraint Automation tool to create constraint set CA_SPS_46545836, containing the following constraint equations:

- CA_SPS_46545836_01 – to manage loading on the F2 transformer for the loss of the TRTS-HYTS-APD1 500 kV transmission lines and the APD Potlines.
- CA_SPS_46545836_02 – to manage loading on the F2 transformer for the loss of the MOPS-HYTS-APD2 500 kV transmission lines and the APD Potlines.

This constraint set was invoked at 0110 hrs on 23 May 2016, and the power system returned to a secure operating state at 0111 hrs. This constraint set also resulted in unexpected market outcomes The 5-Minute dispatch price in South Australia ranged between -$326.43/MWh and the Market Floor Price (MFP) of -$1,000/MWh for 23 dispatch intervals (DIs) between DIs ending 0115 hrs and 0500 hrs. The 5-minute dispatch in Victoria price ranged between -$474.24/MWh and -$896.49/MWh for the same DIs.[12]

Because of the unexpected market impact AEMO reviewed the constraint set the following morning. The review determined that the constraint equations were overly conservative, and constraint set CA_SPS_46545836 was revoked at 0930 hrs on 23 May 2016. Refer to Section 3.3 for more details.

3.3 Review of Constraint Formulation

The next morning on 23 May 2016, AEMO reviewed constraint set CA_SPS_ CA_SPS_46545836 and determined that it was overly conservative and causing unnecessary market impacts.

Constraint set CA_SPS_46545836 was developed using the Constraint Automation tool. This tool uses the results of the contingency analysis (CA) tool to develop the required constraint equations.

As AEMO considers that the trip of either the TRTS-HYTS-APD1 or MOPS-HYTS-APD2 500 kV transmission line may also result in the trip of the APD load, the CA results for these contingencies are highly dependent on how the power system responds to the resulting frequency deviation. As the generation mix and frequency control ancillary service (FCAS) enablement can change every 5 minutes the resulting power flows can also change. While this can be modelled to some extent in the CA tool by using FCAS enablement, the results will only be accurate for the DI being analysed. Therefore, any constraint equation developed using the CA results might not produce optimal results for future DIs.

A more appropriate action for maintaining power system security was to amend the F2 transformer's normal rating from 1000 MVA to 850 MVA, as had been done on previous occasions but was not sufficiently documented. This would effectively result in a fixed margin between the transformer's normal rating and pre-contingent loading, which would have dynamically maintained post-contingent loading to just below the amended maximum allowable level of 1000 MVA.

After AEMO revoked constraint set CA_SPS_46545836 it amended the F2 transformer's normal rating to maintain power system security. The amended normal rating meant that the loading on the

[10] This is discussed further in Section 3.3.
[11] The F2 transformer has two short-term ratings: a 30-minute short-term rating of 1100 MVA and a 15-minute short-term rating of 1200 MVA. Both ratings were amended to 1000 MVA during this incident. Refer to Appendix B for more details.
[12] Refer to the Pricing Event Report available at: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Market-notices-and-events/-/media/F21EE91F19B6429FBD520E2E85C74940.ashx

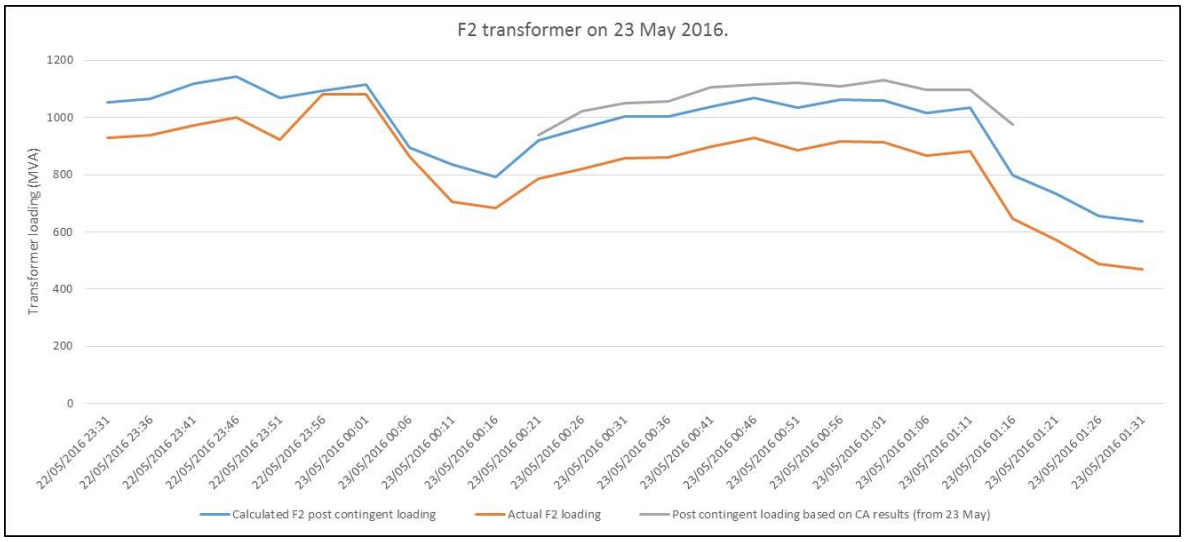
transformer would not exceed 1000 MVA either under system normal conditions or in the event of a credible contingency event.

This arrangement remained in place until, based on advice from AusNet Services, the F2 transformer ratings were returned to normal at 0002 hrs on 24 May 2016.

3.4 Review of Process to Restore Power System Security

Following this event, AEMO has disabled the part of the constraint automation tool that allows AEMO create constraint sets for contingencies that result in load loss. AEMO has also developed a temporary process to determine the accuracy of CA results for contingencies involving the loss of the APD potline loads.[13] Figure 1 shows a comparison of the post-contingent flows on the F2 transformer determined by the CA tool at the time of the incident and the temporary process implemented by AEMO. The figure shows that while the likely post-contingent flows were slightly less than those predicted by the CA tool, the power system was not in a secure operating state from 0036 hrs to 0111 hrs on 23 May 2016, a period of 35 minutes.

Figure 1- F2 Transformer loading



AEMO has also updated its internal procedures to include a process for amending the F2 transformer normal rating in the event that its short-term rating is removed.

4. SCHEDULING ERROR

AEMO has declared a scheduling error in relation to this incident.[14] AEMO will publish a separate report providing more information in relation to the scheduling error.

5. MARKET INFORMATION

AEMO is required by the NER and operating procedures under the NER to inform the market about incidents as they progress. This section assesses how AEMO informed the market[15] over the course of this incident.

For this incident, AEMO was required to inform the market on the following matters:

[13] AEMO is reviewing the contingency analysis tool to see if a more permanent solution can be developed.
[14] As per clause 3.8.24 of the NER.
[15] AEMO generally informs the market about operating incidents as they progress by issuing Market Notices – see AEMO website.

1. Constraint sets invoked with interconnector terms on the left hand side.[16]
    a. Revision of the F2 transformer's short-term rating to 1000 MVA.

       AEMO issued Market Notice 53461 at 0045 hrs, 43 minutes after this rating was applied.

    b. Invoking of constraint set CA_SPS_46545836.

       AEMO issued Market Notice 53465 at 0123 hrs, 13 minutes after the constraint set was invoked.

    c. Revision of the F2 transformer's normal rating from 1000 MVA to 850 MVA and revoking of constraint set CA_SPS_46545836.

       AEMO issued Market Notices 53502 and 53503 (correction to MN 53502) at 0942 hrs and 1023 hrs respectively on 23 May 2016.

    d. Restoration of normal and short term ratings for the F2 transformer at 0002 hrs on 24 May.

       AEMO issued Market Notice 53505 at 0008 hrs on 24 May.

Over the course of this incident AEMO issued appropriate, timely and sufficiently detailed market information.

6. CONCLUSIONS

AEMO has assessed this incident in accordance with clause 4.8.15(b) of the NER. In particular, AEMO has assessed the adequacy of the provision and response of facilities or services, and the appropriateness of actions taken to restore or maintain power system security.

AEMO has concluded that:

1. AEMO did not have procedures in place to manage changes to the F2 transformer rating.
2. The power system was not in a secure operating state for 35 minutes.
3. The delay in restoring the power system to a secure operating state was caused by AEMO failing to respond to the potential overloading of the F2 transformer in a timely manner.
4. AEMO incorrectly used the Constraint Automation tool to develop a constraint set to restore the power system to a secure operating state.

[16] For short term outage AEMO is required to notify the Market of variances to interconnector transfer limits AEMO, *Power System Security Guidelines,* Section 22.

APPENDIX A. – INCIDENT EVENT LOG

Chronological Log of Incident

Time and Date	Event
Sunday, 22 May 2016	
2354 hrs	Short notice outage of the APD No.1 Potline from 283 MW occurred.
2358 hrs	SMTS F2 transformer MVA load increased to 1116 MVA (exceeding the short-term rating of 1100 MVA).
Monday, 23 May 2016	
0002 hrs	AusNet Services advised AEMO that the short term rating for the SMTS F2 transformer was unavailable for the next 24 hrs. AEMO amended the short term rating to 1000 MVA.
0010 hrs	APD No.1 Potline returned to service.
0023 hrs	RTCA started indicating violations on the F2 transformer.
0045 hrs	Market Notice 53461 was issued.
0110 hrs	Constraint set CA_SPS_46545836 was invoked to manage loading on the F2 transformer.
0111 hrs	RTCA violations were cleared.
0123 hrs	Market Notice 53465 was issued.
0930 hrs	Constraint set CA_SPS_46545836 was revoked and AEMO amended the normal rating of the F2 transformer to 850 MVA.
0942 hrs	Market Notice 53502 was issued.
1023 hrs	Market Notice 53503 was issued.
Tuesday, 24 May 2016	
0002 hrs	The short term rating of the F2 transformer was restored and AEMO amended this rating to 1200 MVA[11]. AEMO also amended the normal rating to 1000 MVA.
0008 hrs	Market Notice 53505 was issued.

APPENDIX B. – EXPLANATION OF F2 TRANSFORMER RATINGS

The SMTS F2 transformer ratings are provided below.

Rating Type	Rating (MVA)
Normal rating	1000
30-minute short-term rating	1100
15-minute short-term rating	1200

The normal rating is the maximum allowable continuous loading on the F2 transformer. The loading may exceed this rating under certain conditions in accordance with the short-term ratings.

The F2 transformer loading may exceed the normal rating, but remain within the 30-minute short-term rating, for no longer than 30 minutes in any 24 hour period.

The F2 transformer loading may exceed the normal and 30-minute short-term ratings, but remain within the 15-minute short-term rating, for no longer than 15 minutes in any 24 hour period.

The F2 transformer loading is not allowed to exceed the 15 minute short term rating.

If the conditions of the short-term ratings are not met, AusNet Services[5] may advise AEMO of the removal of both short-term ratings for at least the next 24 hours.

While a 30-minute short term rating is available, AEMO normally uses the 15-minute ratings in constraint equations.