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Trip of Armidale – Coffs Harbour  
96C 132 kV line and Armidale –  
Tamworth 85 330 kV line on  
19 January 2019

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**May 2019**

Reviewable Operating Incident Report under the  
National Electricity Rules

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## INCIDENT CLASSIFICATIONS

Classification	Detail
Time and date of incident	1938 hrs on 19 January 2019
Region of incident	New South Wales
Affected regions	New South Wales
Event type	Protection mal-operation
Generation Impact	No generating unit was disconnected or had its output limited as a result of this incident
Customer Load Impact	No customer load was disconnected as a result of this incident
Associated reports	Nil

## ABBREVIATIONS

Abbreviation	Term
A	Ampere
AEMO	Australian Energy Market Operator
AEST	Australian Eastern Standard Time
DEF	Directional earth fault
kV	Kilovolt
NER	National Electricity Rules

# 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**

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# 1. Overview

This report relates to a reviewable operating incident<sup>1</sup> that occurred on 19 January 2019 in New South Wales. The incident involved the trip of the Armidale – Coffs Harbour 96C 132 kV line (96C line) and the Armidale – Tamworth 85 330 kV line (85 line) at the Tamworth end only.

No generation or customer load was lost as a result of this incident.

As this was a reviewable operating incident, AEMO is required to 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<sup>2</sup>.

AEMO has concluded that:

1. The trip of the 96C line was due to lightning, and all protection operated as designed and as expected to clear the fault.
2. The trip of the 85 line at Tamworth was due to a protection system design error. A similar design error was also identified on the Armidale – Tamworth 86 330 kV line (86 line). The design error involving both lines has been corrected.
3. The design error related to different protection design standards being used at Armidale and Tamworth.
4. TransGrid has confirmed the design error was isolated to 85 and 86 lines only.
5. AEMO correctly reclassified the simultaneous trip of the 96C and 85 lines as a credible contingency after the incident.
6. The power system remained in a secure operating state throughout this incident.

This report is prepared in accordance with clause 4.8.15(c) of the National Electricity Rules (NER). It is based on information provided by TransGrid<sup>3</sup> and AEMO.

National Electricity Market time (Australian Eastern Standard Time [AEST]) is used in this report. At the time of this incident, local time in New South Wales was AEST plus one hour.

## 2. The incident

### 2.1 The incident

At 1938 hrs on 19 January 2019, the 96C line tripped and successfully auto-reclosed 10 seconds later. At the same time, the 85 line tripped at the Tamworth end only, and then successfully auto-reclosed 15 seconds later.

### 2.2 TransGrid investigation

The following is based on information provided by TransGrid.

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<sup>1</sup> See NER clause 4.8.15(a)(1)(i), as the event relates to a non-credible contingency event; and the AEMC Reliability Panel Guidelines for Identifying Reviewable Operating Incidents.

<sup>2</sup> See NER clause 4.8.15(b).

<sup>3</sup> TransGrid is the Transmission Network Service Provider (TNSP) for New South Wales.

## 2.2.1 Trip of 96C line

At 1938 hrs on 19 January 2019, the 96C line tripped due to a high voltage phase<sup>4</sup> to earth fault on the line, with protection relays indicating the fault was approximately one kilometre from Armidale.

TransGrid's lightning recording systems show a lightning strike close to the line at exactly the same time as the fault. Although a line patrol found no evidence of flashed insulators at the predicted fault location, TransGrid has concluded the trip was the result of lightning.

All protection systems operated correctly and as expected to clear the fault within the timeframes specified in the NER<sup>5</sup>. Approximately 10 seconds after the line tripped, it auto-reclosed successfully.

## 2.2.2 Trip of 85 line at Tamworth

Coincident with the trip of the 96C line, the 85 line tripped at the Tamworth end only. This was not an expected outcome for the fault on the 96C line.

At Tamworth substation, the 85 line No. 1 protection relay indicated a directional earth fault (DEF) and the protection had operated to trip the 85 line circuit breaker at Tamworth. The 85 line No. 2 protection relay at Tamworth did not detect a fault, and neither did either of the 85 line protections at the Armidale substation. The 85 line No. 1 protection was isolated at both Armidale and Tamworth at 2116 hrs on 19 January 2019, pending investigation.

Analysis of the voltage waveforms from the fault recorders for both the 85 line and the Armidale – Tamworth 86 330 kV line (86 line) at Armidale showed a depression on the blue phase coincident with the fault on the 96C line, together with a neutral current which should not have been sufficient to initiate a trip of the 85 line. Refer to Appendix A1 for details.

A review of the protection relays by TransGrid for the 85 line identified that the No. 1 protection relay at Armidale had been replaced in March 2018, and it was found that there was a design mismatch between the Armidale end and the Tamworth end in relation to the DEF settings. At Armidale, the DEF settings were set to 20% forward and 15% reverse, while the older relay at Tamworth was set to 10%<sup>6</sup> for both forward and reverse. Normally the DEF settings are the same at both ends of the line.

Although there are no records of the neutral current at Tamworth, it can be assumed that the protection at both Tamworth and Armidale would see similar values of neutral current. At the time of the fault on the 96C line, the neutral current in the 85 line, as measured at Armidale, was greater than 200 ampere (A). This resulted in the pickup of the No. 1 protection DEF forward-looking element at Tamworth, which then sent a DEF inter-trip signal to Armidale. At Armidale, the No. 1 Protection DEF did not operate, because the neutral current did not exceed the 20% forward or 15% reverse setting. As no fault was detected by the DEF protection at Armidale in the forward direction, the intertrip from Tamworth was blocked. This is an expected outcome, because there was no high voltage fault on the 85 line. However, as the fault on the 96C line was not detected in the reverse direction at Armidale, the DEF Reverse Blocking function did not operate, resulting in an echo inter-trip<sup>7</sup> being sent back to Tamworth that resulted in the trip of the 85 line at Tamworth. If the DEF Reverse Blocking function had operated, the echo inter-trip to Tamworth would not have been sent.

The 85 line No. 1 protection was returned to service at 1621 hrs on 20 January 2019, after the settings at the Armidale end were revised to match the Tamworth end.

Further investigations revealed the No. 1 protection system DEF settings on the 86 line were identical to those on the 85 line. The only reason the 86 line did not also trip at Tamworth was that the neutral current in the 86 line was slightly less than the 200 A setting. At 1218 hrs on 20 January 2019, TransGrid isolated the 86 line

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<sup>4</sup> Blue phase.

<sup>5</sup> NER clause S5.1a.8.

<sup>6</sup> This is 10% of the 1 A relay input multiplied by the current transformer ration of 2000:1, which equates to 200 A.

<sup>7</sup> This echo signal is a design feature to pick up earth faults on a line where one end is open. The checking mechanism is that if an intertrip is received and there is no detected local earth fault, an echo intertrip is sent back so that the fault can be cleared.

No. 1 protection to revise the protection settings. The 86 line No. 1 protection was returned to service at 1301 hrs on the same day.

TransGrid has reviewed the process that led to the protection design mismatch between Armidale and Tamworth, and has identified that two different design standards were used. An older standard was in place at the Tamworth end, and a newer standard had been used when the relay at Armidale was replaced in March 2018. TransGrid have advised AEMO that it was an oversight not to align the two standards when designing the new protection schemes for the 85 and 86 lines.

TransGrid has also reviewed the design of other recently revised protection systems. Of the 46 new relays installed, only four have an older relay at one end, and none of these four schemes were found to have incorrect DEF settings.

## 3. Power system security

AEMO is responsible for power system security in the National Electricity Market (NEM). This means AEMO is required to operate the power system in a secure operating state to the extent practicable and take all reasonable actions to return the power system to a secure state following a contingency event in accordance with the NER<sup>8</sup>.

The power system was in a secure operating state throughout this incident. As both the 96C and 85 lines returned to service within 15 seconds, no action was required by AEMO to restore or maintain power system security.

### 3.1 Reclassification

AEMO assessed whether or not to reclassify this incident as a credible contingency event<sup>9</sup>.

After an initial review of the incident, and as TransGrid could not determine the cause(s) of the incident, AEMO correctly reclassified the simultaneous loss of the 96C and 85 lines as a credible contingency from 2030 hrs on 19 January 2019. This reclassification was cancelled at 2218 hrs on the same day, after TransGrid advised AEMO that the cause of the contingency had been identified and was unlikely to reoccur because the No. 1 protection system on the 85 line had been isolated.

## 4. Market information

AEMO is required by the NER and operating procedures to inform the market about incidents as they progress. This section assesses how AEMO informed the market<sup>10</sup> over the course of this incident.

For this incident, AEMO informed the market on the following matters:

1. A non-credible contingency event – notify within two hours of the event<sup>11</sup>.

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<sup>8</sup> Refer to AEMO's functions in section 49 of the National Electricity Law and the power system security principles in clause 4.2.6 of the NER.

<sup>9</sup> AEMO is required to assess whether or not to reclassify a non-credible contingency event as a credible contingency event – NER clause 4.2.3A(c) – and to report how the reclassification criteria were applied – NER clause 4.8.15(ca).

<sup>10</sup> AEMO generally informs the market about operating incidents as the progress by issuing Market Notices – see <https://www.aemo.com.au/Market-Notices>.

<sup>11</sup> AEMO is required to notify the Market of a non-credible contingency event within two hours of the event – AEMO, Power System Security Guidelines, Section 10.3, available at [SO\\_OP 3715 Power System Security Guidelines](#).

- AEMO issued Market Notice 66477 at 1955 hrs on 19 January 2019, 17 minutes after the event, to advise of the non-credible contingency event.
2. Reclassification, details, and cancellation of a non-credible contingency – notify as soon as practical<sup>12</sup>.
- AEMO issued Market Notice 66478 at 2030 hrs on 19 January 2019 to advise that the simultaneous trip of the 96C and 85 lines had been reclassified as a credible contingency.
  - AEMO issued Market Notices 66479 at 2218 hrs on 19 January 2019 to advise that the reclassification of the 96C and 85 lines had been cancelled, because the cause had been identified and a reoccurrence of the incident was unlikely.

## 5. 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. The trip of the 96C line was due to lightning, and all protection operated as designed and as expected to clear the fault.
2. The trip of the 85 line at Tamworth was due to a protection system design error. A similar design error was also identified on the 86 line. The design error involving both lines has been corrected.
3. The design error related to the use of different protection design standards being used at Armidale and Tamworth .
4. TransGrid has confirmed the design error was isolated to the 85 and 86 lines only.
5. AEMO correctly reclassified the simultaneous trip of the 96C and 85 lines as a credible contingency after the incident.
6. The power system remained in a secure operating state throughout this incident.

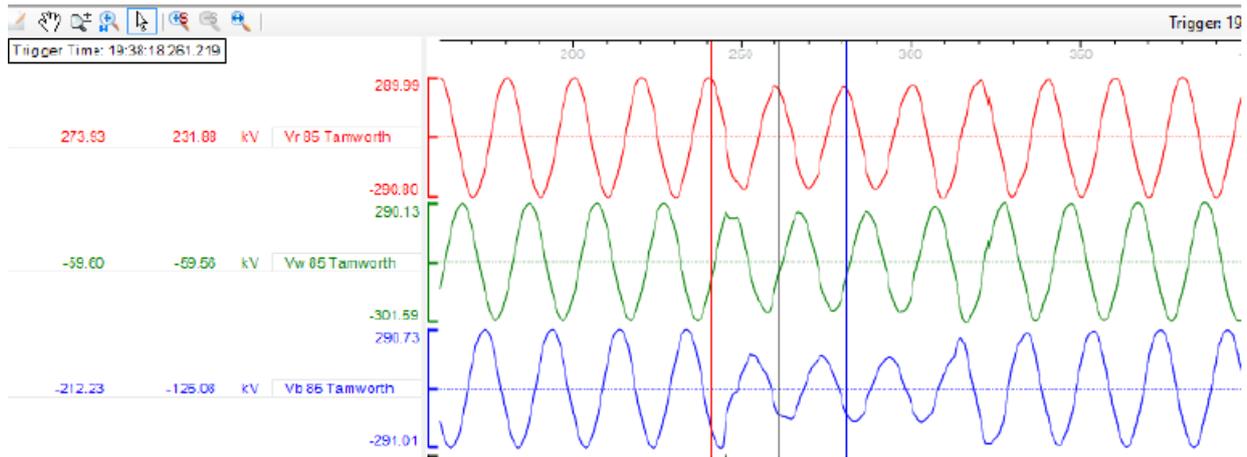
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<sup>12</sup> AEMO is required to notify the market of a reclassification – NER clause 4.2.3(g), details of the reclassification – 4.2.3(c), and when AEMO cancels the reclassification – 4.2.3(h).

# A1. Fault data

The following fault data was provided by TransGrid.

The figure below shows the voltage waveforms for the 85 line, as measured at Armidale during the fault on the 96C line.



The figures below show the neutral current in the 85 line and the 86 line as measured at Armidale at the time of the fault on the 96C line.

