

Loss of SCADA and line protection at Keilor Terminal Station on 29 June 2023

April 2024

Reviewable operating incident
report under the 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.

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Incident classifications

Classification	Detail
Time and date of incident	1452 hrs on 29 June 2023
Region of incident	Victoria
Affected regions	Victoria, Tasmania
Event type	Unknown – AusNet investigation ongoing
Generation impact	44 MW
Customer load impact	No customer load was tripped or automatically shed in this incident

Abbreviations

Abbreviation	Term
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AEST	Australian Eastern Standard Time
ARENA	Australian Renewable Energy Agency
ATS	Altona Terminal Station
AW	Airport West (zone substation)
BESS	battery energy storage system
BLTS	Brooklyn Terminal Station
BU	back up
BY	Braybrook zone substation
CB	circuit breaker
CBF	circuit breaker failure
DC	direct current
DNSP	Distribution Network Service Provider
DPTS	Deer Park Terminal Station
DPV	distributed photovoltaic (generation)
DWDM	dense wavelength-division multiplexing
ES	Essendon (zone substation)
GPSRR	General Power System Risk Review
GPR	ground potential rise
GTS	Geelong Terminal Station
HSM	high speed monitor
HV	high voltage
Hz	hertz
KTS	Keilor Terminal Station
kA	kiloampere/s
kV	kilovolt/s

Abbreviation	Term
kW	kilowatt/s
LNGS	Laverton North Gas Station
MAT	Melbourne Airport (zone substation)
MCB	miniature circuit breaker
MN	market notice
MOV	metal oxide varistor
ms	millisecond/s
NEM	National Electricity Market
NEMOC	National Electricity Market Operations Committee
NER	National Electricity Rules
N/O	normally open
NSP	Network Service Provider
OC	overcurrent
OEM	original equipment manufacturer
PMU	phasor measurement unit
PS	power station
PSSWG	Power System Security Working Group
PTR	permission to restore
p.u.	per unit
PV	Pascoe Vale (zone substation)
RTO	Real Time Operations
SA	Saint Albans (zone substation)
SCADA	supervisory control and data acquisition
SCWF	Salt Creek wind farm
SEF	sensitive earth fault
SF	solar farm
SMTS	South Morang Terminal Station
SSE	Sunshine East (zone substation)
SYTS	Sydenham Terminal Station
TMA	Tullamarine Airport (zone substation)
TNSP	Transmission Network Service Provider
TOA	transmission operating advice
TOC	Transmission Operation & Control
TTS	Thomastown Terminal Station
UNSW	University of New South Wales
V	volt/s
VT	voltage transformer
WF	wind farm
WMTS	West Melbourne Terminal Station



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1 Overview

This report relates to a reviewable operating incident¹ that occurred in Victoria on 29 June 2023 at 1452 hrs. The event involved the trip and auto-reclosure of the Altona Terminal Station (ATS) – Keilor Terminal Station (KTS) 220 kilovolt (kV) line and the trip of the incoming miniature circuit breakers (MCBs) of the KTS 48 volt (V) direct current (DC) supplies at KTS.

Post-incident review identified that the trip of the KTS 48 V DC supplies disconnected all DC supplies to the KTS 220 kV and 66 kV communications equipment and caused the loss of all communications systems from KTS, including from KTS to AEMO and AusNet control rooms. The loss of communications equipment at KTS caused the widespread loss of X and Y line differential protection signalling on 220 kV and 66 kV lines at KTS, including communication with the line remote end stations. The following lines had inoperable primary and backup circuit breaker failure (CBF) protection systems for a period of approximately 105 minutes:

- ATS – KTS 220 kV line.
- Brooklyn Terminal Station (BLTS) – KTS 220 kV line.
- KTS – Thomastown Terminal Station (TTS) 220 kV No. 1 line.
- KTS – TTS 220 kV No. 2 line.
- KTS – West Melbourne Terminal Station (WMTS) 220 kV No. 1 line.
- KTS – WMTS 220 kV No. 2 line.²

The above lines were connected to KTS with no supplementary³ protection. Following the incident, AusNet installed supplementary protection on these six lines between 16 September 2024 and 24 September 2024. During the incident, other 220 kV lines⁴ and 66 kV lines had partial or slower operable protection as detailed in Section 2.3.2.

AEMO has concluded that the power system was not in a secure operating state during the 105 minutes that the five KTS 220 kV lines remained connected with no primary or backup protection systems. Therefore, as the power system was not in a secure operating state for more than 30 minutes, AEMO has determined that this event is a reviewable operating incident. AEMO is therefore 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 security⁵.

AEMO's conclusions findings, recommendations and actions arising from its review are summarised in Table 1.

¹ See National Electricity Rules (NER) 4.8.15(a)(1)(iv), as the event relates to an event where the power system is not in a secure operating state for more than 30 minutes; and the Australian Energy Market Commission (AEMC) Reliability Panel Guidelines for Identifying Reviewable Operating Incidents.

² The KTS – WMTS 220 kV No. 2 line was out of service for a planned outage at the time of the incident.

³ Supplementary protection functions, enabled in line current differential protection relays, act in conjunction with the primary protection function in the event the current differential protection function becomes inoperable e.g. due to the loss of communications signalling.

⁴ DPTS – KTS 220 kV line, GTS – KTS 220 kV No. 1 line and GTS – KTS 220 kV No. 3 line.

⁵ See NER 4.8.15(b).

Table 1 Summary of findings, conclusions, and recommendations

No.	Finding	Recommendations and actions
1	<p>The fault on the ATS – KTS 220 kV line was caused by a bird’s nest on tower T4, close to KTS.</p>	<ul style="list-style-type: none"> • AusNet has removed the bird nest. • AusNet has patrolled the ATS – KTS 220 kV line and located an additional bird nest at T23, which was also removed. • AEMO recommended that AusNet consider reviewing their tower/line inspection procedures in light of this event. AusNet has advised AEMO that: <ul style="list-style-type: none"> – Electricity Safety Regulations 2013 require tower/line inspection at least every 37 months (bushfire risk areas) or 61 months (other areas) and AusNet’s inspection policy of twice per year greatly exceeds this minimum requirement. – Prior to this incident, AusNet had recently undertaken a comprehensive review of its line and tower inspections policy. AusNet therefore considers that their procedures are adequate.
2	<p>The ATS – KTS 220 kV line tripped and reclosed successfully. As only one circuit breaker (CB) at each of ATS and KTS is set to auto reclose, as per design the:</p> <ul style="list-style-type: none"> • KTS 500/220 kV A2 transformer was offloaded at the 220 kV side. • ATS – Laverton North Gas Station (LNGS) 220 kV No. 1 line and LNGS No. 1 transformer were disconnected. 	<ul style="list-style-type: none"> • No action required.
3	<p>The incoming MCBs of the KTS 48 V DC supplies to the 220 kV and 66 kV A and B communications tripped. This removed all DC supplies to the KTS 220 kV and 66 kV communications equipment and caused the loss of all communications systems from KTS.</p> <p>Five out of eight dense wavelength-division multiplexing (DWDM) power supply cards in the communications building had failed and emitted a burnt smell. All eight DWDM power supply cards were from the same original equipment manufacturer (OEM).</p> <p>The supervisory control and data acquisition (SCADA) services from KTS to AusNet and AEMO were interrupted.</p>	<ul style="list-style-type: none"> • AusNet replaced three DWDM power supply cards on 29 June 2023 and the remaining two on 30 June 2023. • AusNet installed voltage limiting devices to the A and B communications 48 V DC supplies on 26 September 2023 as a preventative measure. • AusNet’s investigation into the root cause of the A and B 48 V DC supplies and DWDM power supply card failures at KTS is ongoing. • Once AusNet’s investigation is complete, AusNet will: <ul style="list-style-type: none"> – Share the findings with AEMO. – Share the findings with relevant industry groups, notably the Power System Security Working Group (PSSWG) and National Electricity Market Operations Committee (NEMOC). – Identify whether a review of other terminal station communication, DC systems or contingency plans is required. <p>AEMO and AusNet may identify additional recommendations based on the outcome of this investigation.</p>
4	<p>The loss of communications equipment at KTS caused the widespread loss of line differential protection signalling on the lines at KTS, including the line remote end stations.</p> <p>The loss of protection signalling caused the impairment of both X and Y line differential protection (primary protection) of all 220 kV lines and some 66 kV lines protected by line current differential protection at KTS.</p> <p>Post-incident review identified that five 220 kV lines at KTS suffered a loss of primary and backup CBF protection systems and were in service in this state for approximately 105 minutes. As a result, the power system was not operating in a secure operating state during the period the five KTS 220 kV lines remained connected with no primary or backup protection systems.</p> <p>Between 1615 hrs and 1645 hrs, the information provided to AEMO indicated that five 220 kV lines did not have protection. AEMO considered whether to request AusNet to de-energise the lines under NER 4.6.5(b) and</p>	<p>Following the event:</p> <ul style="list-style-type: none"> • AusNet disabled auto-reclosure on the ATS – KTS and BLTS – KTS 220 kV lines at 1225 hrs on 6 September 2023 to mitigate the unlikely risk of auto-reclosure onto a fault during an absence of protection. • Between 16 September 2023 and 23 September 2023, AusNet added X and Y supplementary phase and earth fault overcurrent protection elements at both ends of the following lines to provide an additional level of protection redundancy (although clearance times are not expected to be within primary clearance times for all faults): <ul style="list-style-type: none"> – ATS – KTS 220 kV line. – BLTS – KTS 220 kV line. – KTS – WMTS 220 kV No. 1 line. – KTS – WMTS 220 kV No. 2 line. • On 24 September 2023, AusNet added X and Y supplementary distance protection elements at KTS and backup phase and earth fault overcurrent elements at TTS on the following lines to provide an additional level of protection redundancy (although clearance

No.	Finding	Recommendations and actions
	<p>determined that it was an unacceptable risk to power system security on the basis that protection was being restored. AEMO did not have confirmation of the protection’s return to service at 1638 hrs at this stage.</p>	<p>times are not expected to be within primary clearance times for all faults):</p> <ul style="list-style-type: none"> – KTS – TTS 220 kV No. 1 line. – KTS – TTS 220 kV No. 2 line. <ul style="list-style-type: none"> • AusNet has developed and implemented a KTS contingency plan to respond to a future event where a line fault at KTS results in the loss of the A and B communications DC systems and therefore the loss of line current differential protection (see Section 2.3.2 for details). The procedure was issued on 6 October 2023. • Following commissioning of additional supplementary protection and development of a KTS contingency plan, AEMO is satisfied that the power system can be re-secured within 30 minutes should this event re-occur. • AusNet has considered the likelihood and risk associated with a similar event occurring at other sites in Victoria and advised AEMO of its view that a contingency plan is not required at any other site under the present circumstances.
<p>5</p>	<p>Situational awareness was lost in both the AEMO National Electricity Market (NEM) Real Time Operations (RTO) and AusNet TOC control rooms.</p> <p>During the incident the AusNet operator received more than 1000 alarms in 5 minutes and more than 2000 alarms within the first hour. Prior to this incident, AusNet proposed an alarms project to better manage alarms in the future and, if approved, is expected to assist in managing this alarm flooding. This finding has emphasised the importance of recommendation 5 of the 2023 General Power System Risk Review (GPSRR) and AEMO’s Operation Technology Roadmap relating to uplift of operational capabilities.⁶</p> <p>Post-incident investigation has confirmed that, during the incident, the AusNet SCADA and supporting data was sufficient to allow earlier identification of the protection outage. However, information readily available to AusNet operators was insufficient to allow them to identify the level of protection that was operational on equipment during the incident.</p>	<ul style="list-style-type: none"> • AusNet has created a protection procedure to enable its operators to identify sources of alternate protection during an outage in order to promptly notify AEMO of protection outages and discussed this procedure at the PSSWG. • AusNet has completed a post-incident discussion and learning session with operators including training on the new protection procedure. • AEMO recommends that all TNSPs review the information readily available to operators to ensure they are able to accurately identify the level of protection which is operational on equipment following DC system, communications and SCADA outages.
<p>6</p>	<p>Transgrid⁷ was aware that protection was impaired and did not promptly inform AEMO.⁸</p>	<ul style="list-style-type: none"> • Transgrid has reviewed their procedures and advised that those procedures appropriately identify the requirement to notify AEMO for protection outages. Transgrid has reminded its control room staff to advise AEMO of any loss of protection. • AEMO has shared the findings of this incident at the PSSWG and reminded all TNSPs of their obligation to notify AEMO of all transmission protection outages.
<p>7</p>	<p>The SCADA service from Deer Park Terminal Station (DPTS) to AusNet was interrupted as both the primary and back up SCADA routes go via KTS. However, AEMO and Transgrid maintained visibility of DPTS throughout the incident.</p>	<ul style="list-style-type: none"> • AusNet is planning to implement an alternative SCADA route to DPTS by 30 June 2024.

⁶ See Section 6.6 of the 2023 GPSRR at https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2023/draft-2023-general-power-system-risk-review/2023-gpsrr.pdf?la=en.

⁷ Transgrid is the owner of Deer Park Terminal Station, which is connected to KTS.

⁸ Under NER 4.8.2(a), if a Registered Participant becomes aware that any relevant protection system or control system is defective or unavailable for service, that Registered Participant must advise AEMO.

No.	Finding	Recommendations and actions
8	Salt Creek Wind Farm (SCWF) tripped from 44 megawatts (MW) in response to the fault on the ATS – KTS 220 kV line due to an incorrect control parameter.	<ul style="list-style-type: none"> Tilt Renewables corrected the parameter on 30 August 2023.
9	The Mortlake South Wind Farm (WF) reduced power output from 83 MW to 53 MW over 13 seconds and returned to 83 MW over the next 24 seconds. Acciona has confirmed that the generation reduction during this event was caused by a fault ride through settings issue.	<ul style="list-style-type: none"> Acciona corrected the fault ride through settings issue on 19 December 2023.
10	This event, where two generators had unexpected responses due to settings issues, highlights the potential for incorrect settings or unexpected performance to exacerbate disturbance events.	<ul style="list-style-type: none"> To raise industry awareness of the need for all generators to ensure settings changes are appropriately managed, AEMO plans to share this finding and relevant details with all NEM generators by the end of Q2 2024. AEMO will consider this and other incidents in its annual review of power system incidents and may identify further recommendations.
11	There was a minimal reduction of small distributed photovoltaic (DPV) systems (<30 kilowatt [kW]) observed in Victoria. However, a significant portion (24%) of larger DPV systems (30-100 kW) were observed to disconnect in Victoria.	<ul style="list-style-type: none"> AEMO and Powercor to complete their ongoing investigation into the cause of the significant portion of DPV unit disconnections for units larger than 30 kW.
12	Basslink experienced commutation failure and successfully rode through the fault.	<ul style="list-style-type: none"> No action required.
13	Throughout this incident, AusNet advised AEMO: <ul style="list-style-type: none"> On 21 August 2023, that the root cause had been identified. On 6 September 2023, an update that the root cause had not been identified. On 21 August 2023, that metal-oxide varistor (MOV) spark gap devices had been installed to prevent the 48 V DC supplies from tripping if a similar event was to occur. On 6 September 2023, an update that the MOV spark gap devices would not eliminate the risk. On 8 September 2023, an update that the MOV spark gap devices had not been installed. 	<ul style="list-style-type: none"> AEMO has reminded AusNet of the importance of providing accurate information in relation to power system security issues. AusNet has reviewed internal processes for communication with site staff, and spoken with those staff involved in miscommunication in relation to this event, to minimise the potential for recurrence.

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 Acciona⁹, AusNet¹⁰, APA Group¹¹, Overwatch Energy¹², Powercor¹³, Tilt Renewables¹⁴, Transgrid¹⁵ and data gathered from AEMO systems.

National Electricity Market (NEM) time (Australian Eastern Standard Time [AEST]) is used in this report.

⁹ Acciona is the owner of Mortlake South Wind Farm.
¹⁰ AusNet is the Declared Transmission System Operator for Victoria.
¹¹ APA Group owns and operates the Basslink interconnector.
¹² Overwatch Energy is the operator of Salt Creek Wind Farm.
¹³ Powercor is a Distribution Network Service Provider (DNSP) for Victoria.
¹⁴ Tilt Renewables is the owner of Salt Creek Wind Farm.
¹⁵ Transgrid is the owner of Deer Park Terminal Station.

2 The incident

2.1 Pre-event conditions

2.1.1 Generation dispatch and demand

A summary of Victorian operational conditions at 1450 hrs on 29 June 2023, just prior to the incident, is shown in Table 2.

Table 2 Victorian key system conditions at 1450 hrs on 29 June 2023

Quantity description	Value (MW)
Victorian operational demand	6,284
Victorian scheduled and semi scheduled generation	6,261
Victorian distributed photovoltaic generation	527
Basslink flow into Victoria (George Town end)	356
Heywood interconnector flow into Victoria	159
Murraylink interconnector flow	0
Victoria – New South Wales Interconnector (VNI) flow into New South Wales	803

Table 3 provides a summary of Victorian generator dispatch at 1450 hrs on 29 June 2023. There was sufficient system strength in Victoria at the time of the incident including three units at Loy Yang A Power Station (PS), two units at Loy Yang B PS, Newport PS and four units at Yallourn PS. Laverton North PS, which is connected to ATS, was not generating at the time.

Table 3 Victorian generator dispatch at 1450 hrs on 29 June 2023

Station name	Dispatched generation (MW)	Station name	Dispatched generation (MW)
Ararat Wind Farm (WF)	38	Loy Yang A PS Unit 2	444
Bald Hills WF	104	Loy Yang A PS Unit 3	468
Bannerton Solar Farm (SF)	14	Loy Yang A PS Unit 4	467
Berrybank WF	170	Macarthur WF	218
Berrybank 2 WF	97	Mt Mercer WF	97
Bulgana Battery Energy Storage System (BESS)	1	Moorabool WF	240
Bulgana WF	36	Mortlake South WF	81
Cherry Tree WF	15	Mt Gellibrand WF	96
Cohuna SF	8	Murra Warra WF	103
Crowlands WF	29	Murra Warra WF Stage 2	42
Dundonnell WF Unit 1-40	138	Newport PS	160
Dundonnell WF Unit 41-51	34	Numurkah SF	15
Dundonnell WF Unit 52-80	105	Oaklands Hill WF	49

Station name	Dispatched generation (MW)	Station name	Dispatched generation (MW)
Eildon PS Unit 1	60	Salt Creek WF	42
Eildon PS Unit 2	60	Stockyard Hill WF	465
Elaine WF	63	Victorian Big Battery	0.2
Gannawarra BESS	1	Wemen SF	16
Gannawarra SF	11	Winton SF	5
Glenrowan West SF	8	West Kiewa PS	16
Karadoc SF	13	Yatpool SF	11
Kiamal SF	54	Yendon WF	88
Kiata WF	14	Yallourn 'W' PS Unit 1	330
Laverton North PS Unit 1	0	Yallourn 'W' PS Unit 2	299
Laverton North PS Unit 2	0	Yallourn 'W' PS Unit 3	303
Loy Yang B PS Unit 1	585	Yallourn 'W' PS Unit 4	370
Loy Yang B PS Unit 2	467	-	-

2.1.2 Prior outages

A planned outage of the KTS – West Melbourne Terminal Station (WMTS) 220 kV No. 2 line commenced prior to the event and overlapped with the duration of the event.

2.2 Event

Network fault and power system response

At approximately 1452 hrs on 29 June 2023, due to a fault on the ATS – KTS 220 kV line near KTS, the ATS – KTS 220 kV line tripped and auto-reclosed. As only one CB at each of ATS and KTS is set to auto-reclose, the KTS 500/220 kV A2 transformer was offloaded at the 220 kV side and the ATS – Laverton North Gas Station (LNGS) 220 kV No. 1 line and LNGS No. 1 transformer were disconnected. The disturbance from the fault was experienced throughout Victoria and in Tasmania via the Basslink DC interconnector. Salt Creek Wind Farm (SCWF) tripped from 44 MW and Mortlake South Wind Farm (WF) reduced power output from 83 MW to 53 MW over 13 seconds and returned to 83 MW over the next 24 seconds. A diagram of the post-incident network configuration is shown in Figure 6 of Appendix A1.

Loss of communications

Co-incident with the fault, the KTS 48 V DC supplies to the A and B communications incoming MCBs tripped. This removed all DC supplies to the KTS communications equipment and caused the loss of all communications systems from KTS. The loss of communications at KTS interrupted SCADA to AEMO and AusNet, and interrupted communications between KTS and its connecting 220 kV and 66 kV substations. The communications disruption also resulted in the widespread loss of line differential protection and CBF signalling at KTS. For the duration of the communications outage, five 220 kV lines remained in operational service with no effective primary or backup protection systems. Due to the impact this incident had on primary and CBF protection systems, AEMO has

determined that the power system was not in a secure operating state for approximately 105 minutes (see Section 3.1). SCADA from DPTS to AusNet was also lost as the communications path is via KTS.

Table 4 Sequence of events

Market time (hhmm or hhmm.ss)	Time since line fault (hh:mm)	Event
1452.57	0:00	<ul style="list-style-type: none"> The ATS – KTS 220 kV line tripped and auto reclosed (see Section 2.3.1 for details). The KTS 500/220 kV A2 transformer was offloaded at the 220 kV side (see Section 2.3.1 for details). The ATS – LNGS 220 kV No. 1 line and LNGS No. 1 transformer were disconnected (see Section 2.3.1 for details). The ATS B4 Trans No. 3 busbar 220 kV CB opened (see Section 2.3.1 for details). KTS A and B 48 V DC supply to 220 kV and 66 kV’s incomer MCBs tripped, interrupting A and B communications equipment of 220 kV and 66 kV equipment (see Section 2.3.2 for details). <ul style="list-style-type: none"> – SCADA from KTS to AusNet and AEMO was lost. – Five 220 kV lines lost effective primary and backup protection. – Three 220 kV lines had reduced protection. – Six 66 kV lines had reduced protection. Failover of DPTS SCADA, which is usually provided via KTS, to GTS was not successful and SCADA from DPTS to AusNet was lost (see Section 2.3.2 for details).¹⁶ The SCWF tripped from 44 MW (see Section 2.3.3 for details). The Mortlake South WF reduced power output from 83 MW to 53 MW over 13 seconds and returned to 83 MW over the next 24 seconds (see Section 2.3.4 for details). Basslink experienced commutation failure and did not trip (see Section 2.3.5 for details).
1500	0:08	<ul style="list-style-type: none"> AEMO replaced all affected data quantities from KTS with state estimator values to improve state estimation.
1637	1:45	<ul style="list-style-type: none"> KTS SCADA, communications and protection were returned to service.
1733	2:41	<ul style="list-style-type: none"> AusNet restored the KTS 500/220 kV A2 transformer onload.
1737	2:45	<ul style="list-style-type: none"> AusNet closed the ATS B4 transformer No. 3 busbar 220 kV CB.
1756	3:04	<ul style="list-style-type: none"> AusNet returned the TTS – WMTS 220 kV No. 2 line to service following completion of the planned outage.
1803	3:11	<ul style="list-style-type: none"> Laverton North PS closed the ATS LNGS No. 1 Gen. transformer 220 kV CB to return ATS – LNGS 220 kV No. 1 line and LNGS No. 1 transformer to service.
1938	4:46	<ul style="list-style-type: none"> Overwatch Energy (operator of the SCWF) advised AEMO that the SCWF reduced output to 0 MW at 1453 hrs. The cause of the reduction in generation was not known. Staff on site reported dimming/flickering lights at the time the generation reduced.
2045	5:53	<ul style="list-style-type: none"> AEMO issued Market Notice 108788 to advise the market of the non-credible contingency and reclassification of the simultaneous trip of the ATS – KTS 220 kV line and the SCWF as a credible contingency.

2.3 Analysis

Based on information provided by registered participants and available from AEMO systems, AEMO has outlined its findings below.

¹⁶ DPTS SCADA service to AEMO is provided via Transgrid, the owner of DPTS, and remained un-interrupted throughout the incident.

2.3.1 Trip of ATS – KTS 220 kV line

On 29 June 2023, at 1452.57 hrs¹⁷ there was a blue phase to ground fault on the ATS – KTS 220 kV line. A fault current of approximately 19.41 kiloamperes (kA) was recorded at KTS with a remote fault contribution of approximately 3.78 kA from ATS. The X and Y line differential protection relays operated at both ends and tripped the line and the fault was cleared after approximately 61.6 milliseconds (ms).

Due to the absence of three-phase line voltage transformers (VTs), the ATS – KTS 220 kV line X and Y protection relays do not have supplementary¹⁸ distance protection enabled, therefore there was no distance to fault recorded. However, the distribution of fault currents indicated the fault was close to KTS.

The protection operated correctly, and the line successfully auto-reclosed by closing only one CB at each end of the ATS – KTS 220 kV line.

At KTS, auto-reclose of the ATS line is achieved by reclosing the ATS line No. 1 busbar 220 kV CB only. The ATS line/A2 transformer 220 kV CB remained open as per design. This resulted in the KTS 500/220 kV A2 transformer remaining energised via its 500 kV side but offload (as the 220 kV CB remained open).

At ATS, there is no dedicated line CB for the KTS line. Instead, the line is directly connected on the No. 3 220 kV busbar. During the ATS – KTS 220 kV line fault, all three 220 kV CBs on the No. 3 220 kV busbar tripped. At ATS, auto-reclose of the KTS line is achieved by reclosing the B3 transformer No. 3 220 kV CB only. The B4 transformer No. 3 busbar 220 kV CB and the LNGS No. 1 line 220 kV CB remained open as per design. This disconnected the ATS – LNGS 220 kV No. 1 line and the LNGS No. 1 transformer¹⁹.

Following the event, AusNet carried out a line patrol and found evidence of a fault at tower T4 near KTS on the ATS – KTS 220 kV line caused by fallen debris from a bird nest. The patrol also found a bird nest containing metallic material, at tower T23. No evidence of a fault was found at T23. The bird nests were removed.

2.3.2 Loss of communications

Trip of 48 V DC incomer MCBs

During the restoration process, it was also identified that five out of eight dense wavelength-division multiplexing (DWDM) power supply cards in the communications building had failed and emitted a burnt smell. All eight DWDM power supply cards were from the same original equipment manufacturer (OEM). AusNet is engaging with the OEM to investigate the root cause of the cards' failure. Three DWDM power supply cards were replaced on 29 June 2023 and the remaining two on 30 June 2023.

At the time of writing this report, AusNet suspect that the trip of the KTS 48 V DC supply to 220 kV and 66 kV communications equipment is related to the ATS – KTS 220 kV line fault and that induction into the DC systems cabling/equipment or other substation earthing issues may have contributed to the DC supply trip during this incident. AusNet's study into the cabling/earthing design within the communications room is expected to be

¹⁷ SCADA recorded time.

¹⁸ Supplementary protection functions enabled in the line current differential protection relays act in conjunction with the primary protection function in the event the current differential protection function becomes inoperable e.g., due to the loss of communications signalling.

¹⁹ The Laverton North PS No. 1 and No. 2 generators were not generating at the time of the event.

complete on 30 April 2024. However, AusNet's investigation into the root cause is ongoing and as such no firm conclusions can yet be drawn.

AusNet installed voltage limiting devices to the A and B communications 48 V DC supplies on 26 September 2023 as a preventative measure however, AusNet cannot confirm that these devices will eliminate the likelihood of a re-occurrence of this incident as the root cause has not yet been identified.

AusNet initially suspected that a possible ground potential rise (GPR), due to the close-in fault near KTS, may have caused the DC supplies MCBs to trip. However, AusNet has confirmed that test results of the station earth grid at KTS are satisfactory and therefore the substation should not be susceptible to GPR issues.

Loss of KTS SCADA

The loss of KTS communications equipment caused the interruption to SCADA service to AusNet and AEMO. Following discussion with AusNet, AEMO replaced all affected data quantities from KTS with state estimator values in accordance with AEMO's procedures. This improved AEMO's EMS state estimation of the power system.

Loss of DPTS SCADA to AusNet

SCADA from DPTS²⁰ to AusNet was lost when the 48 V DC supplies were interrupted. AusNet's post-incident investigation attributed this to both the primary and back up SCADA communications routes for DPTS having connections to KTS.

Loss of line protection

The loss of communications equipment at KTS resulted in the widespread failure of line differential protection signalling on lines connected to KTS, including the line remote end stations. This loss of protection signalling caused the impairment of both the X and Y line differential protection (primary protection) of all 220 kV lines and 66 kV lines at KTS. For the approximate 105-minute duration of the KTS communications outage, the following lines (which are connected to KTS with no supplementary protection) had inoperable primary and backup CBF protection systems:

- ATS – KTS 220 kV line.
- BLTS – KTS 220 kV line.
- KTS – TTS 220 kV No. 1 line.
- KTS – TTS 220 kV No. 2 line.
- KTS – WMTS 220 kV No. 1 line.
- KTS – WMTS 220 kV No. 2 line (on planned outage at the time).

The following KTS lines have supplementary distance protection elements enabled and therefore continued to be protected by distance protection during the KTS communications outage. However, supplementary distance protection may not have cleared all line faults within primary protection times²¹.

²⁰ DPTS is owned by Transgrid. GTS and KTS, the substations connected to DPTS, are owned by AusNet.

²¹ Under NER S5.1a.8(b)-(c) primary protection fault clearance is required within 120 ms at the near end and 220 ms at the remote end of 220 kV lines.

- DPTS – KTS 220 kV line.
- GTS – KTS 220 kV No. 1 line.
- GTS – KTS 220 kV No. 3 line.

Finally, the following KTS 66 kV line's X and Y current differential protection was impaired for the duration of the KTS communications outage. While these lines do not have supplementary distance protection enabled, their protection relays have other protection elements enabled which provide some protection for faults (although these may not meet primary protection time requirements²²).

- KTS – Airport West (AW) 66 kV No. 1 line, X and Y sensitive earth fault (SEF) protection.
- KTS – AW 66 kV No. 2 line, X and Y SEF protection.
- KTS – Essendon (ES) 66 kV line, Y back up (BU) overcurrent (OC) protection and SEF protection.
- KTS – Melbourne Airport (MAT) 66 kV line, X and Y SEF protection.
- KTS – Pascoe Vale (PV) 66 kV line, X and Y SEF protection.
- KTS – Tullamarine Airport (TMA) 66 kV line, X and Y SEF protection.

Post-incident actions in relation to the loss of protection are detailed in Section 2.6.

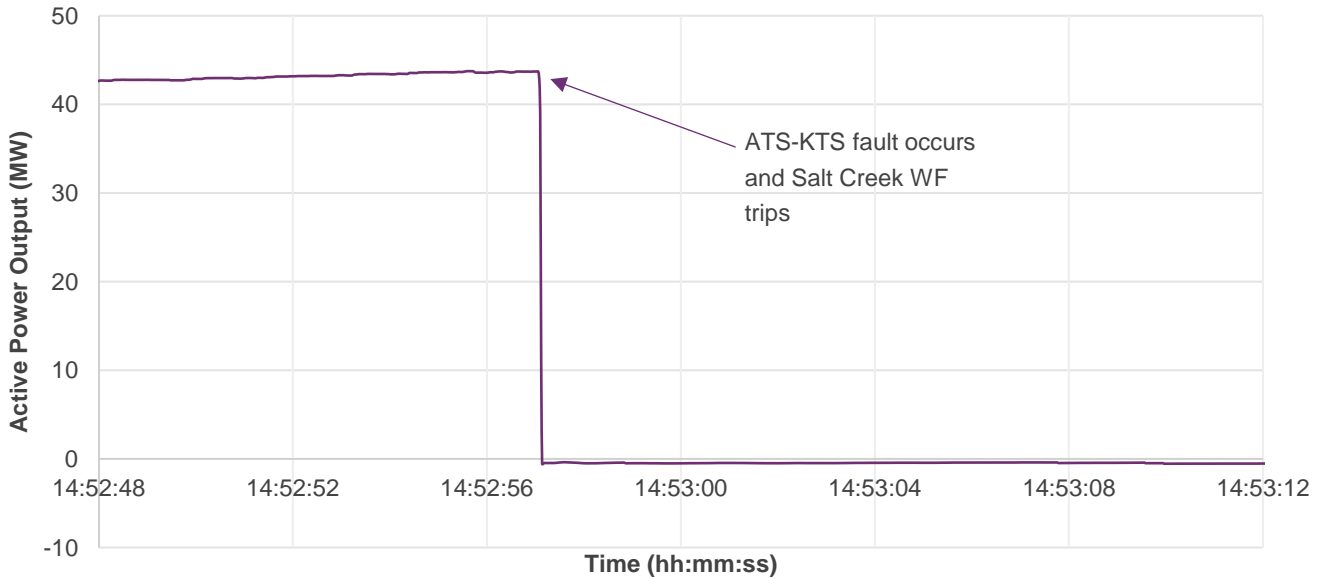
2.3.3 Trip of the Salt Creek Wind Farm

The SCWF unexpectedly tripped from 44 MW at 1452.57 hrs on 29 June 2023 following the fault on the ATS – KTS 220 kV line. Following review of the incident, Tilt Renewables has advised AEMO that the cause of the trip was due to an incorrect control parameter setting. The units of the parameter were originally in amperes; however, a software update caused the units to be changed to per unit (p.u.). Tilt Renewables corrected the parameter in consultation with AEMO on 30 August 2023.

²² Under NER S5.1a.8(b)-(c) primary protection fault clearance is required as necessary to prevent plant damage and meet stability requirements on 66 kV lines.



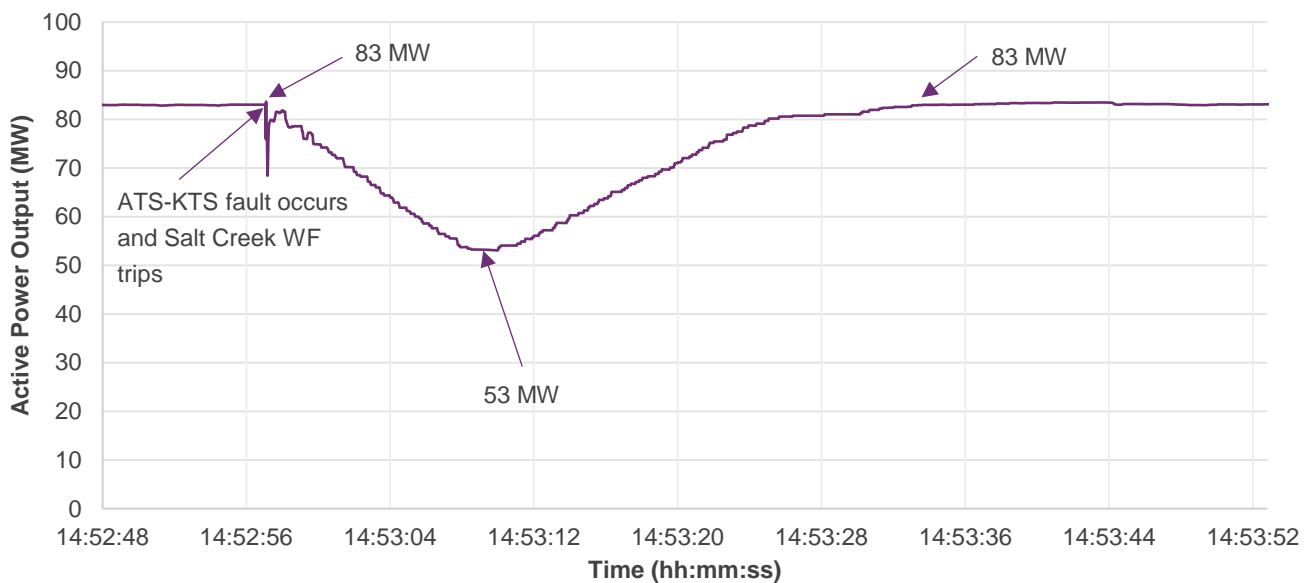
Figure 1 Salt Creek Wind Farm active power output on 29 June 2023



2.3.4 Mortlake South Wind Farm

The Mortlake South WF unexpectedly reduced output at 1452.57 hrs from 83 MW to 53 MW over a 13 second period. The Mortlake South WF subsequently increased output over the next 24 seconds to return to 83 MW. Figure 2 shows the active power output of the generator as recorded by high speed monitors. Acciona has confirmed that the generation reduction during this event was caused by a fault ride through settings issue. Acciona corrected the fault ride through settings issue on 19 December 2023.

Figure 2 Mortlake South wind farm active power on 29 June 2023



This event highlights the potential for incorrect settings or unexpected performance to exacerbate disturbance events. To raise industry awareness of the need for all generators to ensure settings changes are appropriately

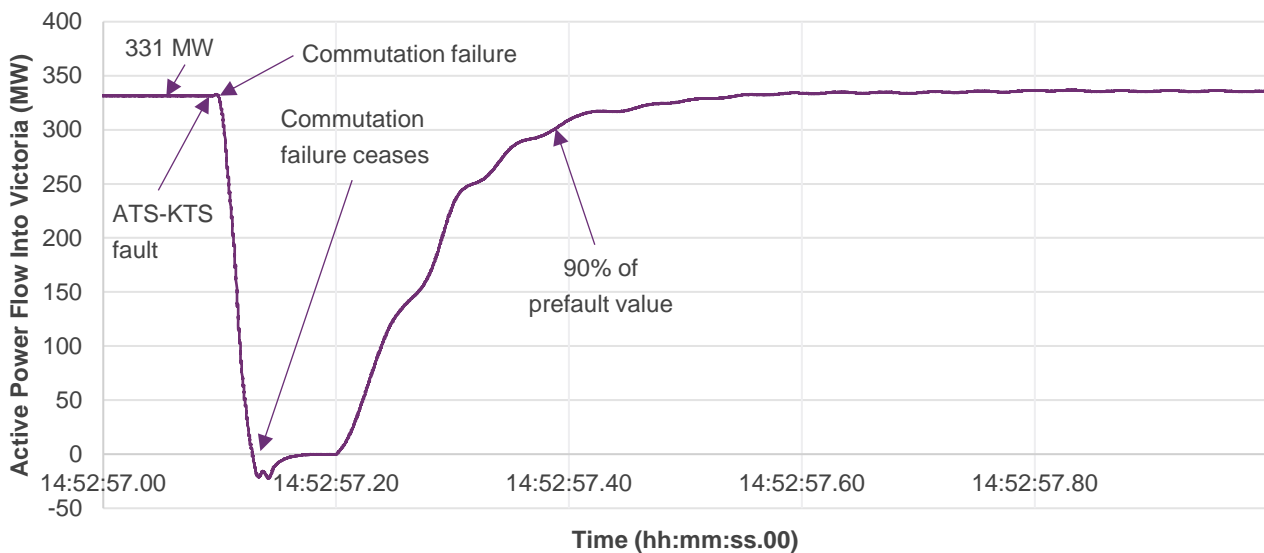
managed, AEMO plans to share this finding and relevant details with all NEM generators by the end of Q2 2024. AEMO will consider this and other incidents in its annual review of power system incidents and may identify further recommendations.

2.3.5 Basslink commutation failure

At 1544 hrs on 29 June 2023, Basslink reported to AEMO a commutation failure that occurred at approximately 1453 hrs and was likely due to a large disturbance of a very short duration on the Victorian system.

At the time of the ATS – KTS 220 kV line fault, Basslink was exporting 331 MW to Victoria with a target of 320 MW. Figure 3 below shows commutation failure starts at 14:52:57.09. Flow on Basslink during commutation failure ceases and recommences after 115 ms increasing to 90% of pre-fault power flow within 300 ms.

Figure 3 Basslink power flow to Victoria on 29 June 2023



As shown above, Basslink experienced commutation failure and successfully rode through the fault disturbance without tripping.

2.4 Situational awareness

AEMO’s post-incident review has concluded that the power system was not in a secure operating state for 105 minutes. Table 5 summarises how situational awareness of relevant parties developed throughout the incident.

Table 5 Summary of situational awareness

Market time (hhmm or hhmm.ss)	Company	Details
1452 hrs to 1502 hrs: Identifying the SCADA outage		
1452.57	AEMO and AusNet	AEMO's Energy Management System (EMS) and AusNet's EMS showed alarms for low voltage at the Brunswick Terminal Station (BTS) 220 kV No. 2 busbar. AusNet's EMS started to receive several communications alarms.
1454	AEMO and AusNet	AEMO NEM RTO ²³ and AusNet TOC discussed the BTS low voltage alarm, at which time AusNet TOC advised AEMO NEM RTO that communications alarms were being received by AusNet TOC's EMS and to ignore the BTS low voltage alarm. AusNet TOC dispatched a crew to KTS to investigate.
1457	AEMO	All KTS SCADA on AEMO's EMS was suspect ²⁴ . AEMO NEM RTO waited for a couple of SCADA scans to see if SCADA data would return to normal.
1500	AEMO and AusNet	AEMO contacted AusNet TOC. AusNet TOC confirmed that there was a SCADA issue at KTS, and a team was investigating. AEMO NEM RTO replaced some SCADA values at KTS to improve state estimation.
1452 to 1502	AEMO and AusNet	Both AEMO NEM RTO and AusNet TOC operators acknowledged in their respective EMS two CBs at ATS had operated and remained open.
	AusNet	SCADA from DPTS to AusNet TOC was interrupted and subsequently AusNet TOC lost visibility of the DPTS – KTS 220 kV line. AusNet TOC asked AusNet staff to complete a patrol of the line.
	AusNet	AusNet TOC received 1,038 SCADA event notifications between 1452.57 hrs to 1457.57 hrs. Among the notifications received there were alarms that X and Y line differential protection communication had failed on the following lines: <ul style="list-style-type: none"> • ATS – KTS 220 kV line. • BLTS – KTS 220 kV line. • GTS – KTS No. 1 220 kV line. • GTS – KTS No. 3 220 kV line. • KTS – TTS No. 1 220 kV line. • KTS – TTS No. 2 220 kV line. • KTS – WMTS No. 1 220 kV line. • KTS – WMTS No. 2 220 kV line, which was out of service at the time. <p>The above alarms were received from ATS, BLTS, GTS, TTS and WMTS. AusNet did not receive alarms at this time about the DPTS – KTS 220 kV line due to the DPTS and KTS SCADA outages.</p> <p>Based on the numerous alarms, AusNet TOC identified that there was a communications issue at KTS, but did not identify that this communications issue extended to some protection systems.</p>
	Transgrid	Transgrid received alarms which alerted operators that DPTS – KTS 220 kV line had lost differential protection. Transgrid operators had identified that supplementary distance protection was available on these lines. Transgrid were not immediately aware of the applicable clearance times of the supplementary protection. The operators notified support staff of the alarms and planned to follow up on the alarms if they were still present at shift handover.
1502	Awareness summary	At this time AusNet was aware that there was a communications issue affecting KTS but did not identify that there was an ongoing protection issue. Transgrid was aware of impacted protection systems at DPTS and had not informed AEMO. AEMO was not aware of any protection impacts and subsequently was unaware that the power system may not have been in a secure operating state. The AEMO and AusNet operators did not discuss the two CBs that changed status and remained open at ATS. AEMO NEM RTO believed the two ATS CBs most likely remained closed and that erroneous statuses were being received as part of the KTS SCADA outage. AusNet TOC believed that CBs were open and planned to immediately request first responders to attend ATS. AusNet TOC did not identify

²³ AEMO NEM RTO has operators responsible for each region. This report refers to Victoria unless explicitly stated. The Tasmania and Victoria operators were in different control rooms during this incident.

²⁴ AEMO's EMS marks SCADA as suspect when the values received are outside of the range expected by the state estimator.

		that the open CBs at ATS matches the network configuration for a trip and auto-reclosure of ATS – KTS 220 kV line.
1502 hrs to 1626 hrs: Identifying potential protection issue		
1509	AusNet	AusNet TOC called field staff working at WMTS on the KTS – WMTS No. 2 220 kV line outage. AusNet TOC requested that field staff attend ATS to investigate the open CBs. AusNet TOC requested to be informed of anything abnormal at WMTS. Field staff at WMTS advised of differential protection alarms on the lines connected to KTS. AusNet TOC noted that there was an ongoing communications issue at KTS and that other first responders had been organised to attend KTS to investigate. AusNet TOC requested the alarms be cleared. Based on this conversation, AusNet TOC did not identify that the communications issue at KTS extended to protection.
1526	AusNet and Transgrid	Transgrid called AusNet to discuss the loss of protection on the DPTS – KTS 220 kV line. AusNet informed Transgrid that there was a SCADA issue at KTS. Transgrid noted the presence of supplementary distance protection, and that the protection would still clear faults but potentially in a slower timeframe.
1526	Awareness summary	Based on the call with Transgrid, AusNet identified that the communications issue may have extended to protection systems. At the time of the incident there was no procedure available to assist the operator in identifying which protection equipment is affected by different types of communication outages, nor whether supplementary or back up protection was available for impacted lines. AusNet TOC planned to immediately ask for support from backroom staff to identify any protection impacts. Transgrid was aware that there was a communications issue at KTS, and that AusNet are investigating. AEMO was not aware of any protection impacts and subsequently was unaware that the power system may not have been in a secure operating state.
1527 hrs to 1615 hrs: Loss of protection confirmation, and ATS – KTS 220 kV line fault identification		
1531	AusNet	AusNet TOC requested AusNet backroom staff to investigate which protection is available under the communications outage.
1536	AusNet	AusNet backroom staff advised AusNet TOC that further investigation was required to confirm the available protection, due to the presence of both hardwired and communications based differential protection systems at KTS.
1544	AEMO and APA Group	APA Group advised AEMO NEM RTO (Tasmania desk) that a Basslink commutation fault had occurred at approximately 1452 hrs and queried if a large disturbance in Victoria had occurred. Basslink noted voltage had been at 0.8 p.u. at Loy Yang Converter station 500 kV.
1555	AEMO and AusNet	AusNet TOC advised AEMO of a network disturbance and confirmed an ongoing a loss of communications to KTS.
1601	AEMO and AusNet	AusNet TOC advised AEMO NEM RTO there was still no visibility of KTS, there was a communications battery issue at KTS, and that AusNet personnel were onsite and working to restore supply.
1606	AEMO and TasNetworks	TasNetworks advised AEMO NEM RTO (Tasmania desk) that a load customer had reported a voltage disturbance at 1452 hrs. TasNetworks also reported low voltage alarms at several substations in Tasmania.
1601 to 1614	AusNet	AusNet field personnel identified that ATS – KTS 220 kV line had tripped and auto-reclosed.
1614	AusNet	AusNet backroom staff identified the level of protection available at KTS and advised AusNet TOC that ATS – KTS, BLTS – KTS, KTS – TTS No. 1 and No. 2, and KTS – WMTS 220 kV No. 1 and No. 2 lines had no protection.
1614	AEMO and AusNet	AusNet TOC advised AEMO NEM RTO that ATS – KTS, BLTS – KTS, KTS – TTS No. 1 and No. 2, and KTS – WMTS 220 kV No. 1 and No. 2 lines had no protection. This advice was received by AEMO 82 minutes after the initiating fault. This information was subsequently revised at 1645 hrs. Later, the post-incident review has found this information to be correct.
1614	Awareness summary	At this time AEMO and AusNet were now aware that there was an issue with protection at KTS and that ATS – KTS 220 kV line had tripped and auto reclosed.
1615 hrs to 1704 hrs: Restoring protection		
1628	AEMO and AusNet	AEMO requested that AusNet TOC investigate the available zone 3 or distance protection extension to cover the lines without protection.
1634	AEMO	AEMO NEM RTO called AusNet TOC to confirm the available protection. AusNet TOC reconfirmed the advice provided at 1614 hrs. AEMO sought clarity regarding the available protection on other KTS assets.

		AusNet TOC confirmed that the 500 kV lines and 500/220 kV transformers connected to KTS have full redundant protection and that DPTS – KTS 220 kV line and GTS – KTS No. 1 and No. 3 220 kV lines have single protection available.
1637	AusNet	105 minutes after the initiating fault (and 23 minutes after AEMO became aware of a full protection outage on a number of lines) power supply to the KTS communications was restored. This restored the KTS protection communications and re-enabled the line current differential protection on the affected lines. AusNet TOC received alarms notifying its operators that the DPTS – KTS 220 kV line differential protection had been lost at 1452 hrs and restored at 1637 hrs.
1638	AEMO	AEMO NEM RTO started to receive SCADA data from KTS.
1645	AEMO and AusNet	AEMO NEM RTO confirmed to AusNet TOC that it was receiving all expected KTS SCADA data. Although protection had been restored, AusNet TOC had not received confirmation of this from the field and was subsequently unable to confirm to AEMO whether protection had been restored. AEMO subsequently requested clarification regarding any back up protection that was available. AusNet TOC advised that faults on the ATS – KTS, BLTS – KTS, KTS – TTS No. 1 and No. 2, and KTS – WMTS No. 1 and No. 2 lines would be cleared by the remote end but at a slower clearing time. The advice regarding remote end clearance superseded the advice provided at 1614 hrs, however, post-incident review by AusNet has determined that this advice was not correct. AusNet updated this advice to AEMO on 21 August 2023 (see Section 3.4).
1645 to 1658	AEMO	Following this advice, AEMO NEM RTO considered reconfiguring the network to minimise the impact of slower fault clearance times, however this was not actioned as AusNet’s latest advice to AEMO stated that protection was in the process of being restored. Protection had been restored at 1637 hrs, however neither AEMO nor AusNet TOC had received confirmation of its restoration. At the time that AEMO was considering these actions, AusNet first responders were in the process of confirming that protection was already in service.
1658	AusNet and AEMO	AusNet TOC confirmed to AEMO NEM RTO that DC supplies had been restored but could not confirm whether protection had been restored.
1704	AusNet and AEMO	AusNet TOC confirmed to AEMO NEM RTO that all protection at KTS had been returned to service.
1704	Awareness summary	At this time AEMO considered that all protection at KTS had returned to its normal pre-fault state. AusNet TOC was unable to confirm if, prior to the restoration of protection, fault clearance times were within the requirements of NER S5.1.9.
1705 hrs to 1938 hrs: Identifying the non-credible contingency and restoring the network		
1720	AEMO	AEMO invoked constraint set V-LAVNTH1_ZERO, following AEMO’s identification that LNGS No. 1 Gen. transformer 220 kV CB had been opened (at 1452 hrs).
1810	AEMO	AEMO revoked constraint set V-LAVNTH1_ZERO as ATS LNGS No. 1 Gen. transformer 220 kV CB was reclosed at 1803 hrs.
1855	AEMO	AEMO reviewed SCADA that identified that the SCWF had tripped from 44 MW at the time of the fault.
1938	AEMO and Overwatch Energy (operator of SCWF)	Overwatch Energy (operator for the SCWF) confirmed to AEMO that the SCWF reduced its power output to 0 MW at approximately 1453 hrs on 29 June 2023 and that the cause of this reduction was unknown. This made AEMO aware that a non-credible contingency event had occurred, as discussed further in Section 3.4.
1938	Awareness summary	AEMO was now aware that a non-credible contingency event had occurred involving trip of the ATS – KTS 220 kV line and the SCWF.

During the incident the AusNet operator received more than 1000 alarms in 5 minutes and more than 2000 alarms within the first hour. The alarms were presented on a live stream with 32 colour coded alarms appearing on each screen. AusNet has identified that there are still opportunities to improve the way this information is presented to operators.

Post-incident investigation has confirmed that, during the incident, the AusNet SCADA and supporting data was sufficient to allow earlier identification of the protection outage. However, the information readily available to AusNet operators was insufficient to allow them to identify the level of protection that was operational on equipment during the incident.

During the event Transgrid were aware of an outage to line differential protection and did not inform AEMO.²⁵

Post-incident actions in relation to situational awareness are detailed in Section 2.6.

2.5 Response of distributed photovoltaic generation

Based on observations from a sample²⁶ of DPV inverters in Victoria, minimal disconnection (shake-off) of DPV was observed for smaller DPV systems (<30 kW). This is consistent with expectations, given the nature of the event (a voltage dip of 0.62 p.u. was observed on one phase at South Morang, with the other phases remaining above 0.9 p.u.). For larger DPV systems (30-100 kW), a significant proportion (24%²⁷) were observed to disconnect (shake-off). Some of these disconnecting systems were installed recently (in 2023) and if set correctly should demonstrate disturbance ride-through behaviours consistent with the AS/NZS 4777.2:2020 standard. AEMO and Powercor are investigating the cause of the high number of large (>30 kW) DPV unit disconnections.

2.6 Post-incident actions and recommendations

Following the event, AusNet has advised AEMO that it has assessed the risks associated with this incident at KTS and other sites (see item 4 and item 8 in Table 6). The following steps have been taken to reduce the risks of any similar future incidents (see Table 6).

Table 6 Post-incident actions and recommendations

Item	Category	Details
1	Fault on ATS – KTS 220 kV line – bird’s nest	<p>AusNet carried out a line patrol and found evidence of a fault at tower T4 near KTS on the ATS – KTS 220 kV line caused by fallen debris from a bird nest. The patrol also found a bird nest containing metallic material, at tower T23. No evidence of a fault was found at T23. The bird nests were removed.</p> <p>AEMO recommended that AusNet consider reviewing their tower/line procedures in light of this event. AusNet has advised AEMO that:</p> <ul style="list-style-type: none"> Electricity Safety Regulations 2013 require inspection at least every 37 months (bushfire risk areas) or 61 months (other areas) and AusNet’s inspection policy of twice per year greatly exceeds this minimum requirement. Prior to this incident, AusNet had recently undertaken a comprehensive review of its line and tower inspections policy. AusNet therefore considers that their procedures are adequate.
2	DWDM power supply card failure	<p>AusNet replaced three DWDM power supply cards on 29 June 2023 and the remaining two on 30 June 2023. See ‘Root cause analysis’ below for further details.</p>
3	Installation of voltage limiting devices	<p>On 21 August 2023, AusNet advised AEMO that the root cause had been identified as earth potential rise and metal oxide varistor (MOV) spark gap devices had been installed to prevent the communications batteries from tripping if a similar event occurred. AusNet later corrected this advice to AEMO on 6 September 2023, to inform that the root cause had not been determined, and on 8 September 2023, to inform that the MOV spark gap devices had not been installed.</p> <p>On 26 September 2023, AusNet installed voltage limiting devices as a preventative measure.</p>

²⁵ Under NER 4.8.2(a), if a Registered Participant becomes aware that any relevant protection system or control system is defective or unavailable for service, that Registered Participant must advise AEMO.

²⁶ Sixty-second resolution data was collected from a sample of 3,259 DPV circuits in Victoria collected by Solar Analytics, provided under the Australian Renewable Energy Agency (ARENA)-funded Project MATCH led by the University of New South Wales (UNSW) Sydney.

²⁷ Based on a sample of 941 circuits in the Solar Analytics sample in the size range 30-100kW.

Item	Category	Details
4	Root cause analysis	<p>AusNet’s investigation into the root cause of the trip of the A and B 48 V DC supplies and DWDM power supply card failures at KTS is ongoing. Once AusNet’s investigation is complete, AusNet will:</p> <ul style="list-style-type: none"> • Share the findings with AEMO. • Share the findings with relevant industry groups, notably the PSSWG and NEMOC. • Identify whether a review of other terminal station communication, DC systems or contingency plans is required.
5	Auto-reclosure disabled	<p>To reduce the risk of an unprotected line auto-reclosing onto a fault during a future KTS line current differential protection signalling failure, the auto-reclose on the ATS – KTS and BLTS – KTS 220 kV lines was disabled at 1225 hrs on 6 September 2023. AusNet plan for auto-reclose on these two lines to remain disabled as part of the Contingency Plan (see below) to mitigate the risk of multiple lines tripping.</p>
6	Additional protection	<p>AusNet has commissioned additional protection since the event on 29 June 2023. On 24 September 2023, supplementary distance protection elements were configured in the X and Y line current differential protection relays at KTS and backup phase and earth fault overcurrent elements have been configured in the line relays at TTS for the:</p> <ul style="list-style-type: none"> • KTS – TTS 220 kV No. 1 line. • KTS – TTS 220 kV No. 2 line. <p>Between 16 September 2023 and 23 September 2023, supplementary phase and earth fault overcurrent protection elements were configured in the X and Y line current differential protection relays at KTS and the line end station for the:</p> <ul style="list-style-type: none"> • ATS – KTS 220 kV line. • BLTS – KTS 220 kV line. • KTS – WMTS 220 kV No. 1 line. • KTS – WMTS 220 kV No. 2 line. <p>The above changes to protection ensure that each of these six 220 kV lines will continue to be protected if KTS line current differential protection signalling fails and causes current differential protection to be impaired. The protection enables re-securing of the power system via the Contingency Plan.</p>
7	Contingency Plan	<p>To further mitigate potential re-occurrence of a similar event, AusNet has developed and implemented a KTS contingency plan in the unlikely event a subsequent line fault at KTS results in the loss of the A and B communications DC systems and therefore the loss of line current differential protection. The contingency plan has been developed to guide operators on the steps required to re-secure the power system following the non-credible loss of the KTS 220 kV and 66 kV A and B communications.</p> <p>The KTS contingency plan will be activated if all KTS SCADA data becomes suspect and AusNet confirms the loss of KTS communications and protection. When the KTS contingency plan is activated, AusNet will undertake switching via remote control to radialise the load supplied by the KTS lines which are being protected by phase and earth overcurrent protection only to reduce the contingency size. The remote switching should be completed within 30 minutes. As part of the plan, AEMO will be required to constrain the generators at Newport and Laverton North to zero to prevent possible islanding while running this network abnormally. The procedure was issued on 6 October 2023.</p>
8	Risks at other sites	<p>AusNet has considered the likelihood and risk associated with a similar event occurring at other sites in Victoria and advised AEMO of its view that a contingency plan is not required at any other site under the present circumstances.</p>
9	Loss of SCADA from DPTS to AusNet	<p>To improve system reliability, AusNet are planning to implement an alternative SCADA route to DPTS by 30 June 2024.</p>
10	Situational awareness – alarm flooding	<p>Prior to this event, AusNet has proposed a new alarms project to better manage alarms in the future and if approved, is expected to assist in managing alarm flooding.</p> <p>These findings emphasise the importance of recommendation 5 of the 2023 General Power System Risk Review (GPSRR) and AEMO’s Operation Technology Roadmap relating to uplift of operational capabilities.²⁸</p>

²⁸ See Section 6.6 of the 2023 GPSRR at https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2023/draft-2023-general-power-system-risk-review/2023-gpsrr.pdf?la=en.

Item	Category	Details
11	Situational awareness – information available for operators	<p>Following the incident:</p> <ul style="list-style-type: none"> • AusNet has created a protection procedure to enable operators to quickly identify what protection is available during a protection outage on any line in AusNet’s network. The procedure also includes references to the relevant regulatory framework and procedures and emphasises the requirement to promptly notify AEMO of protection system outages.²⁹ • AusNet has completed a post-incident discussion and learning session with operators including training on the new procedure. • AusNet has further shared details of its protection procedure for operators with the Power System Security Working Group (PSSWG). AEMO recommended at the PSSWG that all TNSPs review and update the information readily available to operators to ensure they are able to accurately identify the level of protection which is operational on equipment in the event of DC system, communications equipment or SCADA outages.
12	Situational awareness – notification for loss of protection	<p>Following the event, Transgrid reviewed their procedures and advised that those procedures appropriately identify the requirement to notify AEMO of protection outages. Transgrid has reminded its control room staff to advise AEMO on the loss of protection.</p> <p>AEMO has shared the findings of this event at the PSSWG and reminded all TNSPs of their obligation to notify AEMO of all transmission system protection outages.</p>

²⁹ Under NER 4.8.2(a), if a Registered Participant becomes aware that any relevant protection system or control system is defective or unavailable for service, that Registered Participant must advise AEMO.

3 Power system security

AEMO is responsible for power system security in the 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 NER³⁰.

3.1 Protection

During a protection outage, the power system may not be in a secure operating state as the satisfactory limits of the power system would be exceeded following a credible contingency event. In this incident, five 220 kV lines had no effective primary, supplementary or back up protection between 1453 hrs and 1645 hrs. The absence of this protection means that an elongated or uncleared fault could have occurred on the power system, with a high likelihood of exceeding the satisfactory limits of several elements. Consequently, AEMO considers that the power system was not in a secure operating state for 105 minutes.

AEMO was advised of a KTS protection outage at 1614 hrs on 29 June 2023 by AusNet TOC. Following this advice, the AEMO and AusNet control rooms were in frequent discussions regarding management of the power system security issue as detailed in Section 2.4. In accordance with NER 4.6.5(b), AEMO considered reconfiguring the network however this was not actioned based on advice from AusNet TOC that protection restoration was underway. All affected protection was restored at 1637 hrs and AusNet TOC was advised by its staff at KTS shortly before 1704 hrs that protection had been restored. AusNet TOC advised AEMO at 1704 hrs that all protection at KTS had returned to its normal pre-fault state.

3.2 Frequency

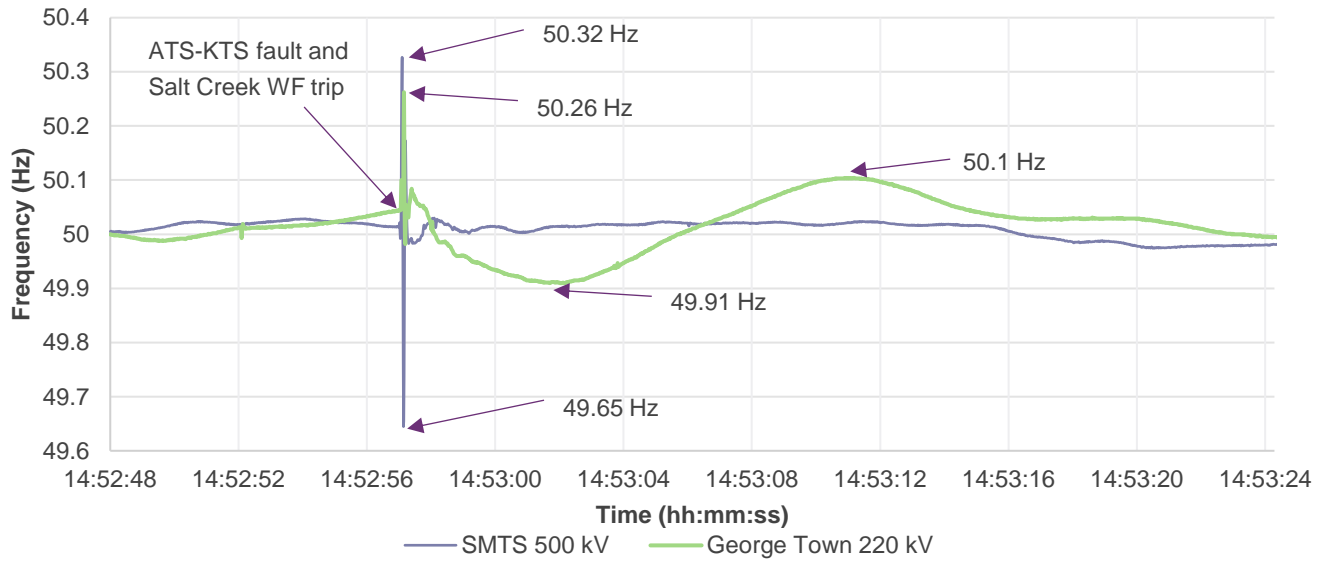
The frequency recorded during the event is shown below in Figure 4. During the fault on ATS – KTS 220 kV, frequency was recorded by a phasor measurement unit (PMU) at SMTS as low as 49.65 hertz (Hz) and as high as 50.32 Hz. Frequency recorded at George Town in Tasmania was recorded to peak at 50.26 Hz, as the fault influenced the Tasmania region via the Basslink interconnector.³¹

³⁰ 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.

³¹ PMUs are not expected to accurately record frequency during a fault due to the ongoing waveform distortion.



Figure 4 Frequency as recorded by phasor measurement units (PMUs) on 29 June 2023



Following clearance of the fault, frequency at SMTS returned to normal frequency ranges. Post-fault frequency at George Town had damped oscillations with a minimum frequency of 49.91 Hz and a maximum frequency of 50.1 Hz. The Frequency Operating Standard (FOS)³² was met for this incident.

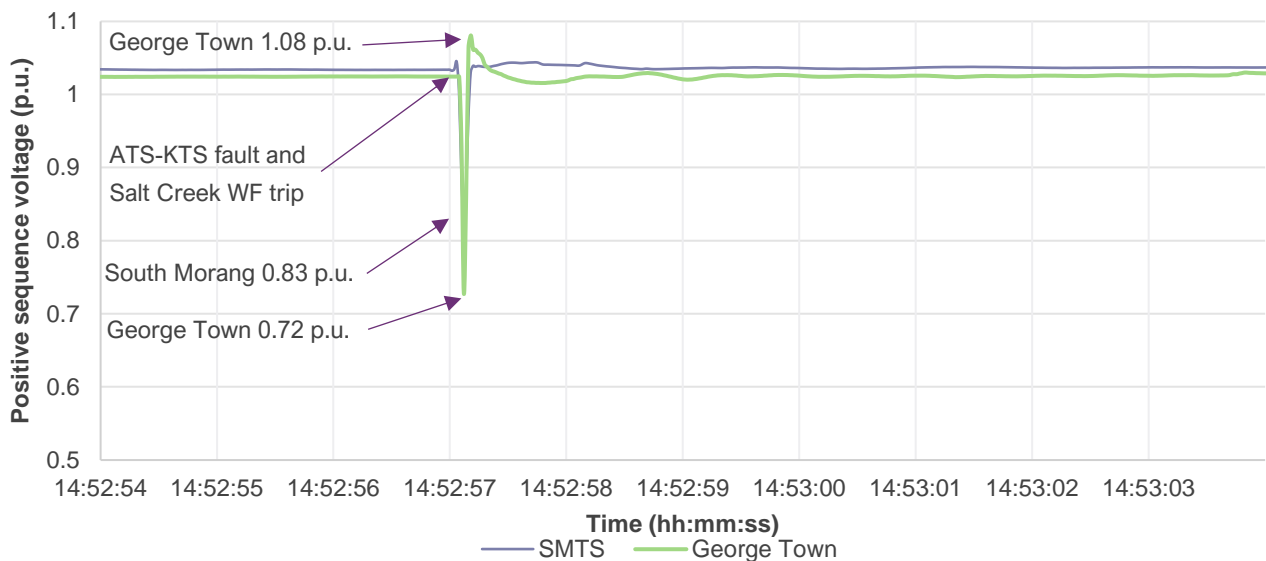
3.3 Voltage

At no point during this incident were transmission system voltages outside of relevant voltage limits defined in the NER, or specified by NSPs in their limits advice to AEMO. Figure 5 shows that the positive sequence voltage at SMTS dipped to 0.83 p.u. during the fault and recovered to within the normal operating values following clearance of the fault. The positive sequence voltage measured at George Town in Tasmania dipped to 0.72 p.u. during the fault and peaked at 1.08 p.u. following clearance of the fault.

³² Frequency Operating Standard, effective 1 January 2020, available at <https://www.aemc.gov.au/media/87484>.



Figure 5 Voltage at South Morang Terminal Station and George Town on 29 June 2023



3.4 Reclassification

In this section AEMO has assessed the appropriateness of AEMO’s actions on whether to reclassify any event relating to this incident as a credible contingency event³³.

Trip of the ATS – KTS 220 kV line and the Salt Creek wind farm

At 1938 hrs on 29 June 2023, Overwatch Energy (operator for the SCWF) advised AEMO that the SCWF reduced its power output to 0 MW at approximately 1453 hrs on 29 June 2023 and that the cause of this reduction was unknown.

Based on this advice, AEMO appropriately assessed the simultaneous trip of the ATS – KTS 220 kV line and the SCWF to be reasonably possible under the present circumstances. At 2051 hrs on 29 June 2023, AEMO issued Market Notice (MN) 108788 to reclassify the simultaneous trip of the ATS – KTS 220 kV line and the SCWF as a credible contingency event until further notice.

Tilt Renewables corrected the parameter in consultation with AEMO on 30 August 2023. Following advice that the parameter which had caused the trip had been corrected, AEMO appropriately assessed the simultaneous trip of the ATS – KTS 220 kV line and the SCWF to be no longer reasonably possible under the present circumstances. At 1205 hrs on 3 October 2023, AEMO issued MN 110111 to advise the market that the reclassification of trip of the ATS – KTS 220 kV line and the SCWF had been removed from 1200 hrs 3 October 2023.

³³ 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).



Trip of the ATS – KTS 220 kV line and the loss of protection

Background

Following a contingency event, AEMO should take all reasonable actions to return the power system to a secure operating state³⁴ within 30 minutes, in accordance with NER 4.2.6(b). During the KTS A and B 48 V DC communications outage, the power system was not in a secure operating state (see Section 3.1) and if this outage was to re-occur AEMO would be required to take actions to re-secure the power system in accordance with NER 4.6.5. As the network at KTS is highly meshed, it is unlikely that this could have been achieved within 30 minutes at the time of the incident.

Following the incident, AusNet has commissioned additional protection and developed a contingency plan in case of a re-occurrence (see Section 2.3.2). AEMO is satisfied that the power system can be re-secured within 30 minutes should this event re-occur.

Reclassification decisions

Following AusNet's advice at 1645 hrs on 29 June 2023 that faults would be cleared by the remote end, AEMO was not made aware that all protection was lost on several lines at KTS until 21 August 2023. This advice was shared with AEMO in the 21 August 2023 report from AusNet, and the report also stated that the fault was caused by GPR and that metal oxide varistor (MOV) spark gap devices had been installed to mitigate the risk of re-occurrence of the event. Based on this advice, AEMO appropriately assessed that abnormal conditions were not present, and that re-occurrence of this event was unlikely under the present circumstances.

Between 4 September 2023 and 7 September 2023, AusNet provided a series of updates to AEMO to advise that:

- The root cause of the trip of KTS A and B 48 V DC communications batteries was still under investigation.
- MOV spark gap devices would not eliminate the risk of re-occurrence of the communications and protection outage.
- There is a possibility that a fault on any feeder connected to KTS could cause the loss of both 48 V DC supplies at KTS. However, AusNet also advised that the probability of such a fault occurring and subsequently causing the loss of both 48 V DC supplies was unlikely.
- Auto-reclose had been disabled on ATS – KTS and BLTS – KTS 220 kV lines on 6 September 2023.
- AusNet had been developing a contingency plan to resecure the system should a communication and protection outage reoccur.

In accordance with the reclassification criteria, the relevant network service provider (NSP) was consulted before deciding on the best course of action in response to any risks presented by abnormal conditions. Based on this advice, AEMO determined not to reclassify the event.

Following the commissioning of additional supplementary protection between 16 September 2023 and 24 September 2023, and issuing of the contingency plan to manage a re-occurrence of this incident on 6 October 2023, AEMO is satisfied that the power system can be re-secured within 30 minutes should this incident re-occur. Based on this, AEMO has assessed there is no increased risk to the power system and does not need to

³⁴ As defined in NER 4.2.4.



consider reclassifying this event. AEMO may re-evaluate this decision if new information is provided by AusNet regarding the risks or mitigations.

AEMO has reminded AusNet of the importance of providing accurate information in relation to power system security issues. AusNet has reviewed internal processes for communication with site staff, and spoken with those staff involved in miscommunication in relation to this event, to minimise the potential for recurrence.

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 market³⁵ over the course of this incident.

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

- Notification of a non-credible contingency event – notify within two hours of receiving the information³⁶.
 - At 1938 hrs on 29 June 2023, Overwatch Energy advised AEMO that the SCWF reduced output to 0 MW at 1453 hrs. This information made AEMO aware that a non-credible contingency event had occurred.
 - AEMO issued MN 108788 at 2051 hrs on 29 June 2023, advising of the non-credible contingency event.
- Reclassification, details, and cancellation of a non-credible contingency – notify as soon as practicable³⁷.
 - AEMO issued MN 108788 at 2051 hrs on 29 June 2023 to advise the market that trip of the ATS – KTS 220 kV line and the SCWF had been reclassified as a credible contingency event from 2045 hrs on 29 June 2023 until further notice.
 - AEMO issued MN 110111 at 1205 hrs on 3 October 2023 to advise the market that the reclassification of trip of the ATS – KTS 220 kV line and the SCWF as a credible contingency had been removed from 1200 hrs 3 October 2023.

³⁵ AEMO generally informs the market about operating incidents as they progress by issuing Market Notices – see <https://www.aemo.com.au/Market-Notices>.

³⁶ 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 7.3.

³⁷ AEMO is required to notify the market of a reclassification – NER 4.2.3A(g), details of the reclassification – NER 4.2.3A(c), and when AEMO cancels the reclassification – NER 4.2.3A(h).

A1. System diagram

The diagram below provides an overview of part of the power system immediately after the incident.

Figure 6 Network configuration after auto-reclosure

