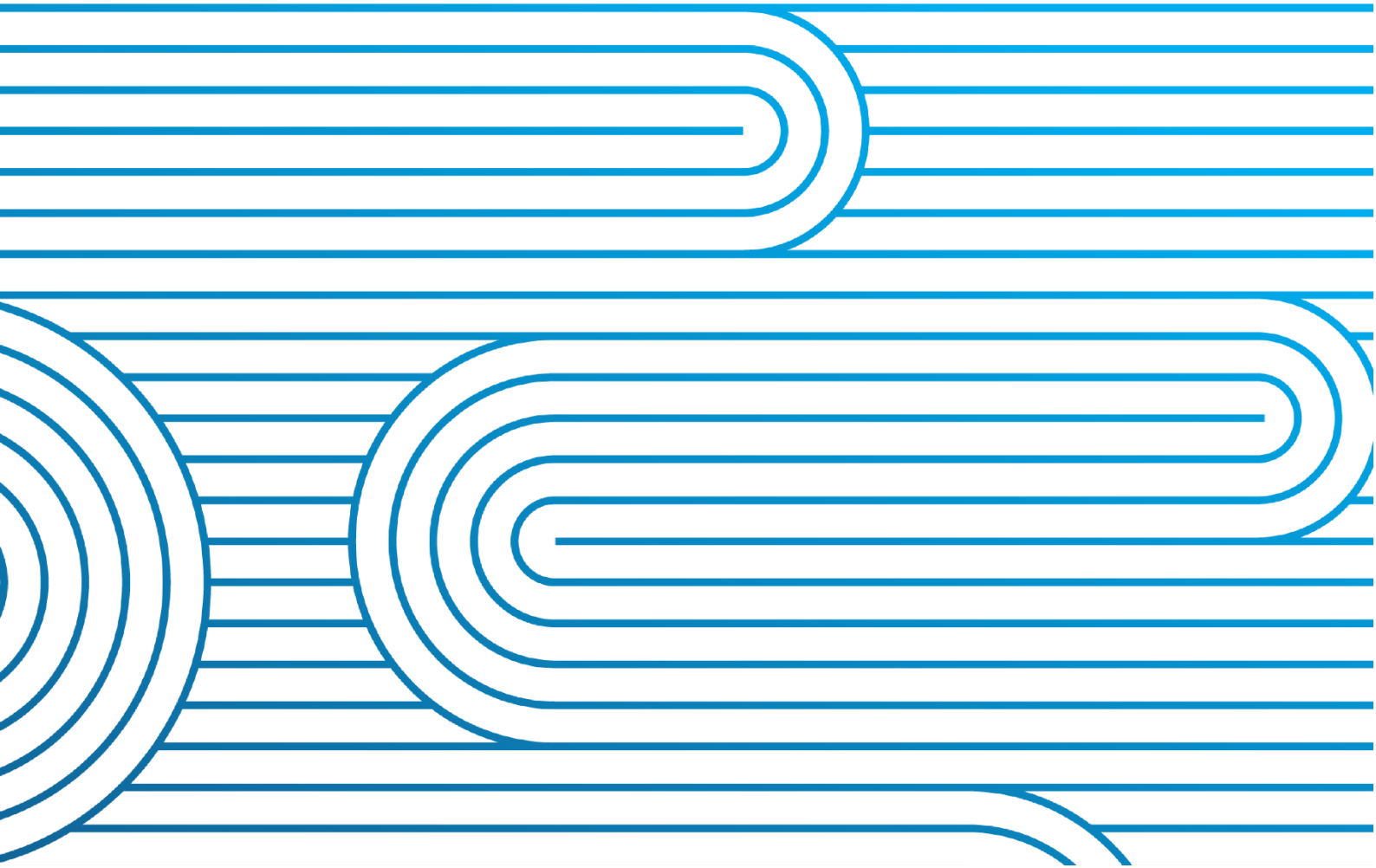
TRANSPOWER

Causation Report
21 December 2024
Under-Frequency Event

System Operator event 4523

May 2025



IMPORTANT

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Contents

1 PURPOSE

On 21 December 2024 the system frequency in the North Island fell below 49.25 Hz, resulting in an under-frequency event (**UFE**).

Pursuant to clause 8.60 of the Electricity Industry Participation Code (**Code**), the System Operator investigated the event to assist the Electricity Authority (**Authority**) in determining a causer of the under-frequency event.

This Causation Report is provided to the Authority pursuant to clause 8.60(5) of the Code and includes the following:

- The System Operator's recommendation of the causer of the under-frequency event.
- The System Operator's reasons for forming its view.
- The information considered in reaching this view.

2 EXECUTIVE SUMMARY

On 21 December 2024, two faults, most likely caused by lightning strikes, occurred on the network between Wairakei and Redclyffe causing both a loss of supply to the Hawke's Bay region and disconnecting generation in the region. The resulting reduction in generation led the North Island frequency to drop to 49.2 Hz at 14:45:53.

Both faults occurred on the Grid Owner's transmission lines – the first one tripped the Tauhara B - Wairakei circuit, the second was a double circuit fault which tripped both the 220 kV circuits supplying Hawke's Bay.

This second fault resulted in the disconnection of generation from Tauhara B, Te Huka C, Harapaki Wind Farm, Tuai and Piripaua with a combined total loss of 391.38 MW of power injection into the system; and a loss of supply for the Hawke's Bay region. The loss of generation and load led to a net export reduction of 224 MW, and a drop in North Island frequency to 49.2 Hz leading to the UFE

The System Operator investigation found that the direct cause of the UFE was the second double-circuit fault which tripped both the Grid Owner's Whirinaki-Wairakei and Harapaki-Tauhara B circuits.

2.1 RECOMMENDATION OF UFE CAUSER

In accordance with clause (a) of the definition of "causer" in Part 1 of the Code, the System Operator recommends that the Transpower in its capacity as Grid Owner be found as the causer of the UFE.

Although the investigation found the second fault disconnected generation, it also found that, without the first fault, the UFE may have been avoided. Specifically, if the Tauhara B-Wairakei circuit been returned to service then the second fault would likely not have disconnected the Tauhara B and Te Huka C stations, and the UFE could have been avoided.

2.2 OTHER RECOMMENDATIONS

The System Operator recommends that the Grid Owner investigate the cause of three pole tripping of Tauhara B CB662 for the recorded single-phase fault, and if this reveals a breach of Schedule 8.3 of the Code, to initiate the self-breach process.

The System Operator also supports the Grid Owner's own recommendation – as mentioned in the Grid Owner's Interruption Report on the Hawke's Bay Loss of Supply, 21 December 2024, sent to the Commerce Commission – to revisit the assumptions detailed in the 2017-18 protection review and assess whether they are still valid. The System Operator would be particularly interested in how effective single pole trip auto reclose schemes are in reducing the risk of supply loss, and in how increased generation on circuits between Wairakei and Redclyffe may increase the likelihood of further under-frequency events.

3 SYSTEM EVENT – 21 DECEMBER 2024

3.1 PARTICULAR ASPECTS OF THIS EVENT

This event has been complex to assess compared with other UFEs caused by one fault that results in disconnection of generation. In particular:

- There was only one UFE, but there were two faults on the transmission system within 7s of each other on closely connected circuits.
- The second fault disconnected generation and resulted in a loss of supply to the Hawke's Bay region. However, without the first fault, the UFE may have been avoided.
- Protection for the fault which triggered the UFE (the second fault) appears to have operated as expected, but the System Operator's investigation into the operations for the first fault have been more complex to assess.
- Immediately preceding the UFE, the Hawke's Bay region had a net export of 224 MW. With a total generation 1.75 times this amount, a significant portion of the locally generated power was supplying the Hawke's Bay region's electricity demand, which was also lost during the event.

3.2 SITUATION PRIOR TO THE UNDER-FREQUENCY EVENT

All transmission assets in the region ahead of the event were in service. Generation in the region was operating as expected for the market conditions with Tuai (TUI), Piripaua (PRI), Harapaki (HRP), Te Huka C (TAC) and Tauhara B (TAB) all generating. There was a severe thunderstorm weather watch in place with lightning recorded.

3.3 THE UNDER-FREQUENCY EVENT

Two faults, most likely caused by lightning strikes, occurred on the network between Wairakei and Redclyffe causing both a loss of supply to the Hawke’s Bay region and disconnecting generation injecting into this part of the network or into Hawke’s Bay region. The resulting reduction in the net generation export from the Hawke’s Bay region led the North Island frequency to drop to 49.2 Hz at 14:45:53.

The first fault occurred at 14:45:43. In response to this first fault, confirmed by the Grid Owner as a blue phase to ground fault (a single pole fault), Tauhara B CB662 tripped all three poles and initiated an auto reclose sequence with a 15 second deadtime. This removed one of two circuits connecting Tauhara B and Te Huka as well as Harapaki to the rest of network. This circuit remained out of service ahead of the second fault.

The second fault occurred 7 seconds later at 14:45:50 and was a two phase to ground fault as confirmed by the Grid Owner. This triggered the initial tripping of two 220 kV circuits, disconnecting Tauhara B, Te Huka C, Harapaki Wind Farm, Tuai, and Piripaua, and resulting in the loss of 168 MW of load and generation supply to Hawke's Bay.

The disconnection of Tauhara B and Te Huka C removed approximately 212.38 MW, while 163.9 MW was removed due to the loss of Harapaki Wind Farm. The disconnection of Tuai and Piripaua stations removed another 15.1 MW of generation injection into the power system. A total of 391.4 MW generation was disconnected. The reduction in net export from the region was 224 MW. The loss of this net generation export caused the North Island frequency to fall to 49.2. At 14:46:10, the grid frequency returned to normal band. Figure 1 below shows the frequency over the event timeframe and the reduction in total generation.

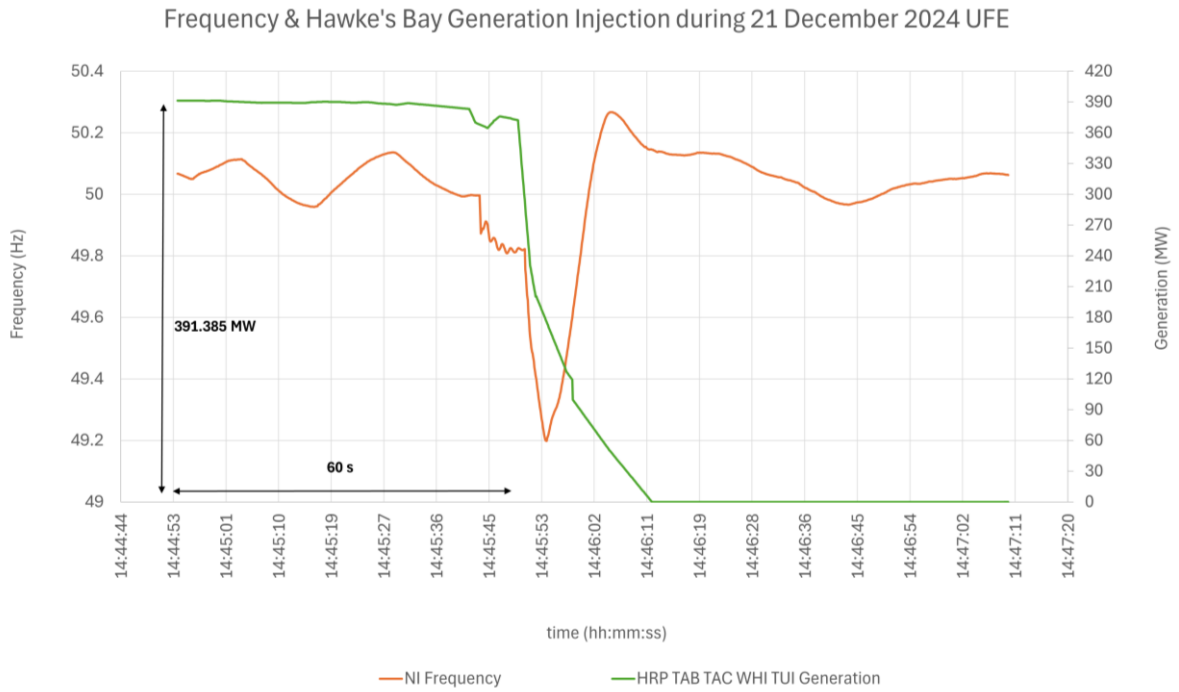


Figure 1: Graph of Frequency and Generation in Hawke's Bay during the 21/12/2024 UFE

Please note *the System Operator's graph above may not map precisely to tripping of the Hawke's Bay generation. This is because there is a time delay in the System Operator's SCADA data*.

3.4 EVENT INVESTIGATION

The System Operator undertook an investigation taking into account System Operator data and information provided by the Grid Owner and Generators in response to System Operator information requests.

Details of this investigation are provided in the System Operator Event Report 4523.

The investigation found that the trigger of the UFE was the second double circuit fault which tripped both Whirinaki-Wairakei and Harapaki-Tauhara B. However, if protection and autoreclose had operated differently for the first fault which tripped Tauhara B – Wairakei and this circuit had been returned to service before the second fault, the UFE could have been avoided.

The investigation found there were contributing factors which increased the likelihood of the event.

These factors are:

1. The affected sections of circuits did not have overhead earth wires which would have reduced the chances of direct lightning strikes to a transmission line or tower causing faults.

2. Protection on Tauhara B CB662 operated as a 3-phase trip for the first fault, for what appears to be a single phase to ground fault.
3. Auto reclose for a three phase trip involves a 15 second deadtime which was longer than the 7s between the faults.
4. There is a high amount of generation connected between Wairakei and Redclyffe which increases the risk of a UFE from transmission line faults.

3.5 RECOMMENDATIONS FOLLOWING EVENT INVESTIGATION

The System Operator's investigation has identified the above contributing factors, included analysis of the faults and observation of protection operation sufficient to recommend a causer.

The investigation also raised questions around the operation of protection for the first fault, noting that protection on Tauhara B CB662 operated for a 3-phase fault for what appears to be a single phase to ground fault. However, the System Operator does not have the protection expertise to comment on or to recommend measures and best practices with regards to protection design. With this in mind, the investigation recommends:

- The Grid Owner investigate the root cause of the protection relay initiating a three pole operation at Tauhara B CB662 instead of a single pole operation.
- The Grid Owner to initiate the self-breach process if the above investigation reveals a breach of Schedule 8.3 clause 4 (4) (a) (ii) of the Code.

The System Operator also supports the Grid Owner's own recommendation – as mentioned in the Grid Owner's Interruption Report on the Hawke's Bay Loss of Supply, 21 December 2024, sent to the Commerce Commission – to revisit the assumptions detailed in the 2017-18 protection review and assess whether they are still valid. The investigation has raised questions about the protection operations and the System Operator would be particularly interested in how effective single pole trip auto reclose schemes are in reducing the risk of supply loss, and in how increased generation on circuits between Wairakei and Redclyffe may increase the likelihood of further under-frequency events.

4 RATIONALE FOR CAUSER RECOMMENDATION

The investigation found that the UFE was triggered by the second double circuit fault which tripped both Whirinaki-Wairakei and Harapaki-Tauhara B and disconnected generators with a combined gross injection at the time of 391 MW – leading to a 224 MW reduction in the region's net export.

The Grid Owner's statement has noted the anti-islanding protection operated after the loss of their circuits, which resulted in Tauhara B, Te Huka C, Harapaki, Piripaua and Tuai being disconnected from the Grid. The System Operator agrees with the Grid Owner's note, as the sequence of events met the conditions of the anti-islanding schemes to arm and operate.

Data from the Generators confirms this assessment.

- Tauhara B and Te Huka C generating stations disconnected as the loss of the Tauhara B-Wairakei, Harapaki-Tauhara B and Whirinaki-Wairakei circuits, satisfies the anti-islanding conditions for the plants.
- Harapaki station's anti-islanding scheme tripped CB242 and CB282.
- The Piripaua and Tuai generation stations responded to support the grid, and subsequently tripped on under frequency protection as the local frequency in the region fell below 43.5 Hz. Due to their comparatively small generation injection, their disconnection alone would not have been sufficient to trigger the under-frequency event.

The investigation has found no other generator act or omission or property caused the circuits to trip.

In accordance with clause (a) of the definition of "causer" in Part 1 of the Code, if an interruption or reduction of electricity from a grid owner's assets is caused by the Grid Owner's property, the 'causer' in relation to that under-frequency event is the Grid Owner.

The System Operator recommends that the causer of the UFE on 21 December 2024 was the Grid Owner, based on the finding that the 220 kV circuit faults, most likely caused by lightning, resulted in the disconnection of generation.

We note that the Grid Owner, in its response to requests for information from the System Operator, set out its view that clause (c) in the definition of "causer" in Part 1 of the Code applies. In the Grid Owner's view the protection and autoreclose operated as expected and in compliance with Code requirements.

It is the System Operator's view that even if clause (c) applied, there are other factors that the System Operator's investigation identified that call into question whether or not the Code requirements have been complied with. The investigation considered the operation of protection for the first fault, noting that protection on Tauhara B CB662 operated as a three-pole trip for what appears to be a single phase to ground fault. However, the System Operator does not have the protection expertise to provide detailed, further analysis on this point. We have therefore recommended that the Grid Owner investigate the root cause of the protection relay initiating a three-pole operation at Tauhara B CB662 and 15s autoreclose deadtime instead of a single pole operation with 1s autoreclose deadtime (if they have not already done so).

It is for the Authority to decide whether clause (c) in the definition of "causer" in Part 1 of the Code applies in this case.

5 CALCULATION OF MW LOST

The purpose of this calculation is to determine the MW value provided to the clearing manager for the purposes of calculating the under-frequency event charge.

The System Operator follows the procedure 'Calculating the Amount of MW lost' (PR-RR-017) to determine the MW lost. This procedure follows the formula set out in clause 8.64 of the Code for calculating an event charge.

The event charge payable by the causer of an under-frequency event (referred to as "Event e" below) must be calculated in accordance with the following formula:

$$EC = ECR \times \left(\sum_{y} (INT_{y,e} \; for \; all \; y) - INJ_D \right)$$

where

EC is the event charge payable by the causer

ECR is $1,250 per MW

INJ_D is 60 MW

$INT_{y,e}$ is the electric power (expressed in MW) lost at point y by reason of Event e (being the net reduction in the injection of electricity (expressed in MW) experienced at point Y by reason of Event e) excluding any loss at point y by reason of secondary Event e

y is a point of connection or the HVDC injection point at which the injection of electricity was interrupted or reduced by reason Event e

As the ECR and INJ_D values are constants the values to calculate and complete the formula are y and $INT_{y,e}$.

Using the event charge formula the calculation is as follows:

Event Charge = $1,250/MW * (391.38MW – 60MW)

Event Charge = $414,225.00

6 CORRESPONDENCE

6.1 CONFIRMATION OF EVENT NOTICE

Note the X-axis on the chart in the notice is incorrectly labelled. The x-axis should be 14:45:03 – 14:46:43. Note, while regrettable this error is immaterial and was of no consequence.

TRANSPOWER CAN

Customer Advice Notice

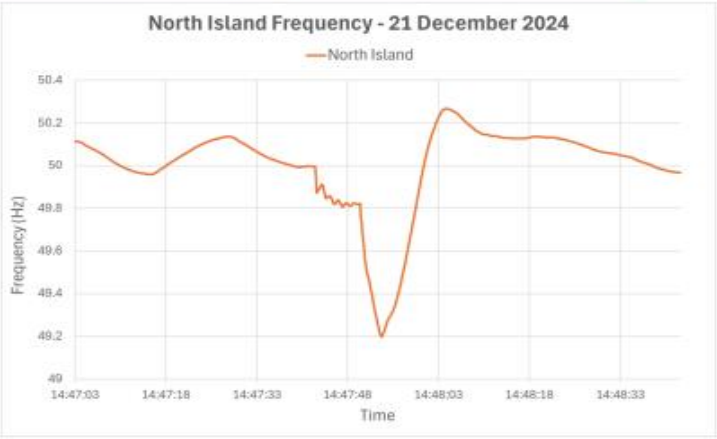
To:	CAN NZ Participants	**From:**	The System Operator
Sent:	23-dec-2024 14:27	**Telephone:**	0800 488 500
Ref:	5860305393	**Email:**	NMData@transpower.co.nz

Revision of:

Under-Frequency Event Confirmation

The system operator wishes to advise market participants of an under-frequency event which occurred in the North Island on 21 December 2024.

Event ID	4523
Affected Islands:	North Island
North Island Minimum Frequency:	49.20 Hz
Time (start of UFE):	14:45:53
Time (of min. frequency):	14:45:54



The System Operator is investigating the cause of the following under-frequency event in accordance with Part 8, clause 8.60 (1) of the Electricity Industry Participation Code 2010. Ancillary Services Agents who were dispatched to provide instantaneous reserves at the time of the event should be prepared to provide information to the System Operator within 5 Business Days of receiving a request for information in accordance with their Ancillary Service Procurement Contracts.

Market Operations
Transpower NZ Ltd
P.O. Box 1021,
Wellington 6140,
New Zealand
Telephone: 04 590 7470
market.operations@transpower.co.nz

A revision of this notice will be issued if there is any change to the situation above.

Transpower New Zealand Ltd The National Grid

6.2 REQUESTS FOR INFORMATION

6.2.1 System Operator request for information – [Contact Energy]

TRANSPOWER

Waikoukou
22 Boulcott Street
PO Box 1021, Wellington
New Zealand
Telephone +64-4-590 7000
Facsimile: +64-4-495 7100

22 January 2025

Gerard Demler
Contact Energy
96 The Terrace
Wellington

Dear Gerard,

21 December 2024 Under-Frequency Event

At 14:45:53 on 21 December 2024 an under-frequency event occurred in the North Island. We are investigating the event and require the following information from you:

- We have assessed the MW lost during the event as 160 MW at Tauhara B (TAB) and 52 MW at Te Huka Unit 3 (TAC). Can you please confirm this assessment or provide data that indicates a different value of MW lost. We rely on SCADA data, but your data from site may be more accurate.
- Could you explain what initiated circuit breakers TAB 1, TAB G1, TAC 4, TAC G1, TAB 1022, TAB CB 742 and TAB CB 652 to trip, i.e. fault condition, anti-islanding and/or other. Please provide details in the explanation.
- Could you provide any other information regarding the event and what you believe may have caused the under-frequency to occur on 21 December 2024.
- Please advise whether or not you could have been the causer of the under-frequency event as per the Code.

Please provide the above information to us in writing by **5pm on 21 February 2025.**

The information you provide will be used by the system operator to recommend to the Electricity Authority who the causer of the event was. The Electricity Authority will make the final determination of causer.

Please contact me if you require any further information.

Yours sincerely,

Ivani Molver
System Operator Investigator
Power System Engineer

CC:
Samantha Naidoo
Corporate Counsel-Compliance & Impartiality

6.2.2 System Operator request for information – [Genesis Energy]

TRANSPOWER

Waikoukou
22 Boulcott Street
PO Box 1021, Wellington
New Zealand
Telephone +64-4-590 7000
Facsimile: +64-4-495 7100

22 January 2025

Steve Leppien
Genesis Energy
Private Bag 3131
Hamilton

Dear Steve,

21 December 2024 Under-Frequency Event

At 14:45:53 on 21 December 2024 an under-frequency event occurred in the North Island. We are investigating the event and require the following information from you:

- We have assessed the MW lost during the event as 9 MW at Tuai (TUI), 6.5 MW at Piripua (PRI). Can you please confirm this assessment or provide data that indicates a different value of MW lost. We rely on SCADA data, but your data from site may be more accurate.
- Could you explain what initiated the breakers for the Waikaremoana Scheme of generators to trip, i.e. fault condition, anti-islanding and/or other. Please provide details in the explanation.
- Could you provide any other information regarding the event and what you believe may have caused the under-frequency to occur on 21 December 2024.
- Please advise whether or not you could have been the causer of the under-frequency event as per the Code.

Please provide the above information to us in writing by **5pm on 21 February 2025.**

The information you provide will be used by the system operator to recommend to the Electricity Authority who the causer of the event was. The Electricity Authority will make the final determination of causer.

Please contact me if you require any further information.

Yours sincerely,

Ivani Molver
System Operator Investigator
Power System Engineer

CC:
Samantha Naidoo
Corporate Counsel-Compliance & Impartiality

6.2.3 System Operator request for information – [Meridian Energy]

TRANSPOWER

Waikoukou
22 Boulcott Street
PO Box 1021, Wellington
New Zealand
Telephone +64-4-590 7000
Facsimile: +64-4-495 7100

22 January 2025

Rhys Bailey
Meridian Energy
98 Customhouse Quay
Wellington

Dear Rhys,

21 December 2024 Under-Frequency Event

At 14:45:53 on 21 December an under-frequency event occurred in the North Island. We are investigating the event and require the following information from you:

- We have assessed the MW lost during the event as 162 MW at Harapaki (HRP). Can you please confirm this assessment or provide data that indicates a different value of MW lost. We rely on SCADA data, but your data from site may be more accurate.
- We have noted in our assessment that HRP was dispatched at 99.49 MW. Can you confirm that this is correct. If correct, can you provide an explanation for HRP deviating from dispatch value by approximately 62 MW.
- Could you explain what initiated CB 242, CB 282, CB 31 and CB 32 to trip i.e. fault condition, anti-islanding condition or other. Please provide details in the explanation.
    - If it was a fault condition, can you specify the fault and expected protection operation, and can you provide information about the fault ride through capability of the plant and the actual fault ride through performance for this event.
- Could you provide any other information regarding the event and what you believe may have caused the under-frequency to occur on 21 December 2024.
- Please advise whether or not you could have been the causer of the under-frequency event as per the Code.

Please provide the above information to us in writing by **5pm on 21 February 2025**.

The information you provide will be used by the system operator to recommend to the Electricity Authority who the causer of the event was. The Electricity Authority will make the final determination of causer.

Please contact me if you require any further information.

Yours sincerely,

Ivani Molver
System Operator Investigator
Power System Engineer

CC:
Samantha Naidoo
Corporate Counsel-Compliance & Impartiality

6.2.4 System Operator request for information – [Grid Owner]

TRANSPOWER

Waikoukou
22 Boulcott Street
PO Box 1021, Wellington
New Zealand
Telephone +64-4-590 7000
Facsimile: +64-4-495 7100

22 January 2025

Mao Reyes
Grid Compliance Manager
Grid Owner
Transpower
Wellington

Dear Mao,

21 December 2024 Under-Frequency Event

At 14:45:53 on 21 December 2024 an under-frequency event occurred in the North Island. We are investigating the event and require the following information from you:

- SCADA indicates there is an Auto Reclose (A/R) functionality on the TAB-WRK circuit. Can you confirm if TAB CB 662 has A/R functionality?
- Can you explain why TAB CB 662 tripped. Can you confirm if A/R was attempted on TAB CB 662, and if it was why was it unsuccessful? Please provide details in the explanation.
- Can you explain the A/R trip to lockout Grid Owner philosophy and does this apply to all sites?
- HRP and TAB have anti-islanding schemes, can you provide information on how this scheme is expected to perform when one electrical path from each generator to WRK is open and the second electrical path from each generator to WRK auto recloses.
- Can you confirm why WRK CB 172, WHI CB 512, TAB CB 682 and HRP CB 232 tripped i.e. fault condition, anti-islanding condition or other. Please provide details in the explanation.
- Could you provide any other information regarding the event and what you believe may have caused the under-frequency to occur on 21 December 2024.
- Please advise whether or not you could have been the causer of the under-frequency event as per the Code.

Please provide the above information to us in writing by **5pm on 21 February 2025**.

The information you provide will be used by the system operator to recommend to the Electricity Authority who the causer of the event was. The Electricity Authority will make the final determination of causer.

Please contact me if you require any further information.

Yours sincerely,

Ivani Molver
System Operator Investigator
Power System Engineer

CC:
Samantha Naidoo
Corporate Counsel-Compliance & Impartiality

6.3 RESPONSES

6.3.1 Contact Energy response

18 February 2025

Ivani Molver
System Operator Investigator
Power System Engineer
cc: Samantha Naidoo
Corporate Counsel – Compliance & Impartiality

Transpower New Zealand Ltd
22 Boulcott Street
Wellington 6011

Dear Ivani,

Subject: 21 December Under-Frequency Event

Thank you for your letter of enquiry dated 22 January 2025. I have sought information from site on this matter and their response to your enquiries are outlined below:

- *We have assessed the MW lost during the event as 160 MW at Tauhara B (TAB) and 52 MW at Te Huka Unit 3 (TAC). Can you please confirm this assessment or provide data that indicates a different value of MW lost. We rely on SCADA data, but your data from site may be more accurate.*

  Contact can confirm that your assessment is correct, our records show 160.9 MW and 52.46 MW from Tauhara B (TAB) and Te Huka Unit 3 (TAC) respectively.

- *Could you explain what initiated circuit breakers TAB 1, TAB G1, TAC 4, TAC G1, TAB 1022, TAB CB 742 and TAB CB 652 to trip, i.e. fault condition, anti-islanding and/or other. Please provide details in the explanation.*

  On the 21st of December 2024 at 14:45 hrs. the 220 kV transmission circuits Tauhara (TAB) - Wairakei (WRK) 1, Wairakei (WRK) - Whirinaki (WHI) 1 and Harapaki (HRP) - Tauhara (TAB) 1 transmission circuits tripped due to a lightning storm in the vicinity of these circuits. This grid event initiated an anti-islanding trip signal to both TAB and TAC inter-tripping both units causing the associated under-frequency event.

Contact Energy Limited Level 2 Harbour City Tower, 29 Brandon Street, Wellington 6011 | PO Box 10742, Wellington 6143
P: +64 4 499 4001 | **F**: +64 4 499 4003 | **W**: contactenergy.co.nz

- *Please advise whether or not you could have been the causer of the under-frequency event as per the Code.*

As the disconnection of both units was initiated by a grid event outlined in our response above, rather than a fault on our units and/or internal systems (either primary and/or secondary), Contact believes that we are not the causer of this under-frequency event as per the Code.

If you require further information on this matter, please get in touch with me in the first instance. Our engineering team are available to discuss any details of their response above.

Yours sincerely,

Gerard Demler
Transmission Manager, Contact Energy

6.3.2 Genesis Energy response

Genesis Energy Limited
The Genesis Energy Building
94 Bryce Street
Private Bag 3131
Hamilton 3204
New Zealand

T. 07 982 7909

28 January 2025

Ivani Molver
System Operator Investigator
Transpower New Zealand Limited
P O Box 1021
WELLINGTON 6140

By email: ivani.molver@transpower.co.nz

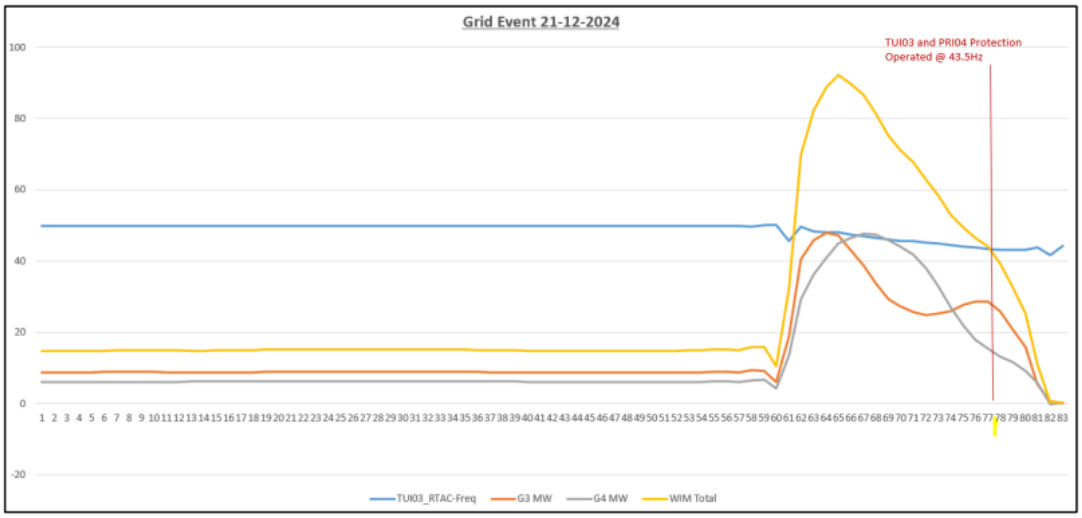
Dear Ivani,

RE: 21st December 2024 Under-Frequency Event

I refer your letter dated 22 January 2025 requesting information from Genesis to help identify the causer of the 21st of December 2024 under-frequency event.

Loss of Injection Figures:
Genesis concurs with Transpower's assessment of the loss of injection figures for Tuai and Piripaua.

Explain What Initiated the Breakers at Waikaremoana to Trip
TUI03 and PRI04 were running at Waikaremoana. Post the Transpower 220kV circuit trippings into Hawkes Bay the two running units attempted to pick up load. But in an islanded/constrained grid situation, they could not match the load demand. The frequency and voltage collapsed at Tuai, and both units tripped at 14:45:51 on under frequency stage 4 protection when the local frequency went below 43.5Hz. The trend below shows the Hz, and the MW of both units.



Could you provide any other information regarding the event and what you believe may have caused the under-frequency to occur on 21 December 2024:

Genesis refers to the Transpower Event/Fault Report (HWB Event Report 21_12_2024) received from John Hughes, Transpower Operations Adviser, on the 08/01/2025. *"On the 21/12/2024 at 14:45 hrs the 220 kV transmission circuits TAB-WRK 1, WRK-WHI 1 and HRP-TAB 1 tripped due to a lightning storm in the vicinity of these circuits."*

Causer:

Genesis considers it was not the causer of the 21st of December 2024 under-frequency event.

Yours faithfully
GENESIS ENERGY LIMITED

Steve Leppien
Regulatory and Quality Assurance Manager

6.3.3 Meridian Energy response

Wednesday, February 19, 2025

Ivani Molver
System Operator Investigator
Transpower
By email: ivani.molver@transpower.co.nz

Meridian Energy Limited
PO Box 10840 Wellington,
New Zealand
0800 496 496
service@meridianenergy.co.nz
meridian.co.nz

Dear Ivani

RE: 21 December 2024 Under-Frequency Event

We refer to your 22 January 2025 letter regarding a North Island under-frequency event at 14:45:53 on 21 December 2024. We respond to the questions in your letter as follows:

Q. **We have assessed the MW lost during the event as 162 MW at Harapaki (HRP). Can you please confirm this assessment or provide data that indicates a different value of MW lost. We rely on SCADA data, but your data from site may be more accurate.**

A. We confirm that assessment. Internal PI data indicates that Harapaki was generating 162 MW prior to the event.

Q. **We have noted in our assessment that HRP was dispatched at 99.49 MW. Can you confirm that this is correct. If correct, can you provide an explanation for HRP deviating from dispatch value by approximately 62 MW.**

A. Yes, Harapaki received a 99.49 MW dispatch instruction at 21-Dec-24 14:30:07. The next dispatch was 0 MW at 21-Dec-24 14:52:47.

The System Operator typically sends out dispatches every 5 minutes, based on metered generation from the wind farm, with a slight lag. It appears that the dispatch of 99.49 MW was based on generation data from 14:28:44, resulting in a lag of about 90 seconds. The PI tag does not show a new dispatch being received for 22 minutes and 40 seconds, which explains the 62 MW difference between dispatch and generation. It is likely that if HRP had received a new dispatch in that period the difference would be significantly lower.

We note that intermittent generation is not required to match the setpoint in the same way as dispatchable generation, as per EIPC 13.82(2)(d).

Q. **Could you explain what initiated CB 242, CB 282, CB 31 and CB 32 to trip i.e. fault condition, anti-islanding condition or other. Please provide details in the explanation.**

A. Meridian could not find any causes from Meridian-owned equipment for CB242 and CB282 to open; no trips were initiated from Meridian-owned relays.

Meridian Transformer T1 and T2 differential protection relays issued LV CB (CB31 and 32) open commands in response to Transpower's HV (CB 242 and 282) breakers opening. This is an expected response and is described in MEL Protection report section-13 for T1/T2 protection scheme.

Q. **If it was a fault condition, can you specify the fault and expected protection operation, and can you provide information about the fault ride through capability of the plant and the actual fault ride through performance for this event.**

A. Not applicable. There was no fault condition recorded by Meridian Protection Relays or PLC alarm log.

Q. **Could you provide any other information regarding the event and what you believe may have caused the under-frequency to occur on 21 December 2024.**

A. No other condition or fault was recorded on the MEL side that could have caused UFE. The cause of Harapaki generation tripping seems to be linked to the HV CB operation, which is not related to any Meridian-owned protection. Meridian can only speculate that if Harapaki generation tripped due to HV transmission availability, other generation might have tripped for similar reasons.

Q. **Please advise whether or not you could have been the causer of the under-frequency event as per the Code.**

A. Based on the previous notes and the evidence presented in the attached document, Meridian does not believe it could be the causer of the under-frequency event given paragraph (a)(i) the EIPC's definition of "causer".

Please let us know if we can be of any further assistance.

Yours sincerely,

Rhys Bailey

Senior Risk Specialist

6.3.4 Grid Owner response

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21 February 2025

Ivani Molver
System Operator Investigator
System Operations
Transpower
Wellington

Dear Ivani

21st December 2025 North Island Under-Frequency Event

I am writing in response to your letter dated 22nd January 2025, concerning the under-frequency event (UFE) that transpired on the 21st December 2024 in the North Island.

You've asked specific questions regarding this event; our responses are as follows:

1. **SCADA indicates there is an Auto Reclose (A/R) functionality on the TAB-WRK circuit. Can you confirm if TAB CB 662 has A/R functionality?**
   TAB CB 662 has auto reclose functionality. This circuit is configured with a single pole trip auto reclose, which operates in the event of an earth fault on the circuit. The protection scheme will open the faulted phase pole only and attempt an auto reclose 1 second later on the faulted phase. If the reclose is unsuccessful, all three poles are tripped. The circuit is also configured with a 3-pole trip auto reclose with sync-check. In the event of a multi-phase fault, all three poles are tripped, with an auto reclose attempted 15 seconds later if the sync-check between the line and bus is successful.

2. **Can you explain why TAB CB 662 tripped. Can you confirm if A/R was attempted on TAB CB 662, and if it was why was it unsuccessful? Please provide details in the explanation.**
   TAB CB 662 tripped due to a blue phase to ground fault on the TAB-WRK-1 circuit approximately 3.57 km from TAB. The protection relay tripped all three poles for this fault and initiated auto reclose. TAB CB 662 employs synchronism check supervision on its 3-pole trip auto reclose function. This operates once the auto reclose dead time times out. The synchronism check function in the relay compares the phase angle and frequency of the bus VT and line VT. If these values are within tolerance, a reclose is then attempted. From available data, the TAB bus VT was indicating a loss of voltage at the time a reclose was attempted, this being the result of the subsequent HRP-TAB-1 and WHI-WRK-1 circuit tripping. When a synchronism check was undertaken by the relay, the line VT voltage was healthy after a successful reclose of WRK162, but the TAB bus VT voltage was zero, resulting in both the phase angle and frequency being out of tolerance, and the check failing. This resulted in the reclosing function declaring a lockout and no reclose being attempted.

3. **Can you explain the A/R trip to lockout Grid Owner philosophy and does this apply to all sites?**
   The Grid Owner's auto reclose philosophy is detailed in TP GP 01.07 (Attachment A). The philosophy for "trip to lockout" is not noted in a single section and is spread throughout the document. Some key points are in sections 3.2.1b, 3.3.2, and 6.1.5 to 5.1.7 of the document. The auto reclose philosophy detailed in the document is generally applied to sites connected to the WRK-WHI-A line. Without a detailed review of "all sites," it is not possible to definitively state if the philosophy is applied to all sites, as it has evolved over time and the philosophy of the time would have applied to when works were undertaken.

4. **HRP and TAB have anti-islanding schemes, can you provide information on how this scheme is expected to perform when one electrical path from each generator to WRK is open and the second electrical path from each generator to WRK auto recloses.**

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The anti-islanding schemes at HRP and TAB will perform differently if the tripping on the remaining connection to WRK is a single pole trip or a 3-pole trip. In the event of a single pole trip on the remaining connection to WRK, both the HRP and TAB anti-islanding schemes will not operate and allow the generation to keep running. The scheme is guarded against a single pole trip by using logic that requires all three poles to be open before the circuit breaker is declared open and the connection lost. In the event of a 3-pole trip on the remaining connection to WRK, the HRP scheme will start a 20-millisecond timer. Once this times out, trips will be sent to each generator protection, and the 220kV HV circuit breakers on each transformer will be tripped (HRP242 and HRP282). The TAB scheme will start a 20-millisecond timer. Once this times out, trips will be sent to the TAB generator protection and the TAC generator protection. Ten seconds after the generator trips are sent, the transformer HV circuit breakers will be tripped. In summary, in the event of a single pole trip and reclose on the remaining connection between the generators and WRK, the anti-islanding scheme will not operate and the generation will remain connected. In the event of a 3-pole trip and reclose, the generation at both HRP and TAB will be tripped before the circuit can reclose (3-pole trip has a 15-second time delay between the trip and a reclose attempt). The operations of both HRP and TAB anti-islanding schemes are detailed in the Grid Offer documents submitted to the system operator.

5. **Can you confirm why WRK CB 172, WHI CB 512, TAB CB 682 and HRP CB 232 tripped i.e. fault condition, anti-islanding condition or other. Please provide details in the explanation.**
WRK CB 172 and WHI CB 512 tripped for a two-phase to ground fault on the WHI-WRK-1 circuit. HRP CB 232 and TAB CB 682 tripped for a two-phase to ground fault on the HRP-TAB-1 circuit. Both the WHI-WRK-1 and HRP-TAB-1 circuits share the same towers on the WRK-WHI-A line. Distance to fault information indicated that the fault was between towers WRK-WHI-A0064 and WRK-WHI-A0067. Lightning data indicates that there were a number of lightning strikes in the area of these towers at the time of tripping, so it is probable that the cause of both trippings was a lightning strike to one of these towers. It is worth noting that the anti-islanding protection operated after the circuit trippings.

6. **Could you provide any other information regarding the event and what you believe may have caused the under-frequency to occur on 21 December 2024.**
Additional information around the event is as follows:
   - At 14:45:43 on 21 December 2024, a blue phase to ground fault occurred on the TAB-WRK-1 circuit, approximately 3.57 km from TAB, causing the protection relay to trip all three poles of TAB CB 662. The auto reclose function was then initiated, which included a synchronism check to ensure phase angle and frequency alignment. Although the line VT voltage was healthy after a successful reclose of WRK162, the TAB bus VT voltage was zero due to the tripping of the HRP-TAB-1 and WHI-WRK-1 circuits at 14:45:50. This discrepancy caused the synchronism check to fail, resulting in the reclose function declaring a lockout and no reclose being attempted. WRK CB 172 and WHI CB 512 tripped for a two-phase to ground fault on the WHI-WRK-1 circuit, while HRP CB 232 and TAB CB 682 tripped for a two-phase to ground fault on the HRP-TAB-1 circuit. Both faults were likely caused by lightning strikes on the shared towers of the WRK-WHI-A line. The anti-islanding protection then operated to ensure the safety and stability of the grid.
   - A UFE occurred at 14:45:53 on 21 December 2024 when the following circuits and generation tripped due to a number of lightning strikes in the area: TAB-WRK-1, WHI-WRK-1, HRP-TAB-1, Tauhara generation, and Harapaki generation.
   - Market participants were promptly informed of this occurrence through a frequency excursion notice (please refer to Attachment B). This notice, issued at 15:07 on 21 December, stated the affected plants or assets that had tripped, and the level of frequency experienced in the North Island, which dropped to 49.20Hz.
   - A customer advice notice (please refer to Attachment C), issued at 14:27 on 23 December, confirmed the occurrence of an under-frequency event in the North Island at 14:45:53 on 21 December 2025.

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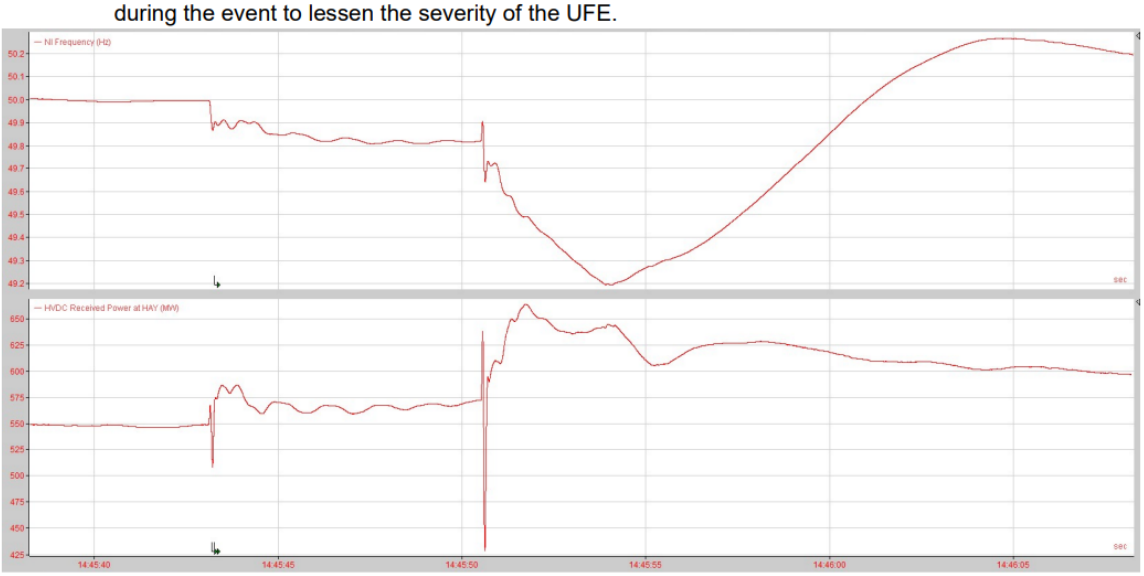
- There were no HVDC events that contributed to the UFE. On the contrary the HVDC system responded to lessen the severity of the UFE. Prior to the event, the HVDC was transferring 549MW north (received power). The transfer was modulated up to 663MW north (received power) during the event to lessen the severity of the UFE.



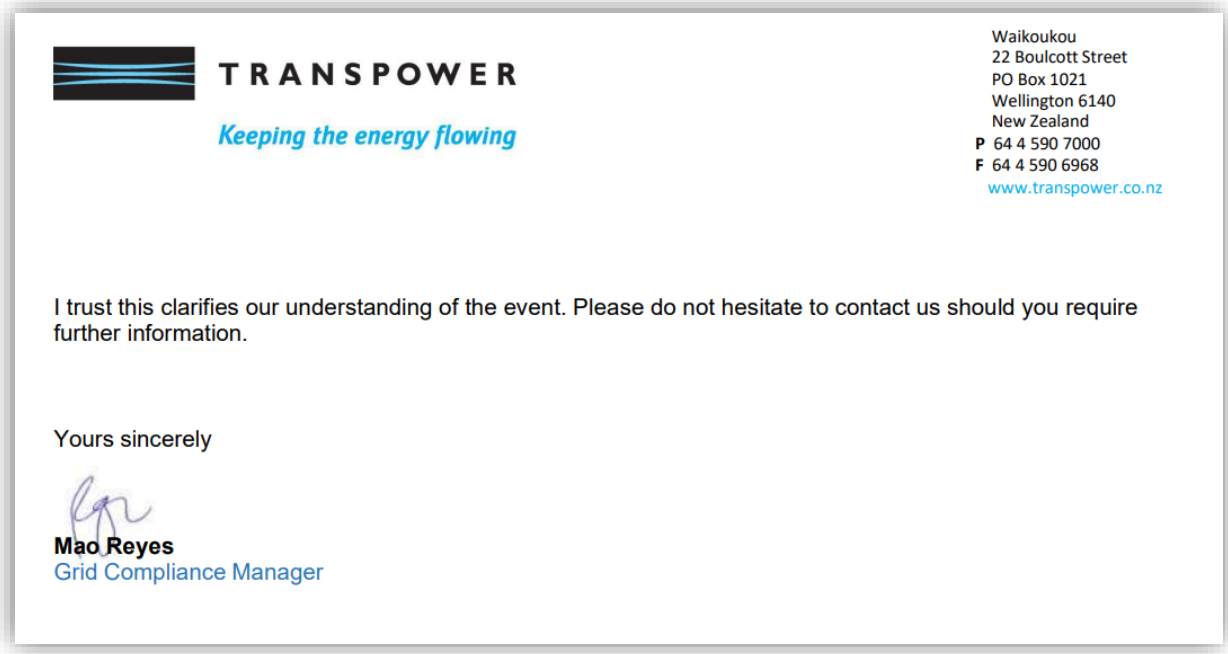
7. **Please advise whether or not you could have been the causer of the under-frequency event as per the Code.**
The definition of causer in the Code at clause (c) states that; "*if an interruption or reduction of electricity occurs in order to comply with this Code, the interruption or reduction of electricity must be disregarded for the purposes of determining the causer of the under-frequency event*".

Schedule 8.3, Technical Code A, clause 4(4)(a) of the Code requires a grid owner to provide protection that: a) will electrically disconnect any faulted asset in minimum practical time and minimum disruption to the operation of the grid or other assets; b) is selective when operating, so that the minimum amount of assets are electrically disconnected; c) is as far as practicable, preserve power system stability.

Schedule 8.3, Technical Code A, clause 4(6) requires an auto-reclose facility at the grid interface to include an appropriate synchronising check facility.

Transpower's protection on TAB-WRK-1, WHI-WRK-1 and HRP-TAB-1 circuits responded appropriately, as expected and in compliance with Code requirements to the lightning strikes and disconnected these circuits. Their tripping resulted in Tauhara and Harapaki generation being immediately disconnected from the grid. Transpower has a synchronising check facility for sites connected on the WHI-WRK-A line. The protection and auto reclose systems operated as designed, and as required by the Code, in response to the fault conditions and the loss of voltage resulting from the lightning strike. The failure of the reclose attempt was due to the specific conditions at the time, including the loss of voltage on the TAB bus VT, which is a critical factor for the synchronism check.

Considering the above information, our view is that clause (c) of the definition of causer applies, and the tripping must be disregarded for the purpose of determining the causer of the UFE.



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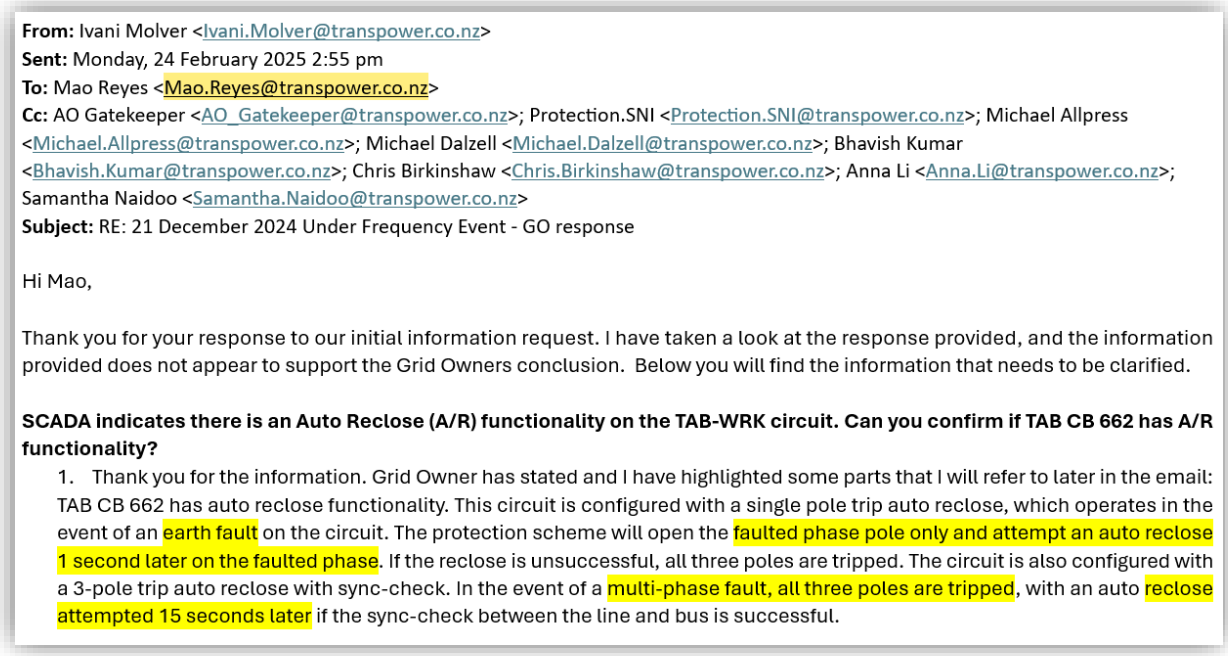
I trust this clarifies our understanding of the event. Please do not hesitate to contact us should you require further information.

Yours sincerely

Mao Reyes
Grid Compliance Manager

The System Operator requested further clarification on the information received. See email correspondence.



From: Ivani Molver <Ivani.Molver@transpower.co.nz>
Sent: Monday, 24 February 2025 2:55 pm
To: Mao Reyes <Mao.Reyes@transpower.co.nz>
Cc: AO Gatekeeper <AO_Gatekeeper@transpower.co.nz>; Protection.SNI <Protection.SNI@transpower.co.nz>; Michael Allpress <Michael.Allpress@transpower.co.nz>; Michael Dalzell <Michael.Dalzell@transpower.co.nz>; Bhavish Kumar <Bhavish.Kumar@transpower.co.nz>; Chris Birkinshaw <Chris.Birkinshaw@transpower.co.nz>; Anna Li <Anna.Li@transpower.co.nz>; Samantha Naidoo <Samantha.Naidoo@transpower.co.nz>
Subject: RE: 21 December 2024 Under Frequency Event - GO response

Hi Mao,

Thank you for your response to our initial information request. I have taken a look at the response provided, and the information provided does not appear to support the Grid Owners conclusion. Below you will find the information that needs to be clarified.

SCADA indicates there is an Auto Reclose (A/R) functionality on the TAB-WRK circuit. Can you confirm if TAB CB 662 has A/R functionality?

1. Thank you for the information. Grid Owner has stated and I have highlighted some parts that I will refer to later in the email: TAB CB 662 has auto reclose functionality. This circuit is configured with a single pole trip auto reclose, which operates in the event of an earth fault on the circuit. The protection scheme will open the faulted phase pole only and attempt an auto reclose 1 second later on the faulted phase. If the reclose is unsuccessful, all three poles are tripped. The circuit is also configured with a 3-pole trip auto reclose with sync-check. In the event of a multi-phase fault, all three poles are tripped, with an auto reclose attempted 15 seconds later if the sync-check between the line and bus is successful.

Can you explain why TAB CB 662 tripped. Can you confirm if A/R was attempted on TAB CB 662, and if it was why was it unsuccessful? Please provide details in the explanation.

2. Grid Owner has confirmed that TAB CB 662 tripped on a blue phase to ground fault approximately 3.57 km from TAB.

With reference to Attachment A and response letter: There is no indication or evidence from the Grid Owner that the fault evolved to a multiphase fault within the single pole open-interval or the reclose was unsuccessful. Instead, it was repeatedly stated that TAB CB 662 tripped on a blue phase to ground fault which should have auto reclosed within 1s according to the information provided. Contradicting the conclusion that protection operated as designed and according to the Code requirements in Sch 8.3, Tech Code A. [GO] The protection operated correctly and met all requirements in Sch 8.3 Tech Code A. The TAB662 protection operated correctly for the fault, identifying and disconnecting the fault in under the 120 ms, as specified in the Code. The Code does not mandate auto reclose performance, except for the requirements outlined in Tech code A, Section 4, Clause 6, which the scheme meets. Therefore, the auto reclose scheme operated as designed in this case.

i. Can you clarify that the fault escalated through the SER logs of the protection relay or other source. Kindly specify/elaborate on the actions in these logs clearly showing that the single pole trip was escalated to a 3 pole trip. This will confirm if auto reclose was attempted but escalated from a single phase to ground faut to a multiple phase fault or unsuccessful reclose. [GO] There was no single pole trip or reclose attempted by TAB662. The fault quantities measured by the TAB662 relay met the requirements of its internal algorithms for a 3 pole trip, and this was the action taken by the relay. The determination of whether the fault requires a single pole trip or a 3 pole trip is based on the relay's internal algorithms, which are set by the relay manufacturer in the relay firmware and are not user-configurable. We have included snapshots of the relay SER logs from both WRK162 and TAB662. These logs show that TAB662 operated on a 3 pole trip for the fault (indicated by relay code 3PT becoming asserted), while WRK162 operated on a single pole trip (indicated by relay code SPT becoming asserted).

TAB662 Relay SER

75	2024/12/21 14:45:43.1250	RELAY_TRIP	ASSERTED
74	2024/12/21 14:45:43.1250	TPB1	ASSERTED
73	2024/12/21 14:45:43.1250	TPA1	ASSERTED
72	2024/12/21 14:45:43.1250	3PT	ASSERTED
71	2024/12/21 14:45:43.1250	TPC1	ASSERTED

WRK162 Relay SER

76	2024/12/21 14:45:43.1267	RELAY_TRIP	ASSERTED
75	2024/12/21 14:45:43.1267	SPT	ASSERTED
74	2024/12/21 14:45:43.1267	TPC1	ASSERTED

ii. In the information provided, you stated that WRK CB 162 successfully reclosed for the same fault at 14:45:43. There was no clarification on why two relays sensing the same fault responded differently. I have a figure 2 below that translates the information provided by the Grid Owner. Kindly clarify this. [GO] Due to the highly meshed nature of a transmission power system, it is common for the same fault to appear differently to relays at either end of the protected circuit. The location of the fault, the source impedance behind each relay, and the impedance of the fault all impact the currents and voltages measured by the relays during a fault. In this specific case, the fault was electrically closer to WRK, and with WRK having a lower source impedance than TAB, this resulted in higher current and more voltage depression measured at the WRK end of the circuit.

3.3 Single pole trip and auto-reclose (SPTAR)

3.3.1 Single pole trip schemes have separate mech boxes and trip circuits for each phase of the circuit breaker. The trip signal is given to each pole dependent on the phase on which the fault has occurred. The reclose signal is given to all poles of the circuit breaker as normal. Faults that evolve to multi-phase during the single pole open-interval are escalated into a 3-pole trip with a longer open-interval.

3.3.2 Faults that arise after auto-reclose and during the reclaim time trip all three poles and do not initiate auto-reclose.

3.3.3 Transpower has typically used SPTAR where there is a history of cross-country faults and where the tripping of both circuits would lead to a loss of supply, islanding or overloading of parallel circuits. Examples are Hawkes Bay 220 kV and KMO-TRK 220 kV.

Figure 1: Attachment A - TP.GP 01.07

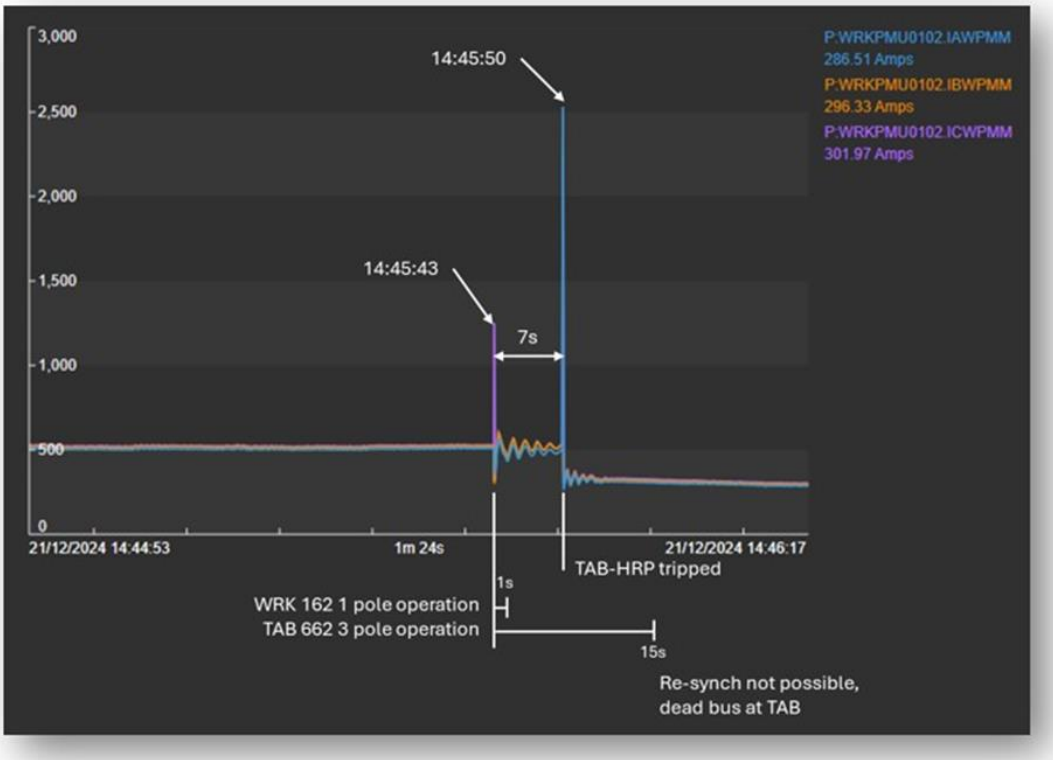


Figure 2: Translation of information

Can you confirm why WRK CB 172, WHI CB 512, TAB CB 682 and HRP CB 232 tripped i.e. fault condition, anti-islanding condition or other. Please provide details in the explanation.

3. The Grid Owner has stated that
    a. "Both the WHI-WRK-1 and HRP-TAB-1 circuits share the same towers on the WRK-WHI-A line. Distance to fault information indicated that the fault was between towers WRK-WHI-A0064 and WRK-WHI-A0067."
    b. "it is probable that the cause of both trippings was a lightning strike to one of these towers."
    c. Can you confirm if the Grid owner thinks this is between or one of the towers. [GO] Both the lightning data that Transpower receives from Metservice and the distance to fault data recovered from the relays has a dynamic error rate due to several differing factors. In this case, both the Metservice Data and distance to fault data correlate to a lightning strike to an area near the vicinity of these towers at the time of tripping. However this is not definitive data, so it impossible to confirm that the lightning strike was within this tower range.
4. Also there has been no mention of earth wire design in the response. The main purpose of the earth wires is the protection of the conductors against the direct lightning strikes. And if the cause is lightning, information around the design of the assets needs to be elaborated on. This will also show that there was adequate precaution taken when designing the line. [GO] The line section where the fault occurred (WRK-WHI-A0064-0067) does not have an overhead earthwire.

    Back in the 1970s, when WRK-WHI-A was constructed, overhead earthwire was typically only fitted at the station end of the line asset for approximately 1km out from the station. This design philosophy was adopted for WRK-WHI-A and other double circuit 220kV lines constructed around the same time. At that time, lightning activity throughout the country was considered low, so a continuous earthwire was deemed unnecessary except in areas with frequent lightning activity (e.g., South Island West Coast, Northland, and Taranaki).

    To further explain the lack of an earthwire on WRK-WHI-A, in the 1970s and earlier, lightning activity was measured in 'thunderstorm days per year'—a day during which lightning was observed or thunder was heard by the station operator. For a long line crossing remote country like WRK-WHI-A, thunderstorm days were only recorded at the WRK and WHI stations, not in the hilly section of the line where most lightning activity occurs. This resulted in a very inaccurate measure of lightning activity compared to today's sophisticated lightning detection networks.

    The retro-fitting of earthwires to overhead lines is considered too expensive and difficult to achieve due to the extra loading imposed on the structures by the earthwire, and the legal issues the new earthwire could trigger due to the change in appearance (extra height, extra 'wire', etc.). Therefore, while retro-fitting an earthwire to WRK-WHI-A has been considered in the past, it was found to be unjustified for the above reasons, so it has not proceeded.

    The effectiveness of lightning protection begins with the selection of the location and route for stations and overhead transmission lines. This is largely applicable to greenfield projects as brownfield sites have been preselected.

Can you explain the A/R trip to lockout Grid Owner philosophy and does this apply to all sites?

5. Thanks for providing the TP.GP 01.07 document, and explaining the logic configured in the circuit. Could you clarify what the reclaim time is in seconds for the circuits between Wairakei and Redcliffe? [GO] All relays on the circuits between WRK and RDF have a 15 second reclaim time after an auto reclose, and a 10 second reclaim time after a manual close.

Noting there are a few gaps in the information provided, please can you let me know when you will be able to get back to me with this information.

Kind Regards

Ivani Molver
Power Systems Engineer
SO Power System Group | Operations

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