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இலங்கை பொதுப்பயன்பாடுகள் ஆணைக்குழு
Public Utilities Commission of Sri Lanka

PUCSL

Report of the Public Hearing held on 03rd & 07th March 2022 at BMICH, on the power failure occurred in the Transmission licensee's (Ceylon Electricity Board) network on 03rd December 2021.

Contents

1 Executive Summary

The island wide power failure occurred on 03.12.2021 lead to the inability of the Transmission Licensee to serve a total energy demand of 9.65 GWh equaling to an estimated economic cost of LKR 1.505 Billion. Therefore, the PUCSL decided to hold a public hearing in terms of section 18 of the PUCSL Act to find out the causes that lead to the failure, the socioeconomic impacts, and to make appropriate recommendations to avoid future repetitions of that nature.

Based on the logged information in protection relays and disturbance recorders at Kotmale and Biyagama GSS, the phase B of Kotmale-Biyagama line 02 has tripped at 11.27.14 (Hours.Minutes.Seconds), with the indication of an earth fault by the line protection relay. Subsequently, three phase trip had occurred owing to an erroneous configuration of the operation of protection function called "End fault protection", by the busbar protection relay of Biyagama GSS. This has taken out Kotmale-Biyagama line-2 from the power system. The operation of the end fault protection function has tripped the healthy phases R and Y. According to the end fault protection logic, the activation of end fault protection cannot happen unless all three phases of the circuit breaker are in open position. However, in this case the end fault protection has activated when only phase B was in open position, without satisfying the end fault protection logic. Hence the initiation of the blackout could have been avoided if the end fault protection was implemented correctly in the Biyagama-Kotmale line-2 at Biyagama end. CEB has corrected the error subsequently despite the lack of documentation in a previous circuit breaker replacement activity during 2015. In order to avoid any errors in implementations, it is recommended to update the written procedures for repairs, replacements, maintenance, modifications, and rectifications for all works carried out by the CEB, any of their agents, contractors or sub-contractors. All diagrams should be validated and certified by an authorized competent officer and such modifications/ alterations shall be duly updated in the As-built drawing.

After tripping the line-2, the Kotmale-Biyagama line-1 has taken up the total load and has not exceeded it's overload limit setting. However, the Kotmale-Biyagama Line-1 also has tripped after 22 seconds (approximately) at 11.27.35 on 03rd December 2021 owing to the operation of earth fault protection by the line protection relay due to the presence of sustained zero sequence current. Subsequently, total power system has collapsed resulting a blackout. Even after the tripping of Kotmale-Biyagama line-2, the Kotmale-Biyagama Line-1 has not overloaded exceeding its phase overcurrent protection limit. Therefore, if this second erroneous tripping has not occurred, the blackout could not have happened. If CEB had adequately scrutinized the sustaining zero sequence currents and taken appropriate actions to eliminate such conditions and adjust the protection settings complying to the transmission line design, then the unwanted tripping of line-1 and consequent blackout could have been avoided. Therefore, it is required to assess the sustaining zero sequence currents specified by the 220kV transmission lines design and adjust the earth fault protections settings of line protection relays to avoid unnecessary tripping of transmission lines. Subsequently, it is required to update the CEB protection document.

At the time of the blackout on 3rd December 2021, only two Units (Unit 1 and 3) were in operation. The plants have shut down due to operation of Voltage Restrained Overcurrent protection (a backup protection) as a result of the power swing in Puttlam – New Anuradhapura line, that did not isolate from the grid.

It is recommended to review the protection schemes of the transmission lines connected to Lakvijaya Power Station taking into account the power plants protection settings, to ensure that the transmission lines do not unnecessarily isolate or cause plant shut down at abnormal operating conditions that does not necessarily endanger equipment. It is required to handover the operation and monitoring activities of generator protection systems to the respective power station staff (at least at the critical power stations like Lakvijaya, Kothmale, Victoria, Kelanitissa, etc) as more coordinated and decentralized protection system operation is a requirement.

The delay in restoring Colombo city power was unacceptable and needs further investigation. Incidents at Kothmale and Kelanitissa revealed that lack of authority and/or knowhow of the technical staff on the protection systems, thus handover of operation and maintenance of generator protection systems to the generator maintenance staff is recommended. Further, it is recommended to improve the restoration manual with a review of the priority listing to incorporate critical loads like hospitals, etc, and also considering the adverse effects from industrial / commercial loads having large starting currents.

2 Acronyms and Abbreviations

CB	Circuit Breaker
CEB	Ceylon Electricity Board
DDR	Digital Disturbance Recorder
DGM	Deputy General Manager
GSS	Grid Substation
GT	Gas Turbine
GWh	Gigawatt hours
IEC	International Electrotechnical Commission
OEM	Original Equipment Manufacturer
MW	Megawatt
PRV	Pressure Relief Valve
PUCSL	Public Utilities Commission of Sri Lanka
SAS	Substation Automation System

3 Introduction

The Public Utilities Commission of Sri Lanka (PUCSL) at the 260th meeting of the Commission held on 3rd December 2021 decided to hold a Public Hearing to investigate into the Island-wide blackout due to the unauthorized power shedding occurred on 3rd December 2021 in the Transmission Licensee's s network.

By virtue of the powers vested with the Public Utilities Commission of Sri Lanka (Commission) under section 18 of the Public Utilities Commission of Sri Lanka Act No. 35 of 2002, a Public Hearing was convened by the Commission to investigate into the total power failure occurred on the Transmission Licensee's network on 3rd December 2021 and of the load shedding subsequent to the said failure.

The consequences of the said power failure include the Transmission Licensee's inability to serve a total energy demand of 9.65 GWh equivalent to an estimated cost of Rupees 1.505 Billion or Rupees 1505 Million to the economy followed by additional consequence, losses & endangers due to the failure. The determination of the Public Hearing was meant to include but not be limited to findings on the cause of the failure and appropriate recommendations on avoidance of future repetitions of similar incidents.

The proceedings of the hearing was arranged and carried out in terms of section 18 (read with section 25) of the PUCSL Act and the Public Hearing Procedures approved by the Commission. Accordingly, the relevant notices were published/sent to relevant parties and written submissions were invited beforehand. 21 witnesses were summoned to give evidence and all necessary documents/information and data for determination were called from the relevant parties.

4 Notification of the Public Hearing

News Paper Notification

The first notice informing the Public Hearing and requesting for submissions from the general public/stakeholders and affected parties was published in newspapers in three languages on 11.01.2022.

The second notice informing the date, time and venue to general public/stakeholders and affected parties was published in newspapers in three languages on 09.02.2022.

Other Notifications

Noticed to the Transmission Licensee-

Notice to the Transmission licensee was sent on 02.02.2022 to the following officer

General Manager

(Authorised Officer under Transmission License No. EL/T/09-002)

Ceylon Electricity Board

No.50, Sir Chittampalam A. Gradiner Mawatha

Colombo 02

Notices on the official website of the PUCSL

Notices to the general public/stakeholders and affected parties regarding the public hearing were published on the website of the PUCSL

Notice containing the list of witnesses and documentation called as evidence at the public hearing was published on the website of the PUCSL and a copy of this notice was sent to the Transmission Licensee for information

5 Public Hearing

Venue, dates/time and Attendance

Venue – BMICH
Dates/Time - 3rd and 7th of March 2022 from 9.30 onwards
Hearing Panel- Chairman & Members of the Commission
Mr. Janaka Ratnayake- Chairman
Professor Janaka Ekanayake- Deputy Chairman
Mr. Mohan Samaranayake- Member
Mr. Udeni Wickramasinghe-Member
Ms. Chathurika Wijesinghe - Member
Honorary Observer : Mrs Malani Ramatunga -Hon. High Court Judge (Rtd)
Instructor : Ms. Janaki Vithanagama, Secretary to the Commission
Assisted by : Ms. Chamila Senanayake- Deputy Director Legal
: Ms. Chethani Senanayake – Asst. Director Legal

Expert Panel assisted the Commission:
Mr. Damitha Kumarasinghe- Director General
Mr. Gamini Herath- Deputy Director General
Mr. Nalin Edirisinghe- Deputy Director General
Dr. Nilantha Sapumanage – Director Inspectorate
Mr. Sameera Adikaram – Deputy Director (Security of Supply)
Mr. Lilantha Neelawala – Deputy Director (Inspectorate)
Mr. S.Krishanath - Deputy Director (Inspectorate)

Other observers
Representatives of the CEB (Transmissio/stakeholdersn Licensees) including lawyers
Representatives from the general public

Witnesses appeared before the Commission

Day 1 (03.03.2022)

1. Ms.R.A.I.I.Ranatunga -Senior Assistant Secretary (representing Ms.Wasantha Perera Secretary, Ministry of Power)
2. Mr. M.R. Ranatunga-Former General Manager /Ceylon Electricity Board
3. Mr.P.W. Hendahewa - Addl. General Manager-Transmission Operation & Maintenance /Ceylon Electricity Board
4. J.P.C.N.J. Patabendi-Electrical Superintendent Biyagama GSS, /Ceylon Electricity Board\
5. Mr. M. Chanaka - Electrical Engineer In charge of Biyagama GSS, /Ceylon Electricity Board
6. Mr. D.D.U. Dompage-DGM Transmission Operation & Maintenance /Ceylon Electricity Board
7. Mr. K.H.K. Kondasinghe -Shift Engineer, Kotmale PS/Ceylon Electricity Board

8. Mr. K.M.I.N. Kuruppu-Chief Engineer (Officer In charge), Kotmale PS/Ceylon Electricity Board
9. Mr. K.A.N. Perera-Chief Engineer, Shift In charge –Lakvijaya PS, Norochcholai/Ceylon Electricity Board
10. Mr.P.W.M.N.A.B. Wijekoon -Power Plant Manager, Lakvijaya PS, Norochcholai/Ceylon Electricity Board
11. Mr. E. Kudahewa-Chief Engineer, System Operation Centre/Ceylon Electricity Board
12. Mr. D.S.R. Alahakoon -DGM, System Control Centre/Ceylon Electricity Board
13. Mr. N.S. Wettasinghe -DGM, Transmission Protection & Control/Ceylon Electricity Board
14. Mr. G.D.N.S. Garusinghe -DGM, Communication Branch/Ceylon Electricity Board

Day 2 (07.03.2022)

1. Mr. D.N. Nawaratnne -DGM, Generation Protection/Ceylon Electricity Board
2. Mr. J.M.K. Jayasekara-DGM, Asset Management (Thermal Electrical) /Ceylon Electricity Board
3. Mr.P.K.N.I Weeraratne-DGM, Corporate Strategy & Regulatory Affairs/Ceylon Electricity Board
4. Ms. U.P.A.H. Seneviratne-DGM, Occupational Health & Safety/Ceylon Electricity Board
5. Mr. K K S Dasanayaka - AGM Corporate Strategy & Regulatory Affairs/Ceylon Electricity Board
6. Dr. Rohantha Abeysekara -General Manager /Ceylon Electricity Board
7. Professor Lilantha Samaranayake -Chairman of the Expert Committee appointed by the Ministry of Power to investigate into the Power Interruption

Written submissions

1. Ceylon Electricity Board Technological Engineers& Superintendents Union
2. Lanka Viduli Podu Sevaka Sangamaya
3. Unionism of Civil Societies against the Electricity Mafia

6 Observations and Analysis of Evidence

An island wide power failure has occurred, starting from an event that caused tripping of one transmission line (line-2) that was delivering power from Kotmale to Biyagama grid substations. The incident has occurred approximately at 11:27 AM on 03rd December 2021. There are two transmission lines of 220 kV that connect Kotmale and Biyagama grid substations, namely Line-1 and Line-2. Line-2 tripped first and subsequently line-1 also tripped. Thereafter, the total power system has collapsed.

As reported by the CEB, the total system failure had begun by the tripping of Kotmale-Biyagama Line-2 at 11.27 hours, followed by the tripping of Kotmale-Biyagama Line-1. The analysis was done with the objective of ascertaining the causes for the island wide power failure and for recommendation of actions required to be taken to avoid a repetition in the future. The analysis was caried out based on the evidences and information received at the public hearing held on 03rd and 07th March 2022.

Based on the logged information in protection relays and disturbance recorders at Kotmale and Biyagama GSS, phase B of Kotmale-Biyagama line-2 has tripped at 11.27.14 (Hours.Minutes.Seconds), with the indication of an earth fault of the line protection relay. Subsequently, three phase trip had occurred owing to an erroneous operation of protection function called "End fault protection", by the busbar protection relay, taking out Kotmale-Biyagama Line-2 from the power system. Thereafter, the Kotmale-Biyagama line-1 had taken up the load and have not surpassed its overload limit. However, the Kotmale-Biyagama Line-1 has also tripped (all 3 -phases) after 22 seconds (approximately) at 11.27.35 owing to the operation of earth fault protection by the line protection relay. Subsequently, the total power system has collapsed resulting a blackout.

Detailed analysis based on the various evidences and information was carried out and given in the next paragraph with conclusions derived under each scenario.

6.1 Tripping of Kotmale-Biyagama Line-2

6.1.1 Analysis on Information Recorded in Line Protection Relay at Kotmale GSS

Fault log of the line protection (Main 1) relay, consist records giving information on pick up and operation of respective line protection functions. According to the recorded information in the fault log and also referring the relay manual and the relay setting files the analysis was carried out.

Relay has initially picked up neutral over current at 11.27.14.523 as indicated by the fault log. Subsequently, differential protection function of the relay has picked up differential current in

Phase B and has operated to trip phase B from Kotmale end at 11.27.14.562. This tripping has occurred complying with the protection settings of the line protection relay.

However, the line protection relay's "*fault locator function*" was unable to determine the fault location. According to the relay manual the *fault Locator function* serves for measuring the fault distance. This function is useful to the quick determination of fault location and the associated rapid troubleshooting increases the availability of the line. The CEB has requested clarification from the relay manufacturer in this regard.

6.1.2 Analysis of DDR records on Line-2 at Kotmale GSS

Digital Disturbance Recorder (DDR) records disturbances and faults occur in respective grid substations in the electricity grid. The DDR records information on the values of voltages, currents and frequency (measured at the GSS) over the time once the DDR is triggered by a disturbance such as fault. Based on the information recorded in DDRs at Kotmale GSS the following analysis was carried out.

Phase B current has tripped within 30ms after the trigger point. Phase R and Y have tripped 320ms after the trigger point approximately. Neutral current has become zero after 320ms from the trigger point approximately.

Further, it was noted that currents in phases R and Y have tripped after 290ms approximately after the phase B has tripped. From this we can conclude that Phases R and Y of the line have become opened by 290ms after the phase B has opened. However, the fault log from line protection relay or the DDR event log do not indicate which Protection equipment have initiated this tripping.

According to the event log of DDR at Kotmale end it was observed that Biyagama line-2 breaker lockout has operated at 11.27.14.874 (time adjusted with Biyagama DDR). However, the relevant protection equipment which initiated this lockout operation could not be verified from the DDR related drawings and signal lists submitted by CEB. There is no record in BEN event log, directly representing the protection function activated to trip phases Y and R.

Further, it can be seen that the phase B voltage has reclosed, 930ms after the tripping of Phase-B.

6.1.3 Analysis on Information Recorded in Line Protection Relay at Biyagama GSS

Fault log of the line protection (Main 1) relay, consist records giving information on pick up and the operation of respective line protection functions. According to the recorded information in the fault log and also referring the relay manual and the relay setting files the analysis was carried out.

The relay has tripped phase B at 11.27.14.568 tripped the line from Biyagama end, owing to the operation of line differential protection function. The relay has received the trip signal from the line protection relay at Kotmale end.

6.1.4 Analysis on Information Related to Busbar Protection at Biyagama GSS

According to the event log of the busbar protection relay, operation of *end fault protection* by the busbar protection relay has caused 3-phase trip of the Kotmale line-2 at 11.27.14.818. This has initiated after the isolation of Phase-B from the line protection relays.

As per the relay manual the activation of end fault protection cannot happen unless all three phases of the circuit breaker are in open position. However, in this case the end fault protection has activated when only phase B was in open position. Hence, it is evident that the implementation of the end fault protection was incorrect.

However, according to CEB there were no record in SAS log, directly representing the activation of end fault protection. CEB in their explanations to Expert Committee has indicated that the indication of end fault protection was not available in the SAS.

6.1.5 Circuit Breaker Status Indication of Biyagam-Kotmale Line at Biyagama GSS

According to the technical manual of busbar protection relay, the circuit breaker open indication is taken from 3 serially connected normally closed contacts. Further, the end fault protection become effective only if the circuit breaker is in clear open position, otherwise the end fault protection is blocked instantly.

However, at the time of operating the End Fault Protection, the line circuit breaker at Biyagama end has opened only the phase B by the operation of line differential protection function by the line protection relay at Biyagama end. At this time other two phases (phase R and Y) were in healthy condition.

In the clarifications provided by CEB, they have stated that there was an error in field wiring which provide the Circuit Breaker status. Further, CEB claim that the error resulted during the replacement of circuit breakers of Kothmale line 1 & 2 in March / April 2015. Hence, the CB status was received incorrectly to the control panel. Further, CEB has stated that, this wiring error has been identified and rectified on 2021-12-26 (Kothmale line-1) and on 2022-01-02 (Kothmale Line-2) respectively.

Hence, it can be concluded that the end fault protection function has operated while only phase B of the circuit breaker was opened. Further, the end fault protection has not operated according to the recommendation in busbar protection relay manual, where the open status of the circuit breaker (all 3 phases) is a prerequisite.

Further, according to the subsequent investigations done by the CEB they have identified that in both the Biyagama-Kotmale Line-1 and Line-2 breaker open status feedback to protection relays were wired incorrectly leading to erroneous input to the protection relay. This has caused the maloperation of the end fault protection of Biyagama-Kotmale line 02 in 03rd Dec 2022.

According to the Expert Committee report this wiring error has reported to the Committee by CEB, after the CEB has corrected the alleged error in the circuit wiring. Further, the Expert Committee has stated that there are no photographic evidence or independent eye witness evidence on what existed before the correction was made by CEB. In addition, the Expert Committee has stated that, some major changes to the wiring as well as the auxiliary circuit

components have been done on December 26, 2021 and on January 02, 2022, with no regard to the ongoing investigative process.

According to the given circuit diagrams, Kotmale line 1 and 2 circuit breaker close feedback signal control wiring has been connected in parallel when the blackout occurred on 3rd December and altered to connect in series during rectification. However, the date of modification was not found. There was no written procedure of commissioning, modifications, rectifications, etc. submitted to the commission for verification. The erection drawings are not professional. Only hand sketches were provided. Completed As-built drawings not submitted. Date of commissioning of the Kotmale Biyagama line-1 and line-2 circuit breakers were mentioned in hand writings.

Further, no handing over documents seen for the modifications carried out in the control system after the blackout. CEB has not provide any evidence to show that the CEB staff practicing the handing over procedure. As per the public hearing statements the handing over was done by verbal communication.

Therefore, it can be concluded that, CEB has not practiced the written procedures during the replacement of circuit breakers of Kothmale line 1 & 2 in March / April 2015. The personnel who had carried out the replacement work have not performed their duty satisfactorily. The incorrect wiring of Biyagama-Kotmale Line-1 and Line-2 breaker open status feedback to protection relays, is a serious negligence and unprofessional work done by CEB.

This was not identified by the CEB until the last total system failure. That means the existing manuals, procedures, guidelines of the CEB were unable to detect the aforesaid erroneous wiring. Or else, even though those manuals, procedures, guidelines are well enough to detect such erroneous wiring, the authorized officers of the CEB have failed to execute their responsibility as designated. If that is the case, it is required to bring procedures in order to liable the officers for their designated work.

6.1.6 Similar Incidents where End Fault Protection Operated

According to the CEB, on 2021-05-11 and 2021-11-29, similar kind of incidents have happened tripping the Biyagama-Kotmale line-2 and line-1 owing to the operation of end fault protection respectively. Further, CEB admits that, in those incidents end fault protection has operated due to the incorrect circuit breaker status received and additionally the currents of healthy phases are above the threshold current required for end fault function to be activated.

Hence, it is evident that CEB has not performed adequate failure analysis to identify the root cause of circuit breaker lockout, during previous occasions of breaker lockout due to end fault protection. If it had been done the incorrect wiring issue could have been resolved prior to the blackout incident on 03rd December 2021.

6.1.7 Analysis of DDR Records at Biyagama GSS

According to the current/voltage vs time graphs obtained from the DDR, the trigger time of DDR indicated as 11.27.14.248. Phase B has tripped within 359ms after this trigger point of DDR. Phase R and Y have tripped approximately 628ms after (i.e. 11.27.14.876) the trigger point. Neutral current has become zero after approximately 320ms from the trigger point. Further, it is noted that currents in phases R and Y have become close to zero after 282ms approximately after the phase B current become zero. Further, 910ms after the tripping of Phase B, the line has gained nominal voltage.

6.1.8 Analysis on User Logged Out Events Recorded in Line Protection Relay

In the events record of Line Main 02 protection relay, it was observed that there are 7 logout events recorded as first records on the day (03rd Dec 2022) that blackout was happened. However, no login information available on the event record set which corresponds to these log outs.

According to CEB, one of the Control Room Operators at Biyagama GS had tried to clear an alarm on 03rd Dec 2021 (before the blackout event) and it has caused the log out events.

Further, CEB has sent a video clip which is sent by the relay manufacturer demonstrating a way how a user logout events (in event log) get recorded in the relay event log even without entering the password and logged in (happens when user press the clear button without logging in). Hence it can be concluded that, if the user press clear button without entering the password and logged in, then technically it is possible to have user logged out events in the event record of Biyagama Kotmale Main 2 protection relay without the corresponding user log in events similar to the seven log out events appeared in the event log.

6.1.9 Information Related to Fault Location

As indicated in section on "*Analysis on Information Recorded in Line Protection Relay at Kotmale GSS*", the line protection relay at Kotmale end of Kotmale-Biyagama line-2 was not able to identify the fault location. However, CEB has estimated the location of fault as 24.1 km from Biyagama end. This was estimated using two ended Negative Sequence Impedance method (based on current and voltage values obtained from line protection relays CEB has calculated symmetrical components of the unbalance at the time of the fault.). According to CEB, the only available physical evidence of the cause of the tripping was a man-made fire directly under the line, very close to the tower number 138 which is located 21.23km from Biyagama end. Further, CEB has provided several photos indicating a place originated a fire near a tower.

According to the current values obtained from disturbance recorders at two ends of the line-2, a difference in phase B currents at the two ends and a difference in ground current at the two ends were observed. This could have initiated by a phase B to earth fault located between the two ends. However, the exact reason that created the ground path for the earth fault in Kotmale-Biyagama Line-2 cannot be identified from the available evidence.

6.2 Tripping of Kotmale-Biyagama Line-1

6.2.1 Analysis on Information Recorded in Line Protection Relay at Kotmale GSS

Fault log of the line protection (Main 1) relay consist records giving information on pick up and the operation of respective line protection functions. According to the recorded information in the fault log and also referring the relay manual and the relay setting files the analysis was carried out.

According to the fault log the relay has picked up neutral over current at 11.27.14.612 and tripped the line at 11.27.36.937. Hence, the relay has taken about 22.325 seconds to operate. Further, the total currents flowing in Line-1 phase R, phase Y and phase B prior to tripping have not surpassed the overcurrent threshold setting (1500A).

According to the Line-1 protection (main 01) relay setting file the threshold for ground overcurrent protection was 80A. Further, the setting indicated that the time dial setting is 0.38 and the curve is IEC normal inverse. Further, according to the setting files of the relays, the ground overcurrent protection threshold of Line-2 at Kotmale end was 80A, while the setting was 150A, at Biyagama end. Therefore, CEB has implemented two different current thresholds setting for ground overcurrent protection at two ends of the line-2, while it is the same (80A) for Line-1.

However, according to the CEB document approved by DGM (Control & Protection) namely "Protection Setting Standard - Principles and Methods for Protection Settings" dated Aug 2019, the relevant setting for non-directional earth fault protection (the protection function activated to trip the line-1) was set to 80A.

Further, according to the data submitted by CEB, the earth fault current threshold for 220kV lines ranges from 80A to 160A. Hence it can be seen that, CEB has not adhered to the recommended value of 80A. Hence it can be concluded that, the CEB document: "Protection Setting Standard - Principles and Methods for Protection Settings" dated Aug 2019, need to be revised, while undertaking an assessment of earth fault current thresholds.

CEB in their explanations have stated that, the staff of Control and Protection branch has implemented the recommended (as in CEB Protection Settings Standard) Earth Fault current setting of 80A in Biyagama – Kothmale Line 1 and 2 on 2019-09-26 while carrying out the routing maintenance of Protection Panel. Further, due to the line outage was received for a limited period of time C&P staff have not been able to carry out this setting revision in Line-2 at Biyagama end.

Further, according to the relay setting history log of Biyagama GSS (line protection relay of Kotmale line-1) the relay has been accessed on 2019-06-26 and parameter values of ground overcurrent function has been changed. However, the exact parameter values of the ground overcurrent protection function that were changed cannot be ascertained through this log.

According to the relay setting history log of Kotmale GSS -line protection relay of Biyagama line-1, the relay has been accessed on 2020-06-12 (last record prior to 2022-12-03) to change settings. However, the exact parameter values that were changed cannot be ascertained through this log. Hence, it can be concluded that the CEB has not altered the line protection relay (Main 1) settings of Kotmale-Biyagama Line-1 after 2020-06-12 (prior to the blackout on 2021-12-03).

DDR indicated a neutral current of 480A for a period of 290ms (based on rough estimates derived from the graphs). According to the IEC normal inverse curve and the relay settings with time dial setting of 0.38 and threshold current setting of 80A, the corresponding tripping time for a current of 480A is 1458ms. Therefore, presence of 480A of neutral current for a period of 290ms along was not enough to trip line-1.

To operate the overcurrent protection function, since picking up the fault the relay has taken 22 seconds and 325ms (11.27.36.937 - 11.27.14.612). It can be seen that after the initial pickup due to the neutral current of 480A which lasted for 290ms, the relay has not been dropped out and go on to trip. CEB stated that subsequently they have tested the relay and found out that the dropout current is 58A.

According to the explanation given by CEB the relay has picked up with the tripping of B phase of parallel line (line-2) and remained picked up due to the presence of continuous zero sequence current which is around 80A. Further, they have stated that, the value of this zero-sequence current is proportional to the phase currents, and with the tripping of Biyagama – Kothmale line-2, the load current has increased, resulting in increase of residual zero sequence current. Further, CEB has stated that the presence of sustaining zero sequence current was further confirmed after the re calibration of the DDR.

According to the OEM response to CEB the dropout value of the function is determined not only by the dropout defined in the IEC standard for normal inverse characteristic but also by the "*Minimum Absolute Dropout Differential*" applicable to internal current transformer category of the relay. When the gap of (pickup value – dropout value) according IEC specification is less than to the "Minimum absolute Dropout Differential" value of the relay, dropout is determined by the value of the latter. Hence, according to the clarifications received by OEM, the drop out value is 58A for the threshold value of 80A (considering the minimum absolute dropout differential as stated by OEM).

From the relevant DDR current vs Time graph (discussed in next section), it is evident that residual neutral current has remained at a value of more than 58A before the line-1 get tripped. Therefore, considering the OEM clarification on drop out current, it is confirmed that the operation of ground overcurrent protection function was inevitable.

Considering the explanation given in the relay manual on dropout characteristic, and the OEM clarification on minimum absolute dropout differential, it is evident that even if the relay dropout characteristic was set as "*instantaneous*" instead of "*disc emulation*" the ground overcurrent protection function would have been operated tripping the line-1, as the dropout value is 58A in this case.

According to the above CEB has calculated (using IEC normal inverse curve) the tripping time considering the two distinctive ground overcurrent values 420A lasted for 290ms and the residual persistent ground current appeared as 80A for rest of the time before tripping. Accordingly, the calculated time by CEB to operate the ground overcurrent function is 22.658 seconds. The actual time was 22.325 seconds (deviation of calculated time is about 1.5% against the actual). Therefore, it can be concluded that Kotmale-Biyagama line-1 has tripped in accordance with the ground overcurrent protection function of the line protection relay (Main 1).

Subsequent to the blackout incident, CEB has increased the pickup setting to 160A to avoid possible recurrence of the operation of ground overcurrent protection. If CEB have adequately assessed the sustaining zero sequence currents against their protection settings of ground overcurrent function of the line protection relay, the unwanted tripping of line-1could have been avoided.

6.2.2 Analysis of DDR Records at Kotmale GSS on Biyagama Line –1

According to the current vs time graphs of line -1 a small neutral current roughly around 80A can be seen at the time of trigger and after 30ms later the neutral current has gone up to 480A

(approx.) and remained for another 290ms and then reduced to roughly 80A and remained. Further, line-1 has tripped after 22 seconds and 382ms after triggering the Kotmale Ben.

Prior to tripping the line-1, the value of neutral current indicated about 80A (from the DDR graphs). Further, it can be seen that the phase currents are below 1500A. Note that the line overcurrent threshold setting was 1500A. Hence it can be concluded that even after the Line-2 was disconnected the line-1 was not overloaded beyond its over current protection limit.

Further, the DDR indicated a neutral current of 480A for a period of 290ms (based on rough estimates derived from the graphs). According to the IEC normal inverse curve and the relay settings with time dial setting of 0.38 and threshold current setting of 80A, the corresponding tripping time for a current of 480A is 1458ms.

Therefore, the aforesaid 480A neutral current have not lasted enough time to trip the line-1.

According to the DDR graphs (current vs time) the Kotmale-Biyagama Line-1 has tripped after 22 seconds and 382ms after the trigger time. Further, as indicated above there was 480A neutral current for a period of 290ms in between the time of DDR triggered time and tripping of the line.

6.3 Lakvijaya Shutdown at the Blackout

At the time of the blackout on 3rd December 2021, only two Units (Unit 1 and 3) were in operation and Unit 2 was taken out for maintenance. As per the submission by Mr. D.N. Navaratne (DGM – Generation Protection) the plant has shut down due to operation of Voltage Restrained Overcurrent protection (composite voltage over current protection) as a result of the power swing in Puttlam – New Anuradhapura line, that did not isolate from the grid. This relay identified as 50C is not found in the detailed settings provided by Mr. D.N. Navaratne or in his own protection setting guidelines submitted.

However, there is a Voltage Restrained Overcurrent setting for Unit 2 (no notation) under item numbers 238-243 ('Generator/ Transformer Protection setting summary of Lakvijaya power plants' submitted by Mr. D.N. Navaratne), and it states 'No Tripping' in all those items in the detailed setting of the power plant. The corresponding settings are blank in case of Unit 1 and Unit 3. Voltage Restrained Overcurrent Protection setting is named as 51V in the setting guidelines submitted by Mr. D.N. Navaratne.

As per CEB's internal investigation reports submitted by Mr D.N. Navaratne, the Voltage Restrained Overcurrent (50C) is a generator protection operation and thus the Unit does go into Fast Cut Back mode as this protection is for the protection of the Generator and not due to an isolation from the grid.

As per the report submitted by Prof Lilantha Samaranayake, Unit 3 and Unit 1 of LVPP had been tripped by the operation of the Composite Low Voltage Over Current protection as a result of transient instability.

Hence, it can be concluded that a further examination is required to find out the exact reason for the tripping of Lakvijaya power plant. Further, the protection schemes of the transmission lines connected to Lakvijaya Power Station need to be reviewed taking into account the power plants

protection settings as well, to ensure that the transmission lines do not unnecessarily isolate or cause plant shut down at abnormal operating conditions that do not necessarily endanger equipment.

6.4 Restoration

According to the reports submitted by Mr E.N.K. Kudahewa (CE- System Operation) and Prof. Lilantha Samaranayake, the restoration was complete by 16.47 hrs., that is 5 hrs. 20 minutes after the blackout, and this is an improvement considering more than 8hrs taken at 2020 blackout. The National System Control Center uses a very recently updated procedure (December 2021) to restore the system following system failure. At the oral submission Mr E.N.K. Kudahewa and Mr D.S.R. Alahakoon (DGM- System Control) stated that there were no major issues in restoration and that they are satisfied with the time taken to restore the system. As per the 2.1.1 of the restoration procedure DGM (System Control) shall inform GM (CEB), Chairman (CEB) etc. of the system failure. However, the person who was covering his duties has not done this as per the statement by Mr M.R. Ranatunga (Former GM, CEB). The following table based on report submitted by Mr E.N.K. Kudahewa, and Prof. Lilantha Samaranayake, lists the actual and potential delays/ issues that had taken place during restoration which may need attention in the future.

#	Equipment	Issue
1	Kothmale Biyagama Circuit 1 Breaker	PRV operation, and testing required to ensure safety of equipment, 2 hour delay
2	Kothmale Biyagama Circuit 2 Breaker	Tripping signal was not resetting and had to seek assistance from Transmission protection branch to reset – 50-minute delay
3	Samanalawewa Unit 1	Under Voltage trip when New Galle Feeder 09 connected
4	Kelanitissa GT 2	Delayed- reason not given
5	Kelanitissa GT 1	Backup protection operation, had to get support from Generation protection branch to rectify

Table 6-1: Delays and issues taken place during restoration

Though there were significant delays at Kothmale Power station, as the restoration was parallelly done through Vitoria power station the effective delay was minimized. Colombo city power restoration has had substantial delay as only 17 MW was loaded even at 2PM. The sequence identified in the restoration manual is to start with GT 04 and GT 02 and later synchronize on GT 01. In this instance that had to start GT 07 (115 MW unit) as well, as GT 01 got delayed.

It is understandable that there could be unexpected equipment malfunctioning at an island-wide failure as these systems are designed for continuous operation. There were several transmission lines that were not energized on time due to many reasons (known and unknown).

Hence it can be concluded that the delay in restoring Colombo city power was unacceptable (GT 01 synchronized only at 3.29 PM) and need further investigation. Further, incidents at Kothmale and Kelanitissa reveal that lack of authority and/or knowhow of the plant technical staff to work with the protection systems at their disposal. handover Thus, the familiarization and handover of the operation and monitoring activities of generator protection to the power station staff or housing one staff from protection branch (at least at the critical power stations like Lakvijaya, Kothmale, Victoria, Kelanitissa, etc) is recommended. E.g. Lakavijaya protection

system operation data can only be accessed by Generation protection staff stationed in Kandy. More coordinated and decentralized protection system operation is a requirement.

The restoration manual may need further improvement, e.g. New Galle Feeder 09 seem to have too much load. Also, the priority is given to Industrial and Commercial loads at restoration and this priority listing may be reviewed to incorporate critical loads like Hospitals, etc. Also, Industrial / Commercial loads may not be the most suitable ones technically as well (large starting currents, etc).

7 Summary of Written Comments

- Written submissions of Ceylon Electricity Board Technological Engineers& Superintendents Union appreciated the move taken to hold the public hearing and requested for an opportunity to make their submissions at the hearing but did not appear before the Commission at the hearing although they were invited to make their submissions.
- Lanka Viduli Podu Sevaka Sangamaya has highlighted the following issues regarding CEB in their written submission but did not appear before the Commission at the hearing although they were invited to make their submissions.
    - Suspicion of a sabotage on the incident of 03.12.2022
    - The incidents of black outs during 2015 & 2016 were confined only to reports. No investigations were carried out on those incidents and the reports were not published
    - The security system was installed expending billions but was not able to prevent a blackout
    - No inquiries were made for allocation of responsibility for occurrence of those incidents
    - Although a modern control system was established in 2020 the blackout could not be prevented and taking a long duration for restoration of the system
    - Blackouts are linked to the times when anew govt or a minister is appointed during the times which the authorities are compelled to implement the proposals made by CEB Engineers that had led to electricity and financial crisis of CEB
    - Poor HR management, silence of the unions protesting against corruption and employees promoting corruptions has surfaced under the circumstances that leads to frauds
- Unionism of Civil Societies against the Electricity Mafia
    - Suspicion of a sabotage on the incident of 03.12.2022 and other power interruption occurred on 29.11.2021 in Kosgama Grid and on 29.11.2021 in Weliwita Grid
    - To exercise powers vested with the PUCSL to intervene in accelerating theinvestigations on those incidents
    - Delay of nealy 2 months in connecting the 3rd plant of Norochcholai subsequent to the blackout
    - To compensate for the losses incurred by the consumers and to the economy
    - To takw legal action against the CEBEU officials for making public statements on implementation of power cuts without approval of the relevant authorities

8 Findings

8.1 Tripping of Kotmale-Biyagama Line-2

Due to the ground current flow occurred in between the two ends of phase B line, the difference in the current flowing through the line-2 of phase B, (measured at Kotmale and Biyagama ends) have reached the threshold value of phase current differential protection setting (i.e. 400A) of the Line protection relay (Main 01) at Kotmale end and has operated to trip the Kotmale-Biyagama line-2 phase B at 11.27.14.562. The Biyagama end of the line-2 has tripped by the operation of line differential protection on receipt of tripping signal from Kotmale end at 11.27.14.568. However, the line protection relay was unable to identify the fault location, and the CEB has requested clarification from the relay manufacturer in this regard on 09th Feb 2022.

8.2 Operation of End Fault Protection at Biyagama Grid Substation

1. Busbar protection relay of Biyagama end has operated the end fault protection function (for detection and disconnection of short-circuits between current transformers and circuit-breaker) tripping phases R and Y at 11.27.14.818 while only phase B of line-2 was open, without satisfying the end fault protection logic described in the respective relay manual. Hence the initiation of blackout could have been avoided if the end fault protection was implemented correctly in the Biyagama-Kotmale line-2 Main 1 line protection relay at Biyagama end.

2. Indication of the operation of end fault protection was not available in the SAS log of the Biyagama grid substation. This unavailability of information in the SAS have delayed the identification of root cause of tripping phase R and Y of Biyagama-Kotmale line-2.

3. CEB has not performed adequate analysis to identify the root cause of circuit breaker lockouts in Kotmale -Biyagama lines during similar lockout incidents happened in previous occasions. If it had been done the incorrect wiring issue could have been resolved prior to the blackout incident on 03rd December 2021.

4. According to the submitted drawings and reports it observed that CEB did not follow the formal procedure for commissioning, modifications, rectifications, etc, during the replacement of circuit breakers of Kothmale. Also, erection drawings were not professional and only hand sketches were provided for circuit breaker modifications. Completed as built drawings were not available for circuit breaker changes. The date of commissioning of the Kotmale Biyagama line-1 and line-2 circuit breakers were mentioned in hand sketched drawings submitted to commission. No handing over documents seen for the modifications carried out in the circuit breaker states feedback to the busbar protection equipment, after the blackout. As per the public hearing statements the handing over was done by verbal communication.

8.3 Suspicious User Logout Events in Biyagama Main 2 Protection Relay

According to OEM of Biyagama Main 2 protection relay, if the user presses the clear button without entering the password and logged in, then it is technically possible to have user log-out events in the event record of Biyagama-Kotmale Main 2 protection

relay even without any corresponding user logging-in events similar to the seven log out events appeared in the event log.

8.4 Tripping of Kotmale-Biyagama Line-1

1. Residual neutral current has remained at a value of more than drop out current value before the line-1 tripped. Therefore, considering the OEM clarification on drop out current, it is confirmed that the operation of ground overcurrent protection function was inevitable. Therefore, it can be concluded that Kotmale-Biyagama line-1 has tripped in accordance with the settings of ground overcurrent protection function of the main 1 line protection relay.

2. Considering the explanation given in the relay manual on dropout characteristic, and the OEM clarification on minimum absolute dropout differential, it is evident that irrespective of the dropout characteristic of the relay, the ground overcurrent protection function would have been operated tripping the line-1, as the neutral current has not reduced to dropout value.

3. Even after the tripping of Kotmale-Biyagama line-2, the Kotmale-Biyagama Line-1 has not overloaded exceeding its phase overcurrent protection limit. Therefore, if line-1 was not tripped (owing to ground overcurrent protection), the blackout could not have happened.

4. Subsequent to the blackout incident, CEB has increased the pickup setting to 160A (more than 10% of the maximum load current) to avoid possible recurrence of the operation of ground overcurrent protection function. Therefore, it can be concluded that if CEB had adequately assessed the sustaining zero sequence currents against their protection settings of ground overcurrent function of the line protection relay, the unwanted tripping of line-1 and consequent blackout could have been avoided.

5. The CEB protection standard: "Protection Setting Standard - Principles and Methods for Protection Settings" dated Aug 2019, need to be revised, while undertaking an assessment of the sustaining zero sequence currents in 220kV lines against their protection settings.

8.5 Tripping of Lakvijaya Power Station

It is required to further examine the exact reason for the tripping of Lakvijaya. Further, the protection schemes of the transmission lines connected to Lakvijaya Power Station need to be reviewed taking into account the power plants protection settings as well, to ensure that the transmission lines do not unnecessarily isolate or cause plant shut down at abnormal operating conditions that do not necessarily endanger equipment. E.g. Under a power swing situation, the best is to trip the line as oppose to tripping generators connected at the ends.

8.6 Delay in Restoration of Power

1. Further, it can be concluded that the delay in restoring Colombo city power was unacceptable (GT 01 synchronized only at 3.29 PM) and need further investigation. Further, incidents at Kothmale and Kelanitissa reveal that lack of authority and/or knowhow of the plant technical staff to work with the protection systems at their disposal. Thus, the familiarization and handover of protection systems to the relevant

power station staff (at least at the critical power stations like Lakvijaya, Kothmale, Victoria, Kelanitissa, etc) is recommended. E.g.Lakavijaya protection system operation data can only be accesses by Generation protection staff stationed in Kandy. More coordinated and decentralized protection system operation is a requirement.

2. The restoration manual may need further improvement, e.g. New Galle Feeder 09 seem to have too much load. Also, the priority is given to Industrial and Commercial loads at restoration and this priority listing may be reviewed to incorporate critical loads like Hospitals, etc. Also, Industrial / Commercial loads may not be the most suitable ones technically as well (large starting currents, etc).

9 Recommendations

9.1 Unnecessary operation of protection functions and inadequate investigations

1. Review the earth fault protections settings of line protection relays, after assessing the sustaining zero sequence currents in 220kV transmission lines, and also with the recommendation of OEM (of line protection equipment), in order to avoid unnecessary tripping of transmission lines. Accordingly, amend the CEB protection document "Protection Setting Standard - Principles and Methods for Protection Settings" with the approval from the authorized person.

2. Make necessary measures to list the records of operation of Busbar protection equipment in substation automation system log in Biyagama grid substation and other grid substations as required, in order to easy identification of the operation of protection functions (eg: operation of End fault protection).

3. Investigate on why the Fault locator function of the line protection relay (main 1) was not being able to identify the fault location of Kotmale-Biyagama Line-2, and correct any shortcomings (if any) in the implementation of aforesaid relay function. Further, assess the implementation of fault locating functionality of other 220kV line protection relays too (As this function is useful to quick determination of fault location and the associated rapid troubleshooting increase the availability of the line.)

4. In compliance with the Electricity (Transmission) Performance Standard regulations no.28, 29 and 30 of 2016, it is recommended that CEB Transmission Licensee to immediately start calculating the performance indices for power system protection and submit PUCSL quarterly basis.

5. CEB (Transmission Licensee) to carry out comprehensive analysis of every power system faults and plant tripping, in order to improve the power system reliability and stability.

9.2 Investigation on earth fault and the faulty wiring

To investigate the possibility of deliberate human interventions in earth fault on Biyagama-Kotmale line-2 and suspected faulty wiring of busbar protection system (wiring to provide circuit breaker status to the busbar protection relay), it is recommended to perform formal investigation by the law enforcement authorities.

9.3 Familiarizing the station staff on protection systems

1. Familiarize the power station staff on protection systems and handover the operation and monitoring activities of protection systems to the power station staff or housing one staff from protection branch (at least at the critical power stations like Lakvijaya, Kothmale, Victoria, Kelanitissa, etc) as more coordinated and decentralized protection system operation is a requirement.

2. Aware the Grid Substation staff on protection systems and relevant error types.

9.4 Adhering with standard written procedures for repairs and modifications.

It is evident that CEB has not maintained the system according to the prudent utility practices. Hence it is recommended to adhere with standard written procedures for repairs, replacements, maintenance, modifications, and rectifications for all works carried out by the CEB. All the diagrams should be validated by an authorized person. There should be an As-built drawing for all alterations. Drawings should be up to the standard, and they need to be readable and understandable for qualified technical staff. It will reduce the troubleshooting downtime and eliminate the dependence on specific people. Also, standard as-built drawings should be kept in all relevant locations.

9.5 Increasing the Transmission Line Redundancy

Kotmale Biyagama transmission line redundancy needs to be increased on a priority basis to avoid overloading the remaining lines during a trip off of one line.

9.6 Tripping of Lakvijaya Power Station

Further examine the exact reason for the Lakvijaya tripping. Review the protection schemes of the transmission lines connected to Lakvijaya Power Station taking into account the power plants protection settings, to ensure that the transmission lines do not unnecessarily isolate or cause plant shut down at abnormal operating conditions that do not necessarily endanger equipment.

9.7 Delay in Restoration of Power

1. Further investigate on the delay occurred in restoring Colombo city power.

2. Improve the restoration manual with a review of the priority listing to incorporate critical loads like hospitals, etc, and also considering the adverse effects from industrial / commercial loads having large starting currents.

10 Appendixes

A - Notices and Advertisements

B – Agenda of the Public Hearing

C – List of Written Submissions

D – List of Documents submitted by the Witnesses

Note: The minutes of the Public Hearing (including evidence and proceedings) and the Documents submitted by the Witnesses can be examined by any person with the written request made to the Commission.

Signed

Members of the Panel

Mr. Janaka Ratnayake- Chairman

Mr. Udeni Wickramasinghe – Member

Mr. Mohan Samaranayake – Member

Ms. Chathurika Wijesinghe - Member

Instructor

Janaki Vithanagama -

Date: 02.07.2022

Appendix - A

PUBLIC UTILITIES COMMISSION OF SRI LANKA

(Public Notice under Section 18 of the
Public Utilities Commission of Sri Lanka Act No. 35 of 2002)

PUBLIC HEARING ON THE ISLAND WIDE POWER FAILURE OCCURRED IN THE TRANSMISSION LICENSEE'S NETWORK 03RD DECEMBER 2021

The Public Utilities Commission of Sri Lanka (Commission) hereby notifies its decision to hold a Public Hearing to investigate on the island wide power failure occurred in the Transmission Licensee's network on 03rd December 2021.

The consequences of the said power failure include the Transmission Licensee's inability to serve a total **energy demand of 9.65 GWh equivalent to an estimated economic cost of Rupees one billion five hundred five million (LKR 1.505 billion or 1,505 million)** & the losses incurred to Distribution Licensees followed by additional consequence endangers, losses and impacts to the people, economy, and consumers due to the failure.

The determination of the Public Hearing will include but not limited to findings on Socio Economic Impacts and appropriate recommendations on avoidance of future recurrences of similar incidents.

The Commission intends to conduct the Public Hearing as prescribed under section 18 read with Section 15 of the Public Utilities Commission of Sri Lanka Act No. 35 of 2002 and according to the procedure approved by the Commission of Public Hearing.

The stakeholders and general public are hereby invited to surrender written submissions if any on the impacts or any issues or information connected with the power failure and the Commission may consider such submissions or may summon such parties if necessary, to give oral evidence at the hearing.

This Public Hearing is held under and by virtue of powers vested with the Commission under Section 18 of the Public Utilities Commission of Sri Lanka Act No 35 of 2002. The Date, Time and Venue will be informed to the public in due course by a similar notice published in the newspapers and via the official website of the Commission (**www.pucsl.gov.lk**)

Written submissions if any should be submitted within 28 days from the date of this notice to:

Chairman
Public Utilities Commission of Sri Lanka
Level 6, BOC Merchant Tower
28, St. Michaels's Road,
Colombo 03

Fax : 011 2292641
Email : consultation@pucsl.gov.lk

For further information and/or clarification please contact Ms. Janaki Vithanagama on 0776618031 or 0112392606-8

BY ORDER OF THE COMMISSION

Janaka Ratnayake
Chairman

11th January 2022

Appendix - A

PUBLIC UTILITIES COMMISSION OF SRI LANKA

(Public Notice under Section 18 of the
Public Utilities Commission of Sri Lanka Act No. 35 of 2002)

PUBLIC HEARING ON THE ISLAND WIDE POWER FAILURE OCCURRED IN THE TRANSMISSION LICENSEE'S NETWORK 03RD DECEMBER 2021

This is further to the paper notice appeared on 11th January 2022 regarding the above public hearing.

The Public Utilities Commission of Sri Lanka (Commission) hereby notifies its decision to hold the said Public Hearing to investigate on the island wide power failure occurred in the Transmission Licensee's Network on 03rd December 2021 on the date and at the venue stated below.

Date : 3rd March 2022 (from 9.30 am 5.00 pm)

Venue : Bandaranaike Memorial International Conference Hall (BMICH),
Bauddhaloka Mawatha,
Colombo 07

For further information and/or clarification please contact Ms. Janaki Vithanagama on 0776618031 or 0112392606-8

BY ORDER OF THE COMMISSION

Janaka Ratnayake
Chairman

Public Utilities Commission of Sri Lanka
Level 6, BOC Merchant Tower
28, St. Michaels's Road,
Colombo 03

Fax : 011 2292641
Email : consultation@pucsl.gov.lk

09th February 2022

Appendix B

Agenda of the Public Hearing on 03rd & 07th of March 2022

Day 1- 03rd of March 2022

SR #	Ref	Witness	Designation	Time
1.	PUCSL/PH 2022-01/W1	Ms. Wasantha Perera	Secretary, Ministry of Power	9.30 AM
2.	PUCSL/PH 2022-01/W2	Mr. M.M.C. Ferdinando	Chairman-Ceylon Electricity Board	9.45 AM
3.	PUCSL/PH 2022-01/W3	Mr. M.R. Ranatunga	Former General Manager - Ceylon Electricity Board	10.15 AM
4.	PUCSL/PH 2022-01/W4	Mr.P.W. Hendahewa	Addl. General Manager - Transmission Operation & Maintenance	10.45 AM
	Tea Break 10.45-11.00			
5.	PUCSL/PH 2022-01/W5	J.P.C.N.J. Patabendi	Electrical Superintendent, Biyagama GSS ,CEB	11.00 AM
6.	PUCSL/PH 2022-01/W6	Mr. M. Chanaka	Electrical Engineer In charge of Biyagama GSS ,CEB	11.30 PM
7.	PUCSL/PH 2022-01/W7	Mr. D.D.U. Dompage	DGM Transmission Operation & Maintenance	12.00 noon
8.	PUCSL/PH 2022-01/W8	Mr. K.H.K. Kondasinghe	Shift Engineer, Kotmale Power Station	12.30 PM
	1.00 - 2.00 PM Lunch Break			
9.	PUCSL/PH 2022-01/W9	Mr. K.M.I.N. Kuruppu	Chief Engineer (Officer In charge), Kotmale Power Station	2.00 PM
10.	PUCSL/PH 2022-01/W10	Mr. K.A.N. Perera	Chief Engineer, Shift In charge – Lakvijaya Power Station, Norochcholai	2.30 PM
11.	PUCSL/PH 2022-01/W11	Mr.P.W.M.N.A.B. Wijekoon	Power Plant Manager , Lakvijaya Power Station, Norochcholai	3.00 PM
12.	PUCSL/PH 2022-01/W12	Mr. E. Kudahewa	Chief Engineer, System Operation Centre, CEB	3.30 PM
	Tea Break 4.15- 4.30 PM			
13.	PUCSL/PH 2022-01/W13	Mr. D.S.R. Alahakoon	DGM, System Control Centre, CEB	4.00 PM

14.	PUCSL/PH 2022-01/W14	Mr. N.S. Wettasinghe	DGM, Transmission Protection & Control	4.30 PM
15.	PUCSL/PH 2022-01/W20	Mr. G.D.N.S. Garusinghe	DGM, Communication Branch	5.00 PM

Day 2- 7th of March 2022

SR #	Ref	Witness	Designation	Time
1	PUCSL/PH 2022-01/W15	Mr. D.N. Nawaratnne	DGM, Generation Protection	9.30 AM
2	PUCSL/PH 2022-01/W16	Mr. J.M.K. Jayasekara	DGM, Asset Management (Thermal Electrical)	10.00 AM
3	PUCSL/PH 2022-01/W17	Mr.P K N I Weeraratne	DGM, Corporate Strategy & Regulatory Affairs	10.30 AM
4	PUCSL/PH 2022-01/W18	Ms. U.P.A.H. Seneviratne	DGM, Occupational Health & Safety	11.00 AM
5	PUCSL/PH 2022-01/W19	Mr. K K S Dasanayaka	AGM Corporate Strategy & Regulatory Affairs	11.30 AM
	Tea Break 11.30-11.45			
6	PUCSL/PH 2022-01/W 21	Dr. Rohantha Abeysekara	General Manager, CEB	12.15 PM
	1.15 - 2.15 PM Lunch Break			
7	PUCSL/PH 2022-01/W22	Professor Lilantha Samaranayake	Chairman of the Expert Committee appointed by the Ministry of Power to investigate into the Power Interruption	2.15 PM
8		Submissions from General Public		2.45 PM
Tea Break 4.00- 4.15 PM				
9		Conclusion Remarks from the Commission		4.15 PM
1		Closure of the event		4.30 PM

List of Written Submissions

1. Ceylon Electricity Board Technological Engineers& Superintendents Union
2. Lanka Viduli Podu Sevaka Sangamaya
3. Unionism of Civil Societies against the Electricity Mafia

Appendix-D

List of Documents submitted by the Witnesses

Witness No.04

Name: Mr.P.W. Hendahewa

Designation: Addl. General Manager-Transmission Operation & Maintenance

1. Manual on Maintenance of Grid Substations and Transmission Lines
2. Manual on Protection of Transmission Lines (Standards/Strategy/Philosophy)
3. Manual on Procedure for taking over the projects
4. Manual on Restoration of system after Blackout
5. CEB's Final Report on the Island-wide Blackout of 3rd December 2021

Witness No.05

Name: JPCNJ Patabendi

Designation: Electrical Superintendent Biyagama GSS, CEB

1. Logbook records of Visitors from 28th November to 3rd December 2021.
2. Wiring Diagram drawing of new breaker at the commissioning in 2015.
3. Wiring diagram before correction of fault.
4. Wiring diagram after correction of fault.
5. Logbook records of error alarms.
6. Loading data of each circuit before the blackout

Witness No.06

Name: Mr. M. Chanaka

Designation: Electrical Engineer In charge of Biyagama GSS, CEB

1. Dates & Times the witness visited the Biyagama Grid Sub Station
2. Summary of the People visited & the Purpose to Biyagama GSS from 28th of November to 3rd of December 2021
3. Exact Date of the Rectification of Fault in Biyagama GSS which is related to Blackout on 3rd December

4. Copy of Log Book at Biyagama GSS from 28th of November until the date which the fault was rectified
5. Erection Drawing of Circuit Breaker Replacement in 2015 & the Drawing of the Wiring of Circuit Breaker Control after the Rectification at Biyagama GSS specifying the changes made in the Rectification.

Witness No.07

Name: Mr. D.D.U. Dompage

Designation: DGM Transmission Operation & Maintenance

1. Operation and Maintenance Manual for Transmission Lines and Substations
2. Original Drawing of the current breaker wiring at Biyagama GSS at the time of commissioning (which was rectified after the Blackout)

Witness No.11

Name: Mr. P.W.M.N.A.B. Wijekoon

Designation: Power Plant Manager, Lakvijaya PS, Norochcholai

- A Witten report explaining reasons with data pertaining to H2 cooling mechanism, H2 leak prevention mechanism that uses oil pressure, and the pressure fluctuations that were observed before 3rd Dec 2021 incident and an explanation as to why it is not related to 3rd Dec blackout incident.

Witness No.12

Name: Mr. E. Kudahewa

Designation: Chief Engineer, System Operation Centre, CEB

- Summary Report on Restoration

Witness No.13

Name: Mr. D.S.R. Alahakoon

Designation: DGM, System Control - CEB

- Prevailing (current) Restoration Guideline

Witness No.14

Name: Mr. N.S. Wettasinghe

Designation: DGM, Transmission Protection & Control

1. Report/record received to the Transmission Control and Protection Branch with the information related to the replacement of circuit breakers of Kotmale-Biyagama 220kV transmission line at Biyagama Substation in 2015.
2. Report on the actions taken by the Transmission Control and Protection Branch after the total failure occurred on 03rd December 2021, to prevent similar failures in future.
3. Manual for transmission system protection standards/philosophy
4. Commissioning and testing reports of the four earth fault relays of both circuits of Kotmale-Biyagama 220kV transmission line
5. Project handover procedure followed by the Transmission Control and Protection Branch related to the transmission protection equipment
6. Explanation for configuring one earth fault relay for "Disk Emulation" reset in Kotmale-Biyagama 220kV transmission line circuit 1 and configuring other 3 earth fault relays in Kotmale-Biyagama 220kV transmission line for "Instantaneous" reset and the effect of the above configuration on tripping of Kotmale-Biyagama circuit 1
7. Explanation for the records indicating the access of Main 2 relay of circuit 2 of Kotmale-Biyagama 220kV transmission line on 03rd December 2021 with Level 01 privileges and logging out seven times over a period of 1 minute at 8:33 am.

Witness No. 15

Name: Mr. D.N. Nawarathna

Designation: Deputy General Manager – Generation Protection

1. Generation Protection – Testing Guideline & Setting Guideline

2. A statement as to Whether there was Generation Protection Issue at Kelanitissa from the Blackout Period on 03/12/2021 to Blackout Restoration Time
3. Relay Settings & External Tripping Scenarios
4. Actions taken by Generation Protection Branch subsequent to the failure to improve the system

Witness No. 17

Name: Mr. P.K.N.I Weerarathne

Designation: DGM, Corporate Strategy, and Regulatory affairs

1. Proof of communication on 2018-2037 Generation plan approval date by PUCSL.
2. Revised long-term generation plan

Witness No. 18

Name: Mrs. U.P.A.H. Seneviratne

Designation: DGM, Occupational Health & Safety

1. Implementation Plan Timeline- Safety Regulation
2. Safety Manual

Witness No. 19

Name: Mr. K.K. S.Dasanayaka

- List of government offices and Institutions those have not paid their dues to CEB

Witness No.20

Name: Mr. G.D.N.S. Garusinghe

Designation: DGM, Communication Branch

1. Generation Protection – Testing Guideline & Setting Guideline
2. A statement explaining whether there was any Generation Protection issue at Kelanitissa Power Station during the Blackout on 03/12/2021
3. Generator protection Relay Settings at Lakvijaya Power Station and External Tripping Scenarios of the same
4. Actions taken by Generation Protection Branch subsequent to the failure to prevent similar failures in future

Witness No. 21

Name: Dr. Rohantha Abeysekara

Designation: General Manager,CEB

1. A comprehensive report about the incident
2. Protection Philosophy
3. The comprehensive report on CEB protection system
4. Time plan for submitting Performance measurement areas.
5. Details of Actions taken by CEB to mitigate island wide blackouts