For discussion on
26 June 2023

Legislative Council
Panel on Environmental Affairs

Power Supply Incident in Some Areas on Hong Kong Island of The Hongkong Electric Company, Limited on 19 April 2023

Purpose

The Government received on 15 May 2023 an investigation report submitted by The Hongkong Electric Company, Limited ("HEC") to the Director of Electrical and Mechanical Services ("the Director") concerning the power supply incident in some areas on Hong Kong Island on 19 April 2023. This paper briefs the Panel on the gist of the report, a copy of which is attached for perusal.

Background

2. As per the Electricity Ordinance (Cap. 406) ("the Ordinance"), the Government monitors the operation of the power companies to ensure the safe and reliable supply of electricity in Hong Kong. The Ordinance stipulates the powers and obligations of electricity suppliers, including, in the case of an electrical accident, giving the Director a report of the cause and what remedial action has been, or will be done, to prevent a recurrence of the accident.

3. The Government is very concerned about the power supply incident and has been closely following up with the HEC on its development. Subsequent to the incident, the Government requested the HEC to conduct an in-depth investigation into the causes and has been monitoring its follow-up work.

4. The Government received on 15 May 2023 the investigation report submitted by the HEC to the Director. The report gives an account of the course and causes of the incident as well as sets out improvement measures. A copy of the report is attached at the **Annex**.

The Incident

5. According to the HEC's report, a 275-kV fault occurred at 00:45 hours on 19 April 2023 and caused a system-wide voltage dip. The fault was originated from the Cyberport 275-kV Switching Station and the voltage dip resulted in power interruption to some customers starting from 00:49 hours. The HEC estimated that around 44 000 customers were affected in this incident, where the longest duration of power interruption to some customers was 48 minutes. The power supply to all affected customers was fully resumed at 01:37 hours.

6. As indicated in the report, the incident involved a set of high-voltage switchgear and high-voltage cables at the Cyberport 275-kV Switching Station. At the time of the incident, commissioning of the high-voltage switchgear was being conducted upon the recent completion of its refurbishment works. One end of the high-voltage switchgear was connected with high-voltage cables; while the other end of the cables was capped with cable cap-ends. The HEC was of the view that as the circuit diagrams of the Energy Management System and on-site labels were insufficient to indicate whether the high-voltage switchgear involved in the incident had been connected with the high-voltage cables, and the engineer in charge was unable to identify the presence of the connected high-voltage cables at site, coupling with the fact that there were no compulsory counter-check requirements for the relevant commissioning, the cables were accidentally energised during the commissioning, leading to the occurrence of the short circuit incident.

7. After the incident, the HEC immediately updated the relevant circuit diagrams, added proper labels on relevant equipment at site and disconnected in its transmission system a total of four sets of high-voltage cables which had been connected in the same manner (including the one involved in the incident) from the corresponding high-voltage switchgears. The Electrical and Mechanical Services Department ("EMSD") has designated staff to perform site inspection and examine relevant information, and confirmed the completion of the above short-term improvement measures.

8. Drawing on the experience of the incident, the HEC has put forward improvement measures which mainly include devising instructions and guidelines for updating site identification labels and circuit diagrams, reviewing

site arrangement of relevant cable circuits, enhancing risk assessments and procedures of commissioning transmission equipment, enhancing training of engineers and improving fault ride-through capability of generation units. The HEC will also review comprehensively the manpower arrangement, equipment and workflow of its Customer Emergency Services Centre, and engage an advisory service to review the incident and propose improvements to various management systems.

Conclusion

9. Having made reference to the views of an independent third-party expert, the EMSD agreed in principle with the causes of the incident and improvement proposals. Also, after discussion with the independent third-party expert, the EMSD requested the HEC to enhance various improvement measures, including examination on whether there is idle equipment connected to the transmission system and recommendations related to records management, training, commissioning and power supply equipment. The EMSD will closely monitor the HEC's implementation of all improvement measures for their early completion with a view to preventing reoccurrence of similar incidents. Meanwhile, the EMSD has also requested CLP Power Hong Kong Limited to review its relevant operation arrangement in the light of the incident in order to enhance safety on power supply.

Environment and Ecology Bureau
Electrical and Mechanical Services Department
June 2023

Annex

Incident of a 275-kV Fault in HK Electric's Power System

on 19 April 2023

INCIDENT INVESTIGATION REPORT

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Incident of a 275-kV Fault in HK Electric's Power System on 19 April 2023

INCIDENT INVESTIGATION REPORT

Submitted by:

Mr. Francis C.Y. Cheng
Operations Director – The Hongkong Electric Company, Limited

Date: 15 May 2023

This report has been translated into Chinese. The Chinese version is for reference only. If there is any conflict or inconsistency between the English version and the Chinese version, the English version shall prevail.

Incident of a 275-kV Fault in HK Electric's Power System on 19 April 2023

Incident Investigation Report (Executive Summary)

Introduction

1.1 A 275-kV fault occurred at 00:45 hours on 19 April 2023 and caused a system-wide voltage dip. The fault was associated with Cyberport 275-kV Switching Station and the voltage dip resulted in power interruption to some customers four minutes later at 00:49 hours and the power restoration was initiated in 33 minutes at 01:22 hours. It was a very rare incident in HK Electric's system, the last power interruption incident of similar scale occurred in the year 1994 which was caused by an incident outside HK Electric system.

1.2 Electricity supply to about 44,000 customers scattered in HK Electric's supply areas was interrupted in this incident. This represented about 4% of the total loading at the time of the incident. The longest duration of power interruption was 48 minutes from 00:49 hours to 01:37 hours, by then the power supply to all affected customers was fully resumed.

1.3 The incident is HK Electric's first major power interruption in almost thirty years. We are taking the matter very seriously and have notified and reported the incident to the Director of Electrical and Mechanical Services. Our Company has immediately set up an Investigation Committee, led by Operations Director, to carry out investigation in relation to the incident, to report on the findings and to recommend improvement measures to prevent similar incidents from happening in the future. The Investigation Committee comprised the following 8 members:

Mr. Francis Cheng	*Operations Director*
Mr. S.T. Ip	*General Manager (Transmission and Distribution(T&D))*
Mr. F.S. Chow	*General Manager (Generation)*
Mr. C.S. Leung	*Head of System Operations*
Mr. Tony Yeung	*Head of Construction & Maintenance (T&D)*
Mr. T.F. Chan	*Head of Operations (T&D)*
Dr. C.L. Lee	*Head of Operations (Generation)*
Mr. Alex Ng	*Group Legal Counsel*

1.4 To keep our customers and the public informed, we had shortly after the incident provided various updates based on our knowledge at the time. From the investigation we have conducted, we now have a full picture that the incident occurred due to a series of events and a number of factors. A spare cable circuit was inadvertently energised during commissioning of refurbished switchgear at the Cyberport 275-kV switching station causing a fault at HK Electric's power supply system. A severe voltage dip of the system followed and affected the generating units at Lamma Power Station, necessitating a shutdown of two of the units and resulting in insufficient power generation to meet the load demand. The combination of these factors escalated into this power interruption.

1.5 The incident is most regrettable, and we apologise again for the inconvenience caused to our customers. We will learn from this lesson and enhance our operations to sustain our commitment to delivering a reliable electricity supply to our customers.

1.6 Our report sets out the findings of our investigation, the causes of the incident, and the recommendations and improvement measures to be taken to prevent similar incidents from happening in the future.

What Happened

Cyberport 275-kV Switching Station and Spare Cable Circuits

1.7 Cyberport 275-kV Switching Station (CPX) at which the incident started is one of the 275-kV switching stations in HK Electric's transmission network for receiving power from Lamma Power Station (LPS). CPX was planned to be commissioned to meet the demand of the Cyberport development in 2002 using two 275-kV cable circuits in the vicinity. Following the installation and commissioning of the two Lamma 275-kV submarine cable circuits to CPX and subsequent network reconfiguration, two of the 275-kV cable circuits connected to CPX have become spare circuits and have been reserved for future use since 2009 as shown in Illustration 1 of the main report.

1.8 At the time of the incident, the 275-kV Gas Insulated Switchgear (GIS) of CPX was under commissioning after completion of the refurbishment of one of the switchgear sections as shown in Figures 1 and 2 of Appendix 2. This section of switchgear is connected to one of the two spare cable circuits (mentioned in 1.7) through a cable isolator. As part of the commissioning, all GIS switches that had been worked on, including the cable isolator (named L53A) connected to the spare cable circuit, had to be energised. According to our standard practice, such commissioning work has to be carried out at mid-night and only one in-service circuit is arranged to supply electricity for the commissioning as an additional precautionary measure in order to minimise possible impacts on both the system and our customers if something unforeseeable happened.

Three-phase Fault during Commissioning

1.9 The engineer in charge carried out the commissioning work according to the approved commissioning procedures at CPX. Another engineer with appropriate qualification was also deployed to CPX to double check the switchgear gas pressure and to carry out specific parts of the commissioning procedures not related to circuit energisation. The whole process was also supported remotely by an engineer in the System Control Centre at Ap Lei Chau, who was responsible for switching on and off the GIS during commissioning according to the site condition as confirmed by the engineer in charge as well as the approved commissioning procedures using remote control facility. At 00:45 hours on 19 April 2023, as per confirmation of the engineer in charge, the engineer at System Control Centre energised the cable isolator whereby a 275-kV three-phase fault occurred and relevant Circuit Breakers (CBs) tripped correctly by backup protection system to isolate the fault. Subsequent investigation concluded that the spare 275-kV cable circuit connecting to the cable isolator with the other end

of the cable capped inside Kai Lung Wan Tunnel portal was inadvertently energised causing the tripping.

Tripping of HK Electric-CLP Power Interconnector Circuits

1.10 HK Electric's power system has been connected with the power system of CLP Power since 1981 through three cross-harbour interconnector circuits for providing emergency support to each other if and when needed. Immediately after occurrence of the fault, the three-phase-fault detection scheme in our system also operated automatically according to the design and disconnected all three interconnector circuits between HK Electric and CLP Power's power systems. This detection scheme is custom-built to prevent blackout of HK Electric's entire system due to possible severe power oscillation between the two power systems of HK Electric and CLP Power. After all three interconnector circuits were disconnected, emergency support from CLP Power was not available anymore.

Impact on the Power System

1.11 It was the first time that a 275-kV three-phase-fault occurred in HK Electric's system, which gave rise to a very severe disturbance to the power system. The fault also caused a severe voltage dip and the system voltage had collapsed to nearly zero for about half a second, which was a very rare incident and caused considerable adverse impacts on the whole power system.

All the generating units at Lamma Power Station and their auxiliary equipment were also seriously affected by this unprecedented power disturbance. The total power generation fluctuated seriously in the first few seconds after the occurrence of the fault. The protection systems of the auxiliary and major equipment functioned to protect them from damage. For example, the lubricating oil pumps of some coal mills affected by the voltage dip were tripped by the undervoltage protection such that the cables and the motors of the pumps had been protected from overheating; and the moving parts of the coal mills had been protected from excessive wear by tripping the mills when the pressure of the lubricating oil dropped. These protection systems were designed for preventing damage of generating units during severe power disturbance rather than allowing them to ride through a system fault.

Shutdown of Two Generating Units and Activation of Under-frequency Load-Shedding

1.12 When the power generation of a power system cannot meet the load demand, the power system becomes unstable and the system frequency will drop. It is necessary to either increase the power generation or reduce the load demand to restore the system to normal. To tackle the situation of low system frequency, an under-frequency-load-shedding protection device is installed in each and every zone substation to disconnect a pre-defined amount of load automatically when the system frequency drops to a particular value in order to prevent a further decrease in system frequency, which would result in a system blackout if not arrested. There are six stages of under-frequency load-shedding that operate at different values of system frequency. After the operation of the first stage, if the system frequency continues to drop even lower, stage 2 will be triggered and so on.

1.13 The Lamma Power Station was prior to the incident operating with five generating units running, namely coal-fired units L6, L7, L8 and gas-fired units L10 and L11. As a result of this severe power disturbance, shutdown of one coal-fired and one gas-fired generating unit, namely L7 and L10, respectively, was required (refer to 1.20.10 to 1.20.11 below).

In the course of the shutdown of L7 and L10, the power output of these two units decreased significantly and the total power generation of HK Electric was insufficient to meet the load demand. It in turn led to a rapid drop in system frequency.

1.14 Before L7 and L10 were completely shut down at 01:04 hours and at 01:08 hours respectively, the system frequency had dropped to the limit that triggered the operation of the first stage of the under-frequency load-shedding scheme. As a result, at 00:49 hours, 49 distribution cable circuits at 16 zone substations were automatically switched off by the protection scheme to reduce the system demand by around 4% in order to restore the balance between electricity generation and demand. Supply to a total of about 44,000 customers scattering in Ap Lei Chau, Tin Wan, Wong Chuk Hang, Wanchai, Causeway Bay, North Point, Shaukeiwan, Heng Fa Chuen, Taikoo, Chai Wan, Central and Pokfulam were affected.

1.15 The under-frequency load-shedding scheme is designed to distribute the disconnected loads all over our supply territory to avoid blackout of an entire district that will inevitably affect the essential loads like hospitals and other public facilities in that district. According to our records, power supply to essential services had not been interrupted in the incident.

Restoration of Electricity Supply

1.16 Gas Turbine No.1B[1] at Lamma Power Station was automatically started up at 00:48 hours. Taking into account the facts that the station auxiliary plants of the remaining generating units, namely L6, L8 and L11, had not yet fully stabilised; and the available capacity of Gas Turbine No.1B was only 27 MW, the on-duty engineer in System Control Centre at Ap Lei Chau made a judgement that restoration of interrupted electricity supply to customers by increasing the output of L6, L8, L11 and Gas Turbine No.1B was risky, as it might lead to further tripping of the remaining generating units still in operation and triggering of more under-frequency load-shed. Based on this and the principles laid down by our inhouse instruction, he decided to restore the interconnector circuits with CLP Power first so that immediate backup power supply could be provided if necessary. The interconnector circuits with CLP Power were put back in service from 01:22 hours to 01:28 hours.

1.17 After the first interconnector circuit was restored at 01:22 hours, a team of engineers in System Control Centre immediately started to send remote control commands to the affected zone substations to restore electricity supply by switching on the affected distribution cable circuits. As no essential loads like hospitals were interrupted in this incident, all affected distribution cable circuits

[1] Gas turbine No. 1 has two engines, only one engine could be selected for under-frequency startup.

were regarded as of the same importance. The engineers in System Control Centre coordinated with each other to determine the restoration sequence with an aim to switch on all affected distribution cable circuits as soon as possible while maintaining the system stability. Electricity supply in various districts were restored simultaneously. The entire supply restoration took 15 minutes to complete at 01:37 hours.

Operation of Customer Emergency Services Centre (CESC)

1.18 Due to the severe voltage dip and the number of customers affected in the incident, our Customer Emergency Services Centre was flooded with telephone inquiries in the first few hours of the incident. In the first hour of the incident, a total of more than 10,000 calls were made to the Chinese/English hotlines of HK Electric, which was more than a thousand times of the daily workload. Since the number of incoming calls far exceeded the number that customer service representatives could answer, we activated the broadcast function of voice message(s) in the call system . If a customer was able to get connected to the call system, they could hear the following message "Some customers may have experienced a power interruption due to a fault in our supply system. We are making arrangement to restore electricity supply as soon as possible. We apologise for any inconvenience caused."

Dissemination of Information

1.19 Following the incident, we disseminated information collected at the time about the incident and our response through various channels, including media statements, telephone messages, corporate website banners, so as to keep our customers and the public timely informed. These public communications are summarised in Appendix 1 to this report.

Investigation

1.20 We have conducted a thorough investigation into a number of areas which include testing the cap-ends of the energised spare cable circuit which were found with signs of flashover in this incident, inspecting the switchgear and other cable circuits involved in this incident and used for energising the section of switchgear after refurbishment, reviewing our relevant records, site identification systems, commissioning procedures, and interviewing relevant personnel. The investigation findings are summarised as follows:

Possible Presence of Spare Cable Circuits in Transmission System

1.20.1 Spare cable circuit in transmission system is uncommon and is for special purposes. Upon re-checking, there are four spare cable circuits (including the one involved in this incident) in our transmission system, all of them were reserved after network reconfiguration and intended for contingency spare or future network expansion.

The Fault Location

1.20.2 Subsequent to the tripping of the circuit breakers, inspections were conducted on all the apparatuses involved, including the GIS at Lamma Power Station (LPS),

GIS at CPX and all associated cable circuits. All apparatuses, including the refurbished GIS at CPX, were checked and confirmed normal.

1.20.3 An independent laboratory was engaged to conduct a detailed analysis of the failed cable end-caps of the spare cable circuit. The findings together with the other electrical tests on the affected spare cable circuit supported the fact that the cable end-caps failed when system voltage, i.e. 275 kV, was applied on them during energisation of cable isolator L53A and caused the system disturbance.

1.20.4 Based on system records and the site findings, it was concluded that the spare 275-kV cable circuit at CPX was inadvertently energised during commissioning of the CPX GIS after refurbishment, which caused a fault in the 275-kV system. All protection operations in this incident were correct and according to design.

The Refurbishment Work

1.20.5 All the refurbishment works at CPX were supervised by the same engineer in charge. During the course of refurbishment, a working team comprising six team members, including two technical supervisors from the original equipment manufacturer (OEM), was assigned to carry out the work. At the time of commissioning, all refurbishment works had been completed and the working team had withdrawn. A qualified engineer was assigned to carry out commissioning work with the engineer in charge to double check the switchgear gas pressure and to carry out specific parts of the commissioning procedures not related to circuit energisation.

1.20.6 In preparation for the refurbishment work, the engineer in charge performed a number of tasks, including among other things:

i. referred to the circuit diagrams of Energy Management System (EMS) [2] which was a customary practice for using it as reference by engineers to prepare the work procedures (including switching and commissioning procedures) and relevant HV Permit-to-work (PTW);

ii. confirmed the circuits connected to the GIS by checking on-site various labels on the GIS: Upon checking at the site, the engineer in charge could not differentiate whether the GIS was connected with or without cable circuit based on the generic "Spare" labels without any other details which were attached to various locations of the GIS.

iii. visually checked the external condition of the cable connection tanks to confirm if there was cable connected to the GIS: the bottom of each cable connection tank is fully concealed by a fire-rated steel enclosure and a corrugated pipe, the engineer in charge could not clearly see any cable connected to the GIS during inspection.

From these, the engineer in charge formed the view that the GIS bay he was going to work on was a spare one with no cable connected. A Permit-to-Work

[2] Energy Management System is an operation computer system installed in System Control Centre for controlling and monitoring of the generation and transmission systems of HK Electric.

(PTW) was then issued to our technical staff to carry out the refurbishment, and risk assessment of the work was also conducted on this basis.

1.20.7 During the course of refurbishment, various tests were carried out to check the electrical and mechanical integrity of the switchgears but no tests were designed to check the presence of spare cable circuit. The engineer in charge also inspected the interior of the cable connection tank as per the inspection checklist. The engineer in charge explained during the investigation that his attention was distracted by the grease found on the surfaces of the cable connection bushings, which he instructed a technician to remove, but he was unable to identify the presence of the spare cable circuit as mentioned above.

The Drawing Records and On-site Labels

1.20.8 For the two circuits which became spare cable circuits at site, the details were also updated in the detailed transmission schematic drawing and other related drawings. However, they were not updated in the circuit diagrams of EMS as there were no explicit guidelines on the updating requirements of these non-operational spare cable circuits in EMS circuit diagrams. Nevertheless, there is an automatic computer system in place to check the connection consistency of all in-service cable circuits, but not spare cable circuits, among various circuit diagrams to ensure the correctness of in-service cable circuits. As a result, the spare cable circuit was not shown in the EMS circuit diagrams which were used commonly by our engineers for GIS refurbishment work. Besides, there was also no specific guidance on the function and limitation of the EMS diagrams in the department.

1.20.9 Generic "spare" labels without any other details attached at site as per common practice could only indicate the function of the spare GIS but could not sufficiently differentiate whether the spare GIS was with and without cable circuit connected.

Shutdown of Two Generating Units that Led to Under-frequency Load Shed

One coal-firing generating unit L7 and one gas-firing generating unit L10 had to be shut down in this incident:

1.20.10 For unit L7, power supplies to major equipment of the boiler were interrupted in this incident. The lubricating oil pumps of the in-service coal mills, i.e. coal mills 7A, 7B, and 7C, stopped and because only one lubricating oil pump was installed for each coal mill, the coal mills were tripped by the protection of low lubricating oil pressure. This was necessary as running without lubrication oil would cause major damages to the coal mills. The firing of the boiler ceased under such condition and the operation engineer had to put the unit off-load eventually after the generator output of the unit dropped to a minimum level.

1.20.11 For unit L10, which consists of a steam turbine and a gas turbine, the generator output dropped and rebounded very substantially during the incident, and the steam turbine of the unit stopped due to a protection operated to prevent its damage. With the steam turbine tripped but the gas turbine still running, the unit load gradually decreased to a minimum level and after an alarm of the generator operated, the operation engineer had to put the unit off-load.

1.20.12 The actions taken by the operation engineers in response to the severe disturbance to the generating units during the incident were assessed and found to be appropriate. They were necessary to safeguard the generating equipment from damage while not imposing additional stress to the system. For example, after the coal mills of L7 stopped, the operation engineer exercised his knowledge and judgment to allow the unit to continuously generate electricity safely for about 19 minutes, even though the generator output dropped gradually from 200 MW at 00:45 hours to 10 MW at 01:04 hours, using the residual steam in the boiler. If the operation engineer had tripped the unit immediately at about 200 MW after all coal mills stopped, it would cause another disturbance to the system and exacerbate the situation.

1.20.13 The under-frequency load-shedding scheme operated as designed and successfully arrested the frequency drop and maintained the integrity of the power system. The decision of the engineers in System Control Centre not to restore the distribution cable circuits switched off by the under-frequency load-shedding scheme until the first interconnector circuit had been restored as well as the subsequent process of supply restoration to the affected distribution cable circuits were assessed and found to be appropriate.

Resources and Quality of Work

1.20.14 All operations, maintenance and commissioning works related to transmission apparatus are conducted or supervised by our own internal resources or OEM supervisors. For the GIS refurbishment, the work was carried out by in-house experienced resources under the full-time on-site supervision of OEM personnel from the manufacturer.

1.20.15 According to our investigation, the refurbishment work was carried out according to procedures and had met the quality requirements. During the post-fault inspections and testing on the refurbished GIS, no abnormalities were found. It was concluded that the incident was not related to either adequacy of resources or quality of refurbishment work.

Incident Causation

1.21 Based on the investigation findings, we attributed the incident to the following causes:

For the 275-kV fault

1.21.1 EMS Circuit diagrams did not record the spare cable circuit

Since spare cable circuits are not designed to be used in daily operation of the power network, they were not specifically marked in the EMS circuit diagrams but were only updated in the detailed transmission schematic drawing and other related drawings. There was also no specific guidance on the function and limitation of the EMS diagrams. As a result, this spare cable circuit was not

shown in those EMS diagrams which were commonly used by our engineers for GIS refurbishment work.

1.21.2 On-site labels were insufficient to indicate whether a spare cable circuit is connected to the switchgear

Generic "spare" labels without any other details were displayed on the switchgear concerned as per past common practices. These labels were designed to indicate the function of the switchgear, but could not sufficiently indicate or differentiate between a switchgear with or without spare cable circuit connected.

1.21.3 The above two factors in aggregate did not provide sufficient indications to the engineer in charge to alert him that the switchgear was connected to a spare cable circuit and hence significantly limited the risk analysis related to the energisation of the concerned cable isolator. Otherwise, the engineer in charge could have taken these into consideration in the risk analysis before preparing for the commissioning operation.

1.21.4 The engineer in charge was unable to identify whether the GIS was connected to a spare cable circuit in his on-site inspection

On-site inspection to find out the actual configuration of the equipment is a critical step in the preparation of the commissioning procedures after refurbishment of the switchgear. Unfortunately, the bottom of each cable connection tank is fully concealed by a fire-rated steel enclosure and a corrugated pipe, making the engineer in charge unable to clearly see any cable connected to the GIS during his inspection. Having seen no cable connections, the engineer in charge concluded, based on the site labels, the EMS Diagrams and his past experiences, that the GIS was not connected to any cable circuit.

1.21.5 No compulsory counter-check requirements for commissioning of refurbished GIS

In HK Electric, counter-check requirements have been adopted for high-risk or critical tasks involving GIS. For GIS refurbishment, all critical tasks had been counter-checked by an independent qualified engineer. However, for commissioning, as the refurbishment did not involve replacement of insulation parts or network change, the commissioning procedure was not counter-checked by another qualified engineer at site. This incident could have been avoided if another qualified engineer had been deployed to conduct an independent site inspection to confirm the correctness and suitability of the commissioning procedure.

<u>For the Power Interruption</u>

1.21.6 Consequential Power Disturbance and Severe Voltage Dip affected generating units at Lamma Power Station

The consequential power disturbance and severe voltage dip caused by the 275-kV fault affected the generating units at Lamma Power Station and units L7 and L10 had to be shut down due to tripping of auxiliary or main equipment and there

was insufficient generation to meet customers' demand as illustrated in 1.20.10 and 1.20.11 above.

The shutdown of the two generating units was inevitable to safeguard the generating equipment from damage. The action was considered to be proper and necessary in order to avoid the risk of a worse case of prolonged outages of the generation units having more serious impacts on customers.

Recommendations and Improvement Measures

The following remedial actions were formulated in respect of a number of areas, including among others, site labels and circuit diagrams, training of engineers, commissioning of transmission equipment, fault ride-through capability of generating units. Some of these measures, including disconnection of the four spare transmission cable circuits and improvement of site labels and update of EMS circuit diagrams have already been implemented and completed:

1.22 Site Labels and Circuit Diagrams

Site labels showing details of the spare cable circuits were added at sites (Figures 4 to 7 in Appendix 2) to differentiate these spare switchgear bays connected to a spare cable circuit from other spare switchgear bays without cable circuit connected. The labels of all four circuits were updated. The EMS circuit diagrams were updated (Figure 3 in Appendix 2) to include a spare cable circuit connected to the switchgear with remarks to alert engineers at System Control Centre and other site engineers. Consistency among the detailed transmission schematic drawings in our geographical information system, the EMS circuit diagrams and site labels were checked and no further discrepancies were found. Instruction and guidelines for updating site identification labels, the detailed transmission schematic drawings, single line diagram and EMS circuit diagrams will be established by end June 2023.

1.23 Site Arrangement of Spare Cable Circuits

Immediate checking of spare GIS bays in our whole transmission network was completed. Four spare cable circuits in our transmission system were identified, all were left over after network re-configuration and were kept for future contingency use or network expansion. Two of the circuits are 275-kV spare cable circuits at CPX and the other two are 132-kV spare cable circuits at Kennedy Road 132-kV Switching Station and Apleichau 132-kV Switching Station. Internal inspection of the four GIS bays with spare cable connections as mentioned above was completed and the spare cable circuits had all been disconnected from the respective GIS. Complete segregation of spare cable circuits from our GIS will be completed by July 2023 upon delivery of the required modification materials from the original equipment manufacturer (OEM). Furthermore, guideline to detail the connection arrangement and labelling of spare GIS bays will be established by June 2023.

The site labelling, switchgear arrangement and relevant drawings of distribution spare cable circuits will also be checked and the practices will be aligned with that of spare transmission cable circuits as much as possible. The guidelines on

handling spare distribution cable circuits will also be established. This will be completed by Q3 2023.

1.24 Training of Engineers

The engineer in charge concerned had been suspended for all work-related authorisation in our Transmission and Distribution network. He has been taken away from operational duties and placed in a unit to provide logistics support until he has regained confidence and has passed the interviews by the relevant assessment panels before resuming his normal operational duties. Coaching and site training of our engineers, in particular, in handling new transmission apparatuses/configurations will be enhanced. Guidelines on the limitations and purposes of each type of transmission diagram will also be established. Preparation of the guidelines and the training will be completed by Q3 2023.

1.25 Risk Assessment and Enhanced Procedures for Commissioning of Transmission Equipment

Immediately after the incident, all relevant transmission refurbishment works have been temporarily suspended until the guidelines have been formulated. In addition, additional resources have been deployed to check critical infrastructure in transmission network to ensure reliability and stability of supply. The commissioning procedures of transmission equipment after various types of works, including the checking and approval process as well as the selection criteria of dedicated commissioning circuit will be further enhanced. In addition, the settings of protection system(s) to provide faster protection during commissioning will also be formulated to cater for unforeseeable circumstances. All these will be completed by Q3 2023.

Counter-check requirements have been adopted for commissioning of all GIS immediately, whether it is a new or refurbished one. Another qualified engineer will be deployed to check the commissioning procedure prepared by the engineer in charge and inspect the site to confirm the correctness and suitability of the procedure.

The critical steps in works on transmission system which required counter-checks will be holistically reviewed and confirmation of the presence or absence of spare cable circuits will be included as one of such steps. The review will be completed and relevant instructions will be issued by June 2023.

1.26 Fault Ride-through Capability of Generation Units

We are reviewing with the OEM regarding the responses of generating units L7 and L10 during the incident, and seeking their recommendations to improve both coal-fired and gas-fired generating units to ride through similar severe fluctuations of system voltage. We target to finalise the improvement plan by end 2023.

1.27 Customer Emergency Services Centre

We will comprehensively review the manpower arrangement, equipment and work flow of the Customer Emergency Services Centre and explore other possible means to effectively disseminate information on major power abnormalities to customers by Q3 2023.

1.28 Advisory Service

We will engage advisory service by June 2023 to review the incident and propose improvements of various management systems such as the drawing updating system, quality control system of transmission work, counter-check requirements of critical steps, qualification and training system, etc. We target to complete the review in three months and all recommendations will be implemented by end 2023.

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Incident Investigation Report

1 Introduction

1.1 A 275-kV fault occurred at 00:45 hours on 19 April 2023 and caused a system-wide voltage dip. The fault was associated with Cyberport 275-kV Switching Station. The voltage dip triggered a series of events that resulted in power interruption to some customers four minutes later at 00:49 hours and the power restoration was initiated in 33 minutes at 01:22 hours. It was a very rare incident in HK Electric's system, the last power interruption incident of similar scale occurred in the year 1994 which was caused by an incident outside HK Electric system.

1.2 Electricity supply to about 44,000 customers scattered in HK Electric's supply areas was interrupted in this incident. This represented about 4% of the total loading at the time of the incident. Some experienced power interruption of up to 48 minutes from 00:49 hours to 01:37 hours, by then the power supply to all affected customers was fully resumed.

1.3 The incident is HK Electric's first major power interruption in almost thirty years. We are taking the matter very seriously and have notified and reported the incident to the Director of Electrical and Mechanical Services. Our Company has immediately set up an Investigation Committee, led by Operations Director, to carry out investigation in relation to the incident, to report on the findings and to recommend improvement measures to prevent similar incidents from happening in the future. The Investigation Committee comprised the following 8 members:

Mr. Francis Cheng	*Operations Director*
Mr. S.T. Ip	*General Manager (Transmission and Distribution(T&D)))*
Mr. F.S. Chow	*General Manager (Generation)*
Mr. C.S. Leung	*Head of System Operations*
Mr. Tony Yeung	*Head of Construction & Maintenance(T&D)*
Mr. T.F. Chan	*Head of Operations (T&D)*
Dr. C.L. Lee	*Head of Operations (Generation)*
Mr. Alex Ng	*Group Legal Counsel*

1.4 To keep our customers and the public informed, we had shortly after the incident provided various updates based on our knowledge at the time. From the investigation we have conducted, we now have a full picture that the incident occurred due to a series of events and a number of factors. A spare cable circuit was inadvertently energised during commissioning of refurbished switchgear at the Cyberport 275-kV switching station causing a fault at HK Electric's power supply system. A severe voltage dip of the system followed and affected the generating units at Lamma Power Station, necessitating a shutdown of two of the units and resulting in insufficient power generation to meet the load demand. The combination of these factors escalated into this power interruption.

1.5 The incident is most regrettable, and we apologise again for the inconvenience caused to our customers. We will learn from this lesson and enhance our operations to sustain our commitment to delivering a reliable electricity supply to our customers.

1.6 This report sets out the findings of our investigation, the causes of the incident, and the recommendations and improvement measures to be taken to prevent similar incidents from happening in the future.

2 Background

2.1 Cyberport 275-kV Switching Station and Spare Cables

2.1.1 Cyberport 275-kV Switching Station (CPX) at which the incident occurred is one of the 275-kV switching stations in HK Electric's transmission network for receiving power from Lamma Power Station (LPS). The power received is transmitted to the Southern District and to the northern belt of Hong Kong Island.

2.1.2 To cope with the increasing load demand associated with the development of Cyberport and Southern District, four 275-kV cable circuits were laid from CPX to connect to two existing 275-kV cable circuits near Kai Lung Wan Portal in 2002.

2.1.3 Following the installation and commissioning of the two Lamma Power Station to Cyberport 275-kV submarine cable circuits in 2006, the two 275-kV cable circuits which were used to supply CPX in 2002 were restored to their original configuration. Two of the four CPX cable circuits were then extended and connected to Marsh Road 275-kV Switching Station in Wanchai in 2009 for delivering power to the northern part of Hong Kong Island while the remaining two have since become spare cable circuits. One end of these two spare cable circuits was capped inside Kai Lung Wan cable tunnel portal while the other end remained connected to the 275-kV switchgear of CPX.

2.1.4 As these two spare cable circuits were laid in a common trench with the other two extension cable circuits to Marsh Road 275-kV Switching Station, they were designed to be reserved for future use such as possible emergency repair of the extension cable circuits as well as for possible future network reinforcement/expansion. While these spare cable circuits were connected to CPX, considerable amount of works including cable jointing and testing would be required before they could be put into service. The two cable isolators at CPX connecting to these two spare cable circuits were opened and locked by unique lock to ensure these spare cable circuits were securely separated from our in-service transmission network. Details of the network change mentioned in 2.1.3 and 2.1.4 are shown in Illustration 1.

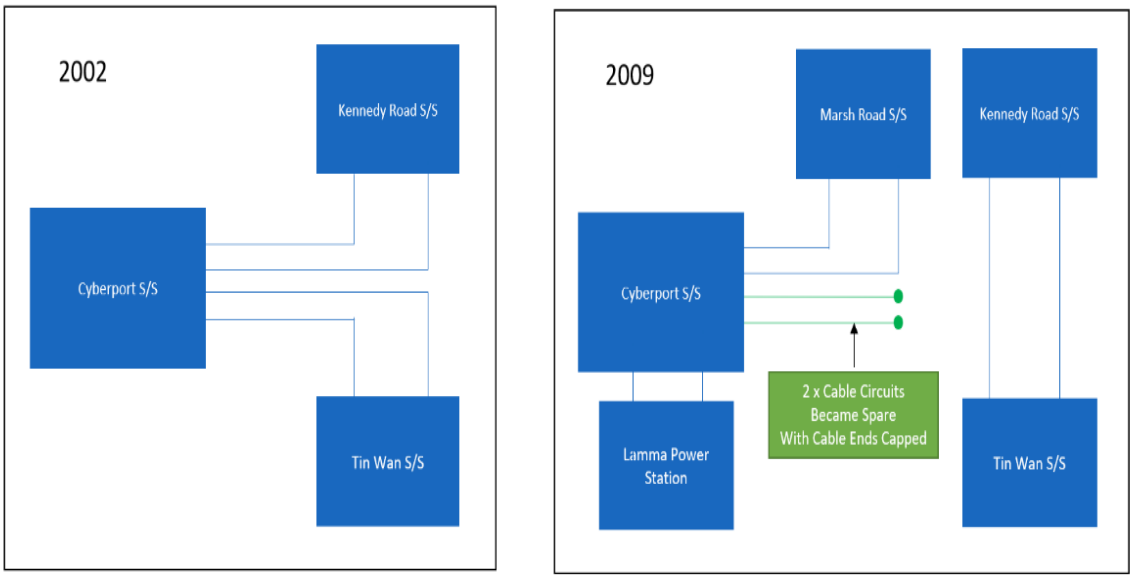


Illustration 1. Network Change at CPX in 2002 and 2009

2.2 Refurbishment of Gas Insulated Switchgear at CPX

2.2.1 At the time of the incident, the 275-kV Gas Insulated Switchgear (GIS) of CPX was being refurbished. The switchgear is filled with Sulphur Hexafluoride gas for insulation purpose.

2.2.2 The GIS installed at CPX was supplied and installed by the original equipment manufacturer (OEM) in 2002, and was designed and manufactured according to international standards. Cross sectional drawing of the GIS involved in this incident is shown in Figure 1 of Appendix 2.

2.2.3 All GISs are subject to 5-yearly general maintenance. The general maintenance involves quality check of the insulation gas, functional check and alarm testing of the switchgear, etc. The cable isolator and earth switch for controlling the spare cable circuit were not required to be operated for such maintenance work and therefore not disturbed. The general maintenance does not include any internal inspection and detailed checking of each and every part of the switchgear. The switchgear OEM recommended conducting comprehensive refurbishment of GIS around every 15 to 20 years in order to maintain its reliability. The comprehensive refurbishment of GIS involves detailed inspection of all their internal and external parts and replacement of consumable materials subject to wear and tear during normal operations, such as the current-carrying contacts.

2.2.4 Transmission GIS refurbishment was first introduced into HK Electric's transmission network in 2003. The GIS refurbishment at CPX was the first one since its commissioning in 2002. The refurbishment work was carried out solely by our experienced in-house technical staff under the full-time supervision of on-site OEM personnel to ensure work quality.

2.2.5 Refurbishment of the CPX GIS commenced in February 2023 according to schedule. Each GIS section took about three weeks to complete. The refurbishment of the concerned GIS section commenced on 22 March 2023 and was completed on 18 April 2023. The

scope of refurbishment of this section of GIS is marked in the associated Energy Management System (EMS)[1] circuit diagram as shown in Figure 2 of Appendix 2.

3 The Incident

3.1 What happened

The following is an account of what happened during the incident on 19 April 2023.

3.1.1 Before the Power Interruption

The refurbishment of the concerned switchgear section was completed on 18 April 2023 as planned. This section of GIS is connected to one of the two spare cable circuits as mentioned in 2.1.4 through a cable isolator which was opened and locked. During the course of the refurbishment, the concerned section of the GIS was de-energised, all switches controlling the spare cable circuit were unlocked for functional tests and inspection of internal parts. As part of the commissioning procedures, all GIS switches that had been worked on, including the cable isolator (named L53A) connected to the spare cable circuit, had to be energised. According to our standard practice, such commissioning work has to be carried out at mid-night and one single in-service circuit is arranged to supply electricity for the commissioning as an additional precautionary measure in order to minimise possible impacts on both the system and our customers if something unforeseeable happened.

3.1.2 Three-phase Fault During Commissioning

The engineer in charge was the authorised person responsible for the whole commissioning work at CPX according to the approved procedures. Another engineer with appropriate qualification was also deployed to CPX to double check the GIS gas pressure and to carry out specific parts of the commissioning procedures not related to circuit energisation. The whole process was also supported remotely by an engineer in the System Control Centre at Ap Lei Chau, who was responsible for switching on and off the GIS during commissioning according to the site condition as confirmed by the engineer in charge as well as the approved commissioning procedures using remote control facility. At 00:45 hours on 19 April 2023, as per confirmation of the engineer in charge, the engineer at System Control Centre energised the cable isolator whereby a 275-kV three-phase fault occurred and relevant Circuit Breakers (CBs) of the dedicated commissioning circuit tripped correctly by backup protection system to isolate the fault. The simplified network arrangement at the time of commissioning is shown in Illustration 2 below. Subsequent investigation concluded that the spare cable circuit connecting to cable isolator L53A was inadvertently energised. The spare cable circuit is an oil-filled cable. One end of the cable is connected to the GIS while the other end is capped to contain the insulation oil. Flashover occurred at the cable cap-ends immediately when a high voltage, i.e. 275 kV, was applied. The cable cap-ends are used to contain the insulation oil of the spare cable circuit and are not designed to withstand any high voltage. The fault was then isolated by the protection system as designed within half a second.

[1] Energy Management System is an operation computer system installed in System Control Centre for controlling and monitoring of the generation and transmission systems of HK Electric.

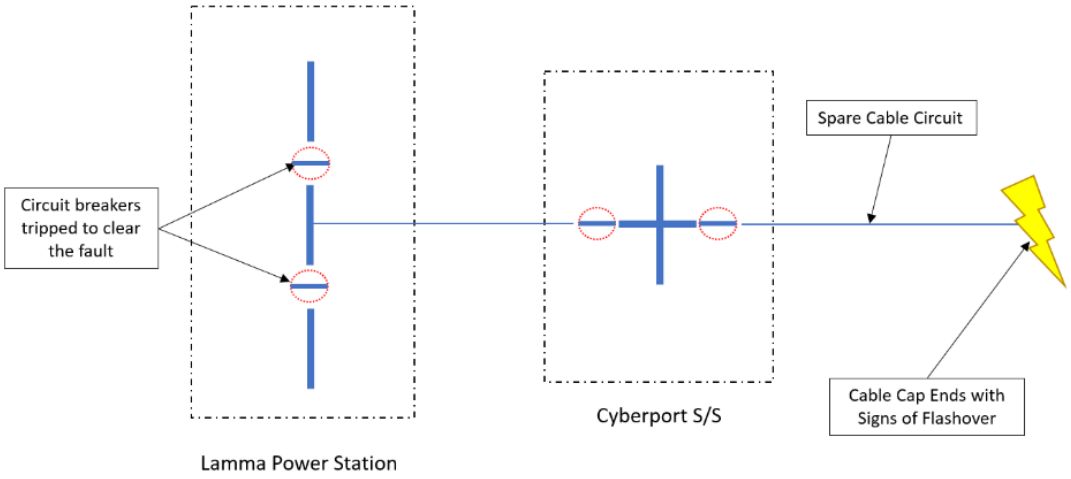


Illustration 2. Network Arrangement at the Time of Commissioning

3.1.3 Impact on the Power System

It was the first time that a 275-kV three-phase fault occurred in HK Electric's system, which gave rise to a very severe disturbance to the power system. The fault also caused a severe voltage dip and the system voltage had collapsed to nearly zero for about half a second, which was a very rare incident and caused considerable adverse impacts on the whole power system.

All the generating units at Lamma Power Station and their auxiliary equipment were also seriously affected by this unprecedented power disturbance. The total power generation in Lamma Power Station fluctuated seriously in the first few seconds after the occurrence of the fault (refer to Illustration 3 below). The protection systems of the auxiliary and major equipment functioned to protect them from damage. For example, the lubricating oil pumps of some coal mills affected by the voltage dip were tripped by the undervoltage protection such that the cables and the motors of the pumps had been protected from overheating; and the moving parts of the coal mills had been protected from excessive wear by tripping the mills when the pressure of the lubricating oil dropped. These protection systems were designed for preventing damage of generating units during severe power disturbance rather than allowing them to ride through a system fault.

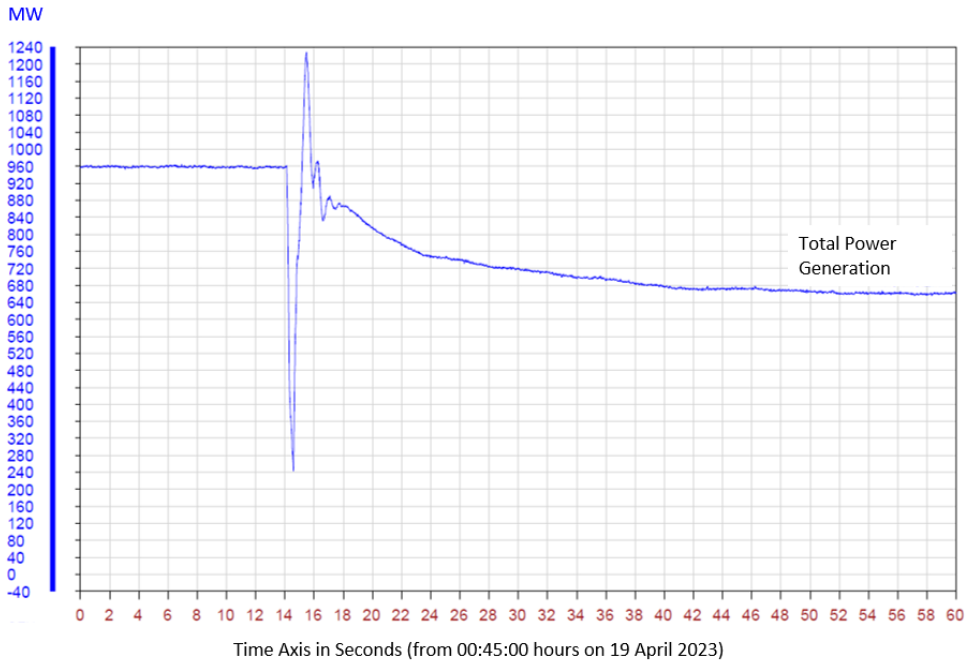


Illustration 3. Total Power Generation of Lamma Power Station on 19 April 2023 at 00:45 Hours

A lot of other equipment in Lamma Power Station, although not directly involved in power generation at the time, such as air-conditioners, battery chargers, IT equipment, fire alarms and security surveillance cameras, were also affected in this incident. All of them were restored to normal afterwards and no damages were found.

3.1.4 Tripping of HK Electric-CLP Power Interconnector Circuits

HK Electric's power system has been connected with the power system of CLP Power since 1981 through three cross-harbour interconnector circuits for providing emergency support to each other if and when needed. Immediately after occurrence of the fault, the three-phase-fault detection scheme in our system also operated automatically according to the design and disconnected all three interconnector circuits between HK Electric and CLP Power's power systems. This detection scheme is custom-built to prevent blackout of HK Electric's entire system due to possible severe power oscillation between the two power systems of HK Electric and CLP Power. After all three interconnector circuits were disconnected, emergency support from CLP Power was not available anymore.

3.1.5 Shutdown of Two Generating Units and Activation of Under-frequency Load-Shedding

When the power generation of a power system cannot meet the load demand, the power system becomes unstable and the system frequency will drop. It is necessary to either increase the power generation or reduce the load demand to restore the system to normal. It is important to maintain a steady system frequency because the generating units installed in HK Electric's system are synchronised generators and are designed to run at a frequency of 50 Hz. There would be damages to the generating units if they were run at a frequency significantly deviating from 50 Hz. Hence, the generating units will trip if the system frequency is significantly higher or lower than 50 Hz. To tackle the situation of low system frequency, an under-frequency load-shedding protection device is installed in each and every zone substation to disconnect a pre-defined amount of load

automatically when the system frequency drops to a particular value in order to prevent a further decrease in system frequency. Otherwise, more generating units may trip and that will worsen the situation and may result in a system blackout. There are six stages of underfrequency load-shedding that operate at different system frequencies. After the operation of the first stage, if the system frequency continues to drop even lower, stage 2 will be triggered and so on.

The Lamma Power Station was prior to the incident operating with five generating units running, namely coal-fired units L6, L7, L8 and gas-fired units L10 and L11. As a result of this severe power disturbance, shutdown of one coal-fired and one gas-fired generating unit, namely L7 and L10, respectively, was required (details are given in section 4.5.1)

In the course of the shutdown of L7 and L10, the power output of these two units decreased rapidly and the total power generation of HK Electric was insufficient to meet the load demand. It in turn led to a rapid drop in system frequency.

Before L7 and L10 were completely shut down at 01:04 hours and at 01:08 hours respectively, the system frequency had dropped to the limit that triggered the operation of the first stage of the under-frequency load-shedding scheme. As a result, at 00:49 hours, 49 distribution cable circuits at 16 zone substations were automatically switched off by the protection scheme to reduce the system demand by around 4% in order to restore the balance between electricity generation and demand. Supply to a total of about 44,000 customers scattering in Ap Lei Chau, Tin Wan, Wong Chuk Hang, Wanchai, Causeway Bay, North Point, Shaukeiwan, Heng Fa Chuen, Taikoo, Chai Wan, Central and Pokfulam were affected. The under-frequency load-shedding scheme is designed to distribute the disconnected loads all over our supply territory to avoid blackout of an entire district that will inevitably affect the essential loads like hospitals and other public facilities in that district. According to our investigation and records, power supply to essential services had not been interrupted in the incident.

3.1.6 Restoration of Electricity Supply

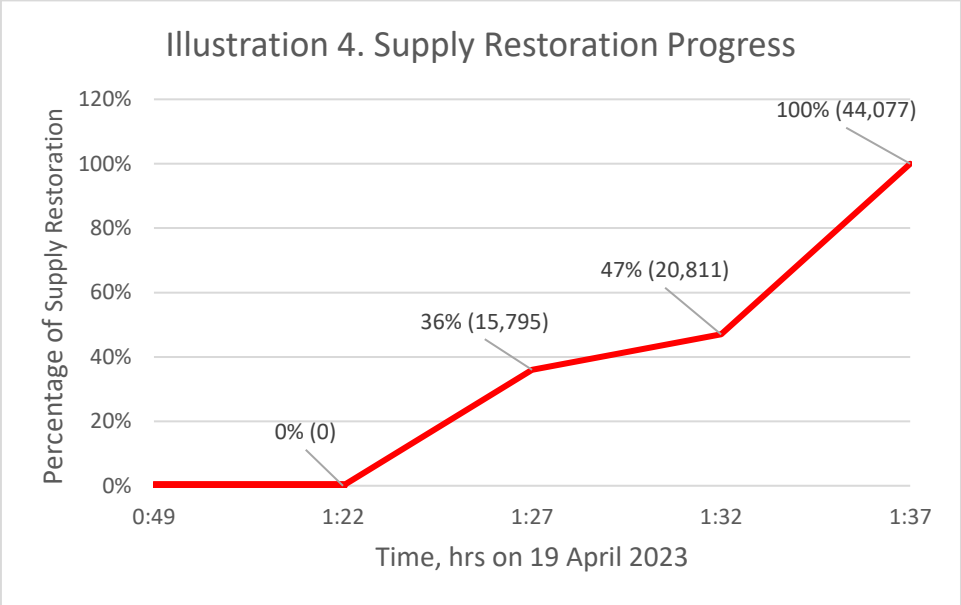
Gas Turbine No.1B2 at Lamma Power Station was automatically started up at 00:48 hours. Taking into account the facts that the station auxiliary plants of the remaining generating units, namely L6, L8 and L11, had not yet fully stabilised; and the available capacity of Gas Turbine No.1B was only 27 MW, the on-duty engineer in System Control Centre at Ap Lei Chau made a judgement that restoration of interrupted electricity supply by increasing the output of L6, L8, L11 and Gas Turbine No.1B was risky, as it might lead to further tripping of the remaining generating units still in operation and triggering of more under-frequency load-shed. Based on this and the principles laid down by our inhouse instruction, he decided to restore the interconnector circuits with CLP Power first so that immediate backup power supply could be provided if necessary. The interconnector circuits with CLP Power were put back in service from 01:22 hours to 01:28 hours.

After the first interconnector circuit was restored at 01:22 hours, a team of engineers in System Control Centre started to send remote control commands to the affected zone substations to restore the disconnected distribution circuits by making use of software

[2] Gas turbine No. 1 has two engines, only one engine could be selected for under-frequency startup.

programmes installed on EMS and DMS[3]. As no essential loads were interrupted in this incident, all affected distribution cable circuits were regarded as of the same importance. The engineers in System Control Centre coordinated with each other to determine the restoration sequence with an aim to switch on all affected distribution cable circuits as soon as possible while maintaining the system stability. Electricity supply in various districts were restored simultaneously. The entire supply restoration took 15 minutes to complete at 01:37 hours.

The load restoration timeline is summarised as follows:



Time of restoration of electricity supply	No. of customers remained being affected	Remaining affected percentage	No. of customers with supply restored	Percentage of restoration
Supply Interruption at 00:49 hours	44,077	100%	0	0%
Commencement of restoration at 01:22 hours	44,077	100%	0	0%
5 minutes after commencement of restoration	28,282	64%	15,795	36%
10 minutes after commencement of restoration	23,266	53%	20,811	47%
15 minutes after commencement of restoration	0	0%	44,077	100%

[3] DMS is the abbreviation of Distribution Management System which is the computer system installed in System Control Centre for controlling and monitoring of the distribution system of HK Electric.

3.1.7 Operation of Customer Emergency Services Centre (CESC)

Due to the severe voltage dip and the number of customers affected in the incident, our Customer Emergency Services Centre was flooded with telephone inquiries in the first few hours of the incident. In the first hour of the incident, a total of more than 10,000 calls were made to the Chinese/English hotlines of HK Electric, which was more than a thousand times of the daily workload. Since the number of incoming calls far exceeded the number that customer service representatives could answer, we activated the broadcast function of voice message(s) in the call system. If a customer was able to get connected to the call system, they could hear the following message "Some customers may have experienced a power interruption due to a fault in our supply system. We are making arrangement to restore electricity supply as soon as possible. We apologise for any inconvenience caused."

3.1.8 Dissemination of Information

Following the incident, we disseminated information collected at the time about the incident and our response through various channels, including media statements, telephone messages, corporate website banners, so as to keep our customers and the public timely informed. These public communications are summarised in Appendix 1 to this report.

4 Investigation

Following the incident, we have conducted a thorough investigation into a number of areas which include testing the cap-ends of the energised spare cable circuit which were found with signs of flashover in this incident, inspecting the switchgear and other cable circuits involved in this incident and used for energising the section of switchgear after refurbishment, reviewing our relevant records, site identification systems and commissioning procedures, and interviewing relevant personnel. The process and findings are summarised as follows:

4.1 Possible Presence of Spare Cable Circuits in Transmission System

Spare cable circuit in transmission system is uncommon and is for special purposes. Upon re-checking, there are four spare cable circuits (including the one in concern) in our transmission system, all of them were reserved after network reconfiguration and intended for contingency spare or future network reinforcement/expansion. Two of them are 275-kV cable circuit connecting to CPX and the other two are 132-kV cable circuit connected to Kennedy Road 132-kV Switching Station and Apleichau 132-kV Switching Station.

4.2 The Fault Location

4.2.1 Subsequent to the tripping of the circuit breakers, inspections were conducted on all the apparatuses involved, including the GIS at Lamma Power Station (LPS), GIS at CPX and all associated cable circuits. All apparatuses, including the refurbished GIS at CPX, were checked and confirmed normal. The affected spare cable circuits had a flashover at the Kai Lung Wan Tunnel Portal area. After exposing the cable cap-ends (the spare cable circuit consists of three single-core cables with each end of the single-core cable sealed

with an individual metallic cap), signs of flashover at all the three cable cap-ends were found.

4.2.2 An independent laboratory was engaged to conduct a detailed analysis of the failed cable cap-ends. Based on the analysis, the degree of damage and the test results of the cap-ends matched with the fault data collected from the system during the fault. As mentioned earlier, the cable cap-end was merely used to cap and contain the insulation oil of the spare cable circuit and was not designed to withstand any high voltage. These findings together with the other electrical tests on the spare cable circuit supported the fact that the cable cap-ends failed when system voltage, i.e. 275 kV, was applied on them during energisation of cable isolator L53A and caused the system disturbance.

4.2.3 Based on the system records and the site findings, it was concluded that the spare 275-kV cable circuit at CPX was inadvertently energised during commissioning of the CPX GIS after refurbishment, which caused a fault in the 275-kV system.

4.2.4 All protection operations in this incident were correct and according to design.

4.3 <u>The Refurbishment Work</u>

4.3.1 The concerned GIS bay was the third section of CPX GIS switched off for refurbishment.

4.3.2 All the refurbishment works at CPX were supervised by the same engineer in charge. He joined HK Electric in 2012. He acquired his transmission authorisation in 2021 and had since carried out refurbishment of more than 20 no. of GIS bays, including a spare GIS bay with no spare cable circuit connected at another switching station, since 2021. He has been working in the transmission unit for more than five years, and has received appropriate training related to transmission apparatuses. During the course of refurbishment, a working team comprising six team members, including two technical supervisors from the OEM, was assigned to carry out the work. The engineer in charge also stationed at site from time to time to oversee the work quality and progress. At the time of commissioning, all refurbishment works had been completed and the working team had withdrawn. A qualified engineer as mentioned in 3.1.2 was assigned to carry out commissioning work with the engineer in charge.

4.3.3 The concerned GIS at CPX was switched off on 22 March 2023. All switchgear compartments, circuit breakers, isolators and earthing switches were checked by the working party. Consumable parts were replaced and tests were carried out to check the functional and electrical integrity of the switchgear according to the OEM's recommended procedures.

4.3.4 As the scope of refurbishment did not involve any cable alteration or network change, it was a customary practice for the engineer in charge to refer to the EMS circuit diagrams, instead of the detailed transmission schematic drawings, for preparing the work procedures, including switching and commissioning procedures.

4.3.5 In preparation for the refurbishment work, the engineer in charge performed a number of tasks, including among other things, 1) referred to the EMS circuit diagrams which was a customary practice for using it as reference by engineers to prepare the HV Permit-to-work (PTW); 2) confirmed the circuits connected to the GIS by checking on-site various labels on the GIS; and 3) visually checked external condition of the cable connection

tanks to confirm if there was cable circuit connected to the GIS. It is an important part of our procedure that the engineer in charge has to check personally at site on the consistency of these items before issuing of PTW. Although generic "Spare" labels without any other details were attached to various locations of the GIS, the engineer in charge could not differentiate whether the GIS was connected with or without cable circuit from this information. Also, the bottom of each cable connection tank is fully concealed by a fire-rated steel enclosure and a corrugated pipe, the engineer in charge was unable to clearly see any cable connected to the GIS during inspection. From these, he formed the view that the GIS bay he was going to work on was a spare one with no cable connected. A Permit-to-Work (PTW) was then issued to our technical staff to carry out the refurbishment, and risk assessment of the work was also conducted on this basis.

4.3.6 During the course of refurbishment, various tests were carried out to check the electrical and mechanical integrity of the switchgears but no tests were designed to check the presence of spare cable. All these tests were conducted in strict accordance with the recommendations of the OEM. In addition, a quality system on the work procedures, tools control, valves control and quality of insulation gas was implemented at site to ensure work quality.

4.3.7 During the course of refurbishment, the engineer in charge also inspected the interior of the cable connection tanks as per the inspection checklist. The engineer in charge explained during the investigation that his attention was distracted by the grease found on the surfaces of the cable connection bushings, which he instructed a technician to remove, but he was unable to identify the presence of the spare cable circuit as mentioned above.

4.3.8 At 00:45 hours, the engineer at the System Control Centre energised the concerned cable connection tanks as per confirmation by the engineer in charge as per the commissioning procedures. A three-phase short-circuit fault then occurred. As the spare cable circuit was not readily available for service as mentioned in 2.1.4 and the fact that the switches controlling the spare cable circuit before the refurbishment were all locked under normal circumstances, no individual protection devices were required to protect a dead spare cable circuit. Consequentially, the fault was detected by the backup protection of the dedicated energising circuit connected to Lamma Power Station and isolated by tripping of the related circuit breakers. Illustration 2 showed the details of network arrangement at the time of tripping.

4.4 <u>The Drawing Records and On-site Labels</u>

4.4.1 At HK Electric, different types of circuit records are maintained for different purposes, and the level of information and details depend on what are considered relevant for the intended users. These records may include simplified single line diagrams for operation purpose, EMS circuit diagrams for real-time monitoring and control of live apparatuses, and detailed circuit diagrams stored in our geographical information system for planning purpose, etc. In each case it is the responsibility of the commissioning engineer to update the required drawings or to notify the relevant party to update the required drawing after any network changes. Nevertheless, there is an automatic computer system in place to check the connection consistency of all in-service cable circuits, but not spare cable circuits, among various circuit diagrams to ensure the correctness of connection of in-service cable circuits.

4.4.2 The network re-configuration project of CPX was completed in 2008/2009 and relevant cable connections details were updated to all relevant records, including the simplified single-line diagram, EMS circuit diagrams and the detailed transmission schematic drawing, etc. For the two circuits which became spare cable circuits at site, the details were also updated in the detailed transmission schematic drawing. However, they were not included in the EMS circuit diagrams as there were no explicit requirements on the updating requirements of these non-operational spare cable circuits in EMS circuit diagrams. Also, the computer programme as mentioned in 4.4.1 above was not designed to check spare cable circuits, as a result, the affected spare cable circuit was not shown in the EMS circuit diagrams which were used commonly by our engineers for GIS refurbishment work. Besides, there was also no specific guidance on the function and limitation of EMS diagrams.

4.4.3 Although generic "spare" labels were attached at site, such labels did not have other details and were displayed as per the common practice. Those labels did not indicate the crucial fact that the spare GIS was connected to a cable circuit. As a result, the labels could only indicate the function of this GIS but could not sufficiently differentiate whether the spare GIS was with or without cable circuit connected.

4.5 Shutdown of Two Generating Units that Led to Under-frequency Load Shed

4.5.1 One coal-firing generating unit L7 and one gas-firing generating unit L10 had to be shut down in this incident:

(a) For unit L7, power supplies to major equipment of the boiler were interrupted in this incident. The lubricating oil pumps of the in-service coal mills, i.e. coal mills 7A, 7B, and 7C, stopped and because only one lubricating oil pump was installed for each coal mill, the coal mills were tripped by the protection of low lubricating oil pressure. This was necessary as running without lubrication oil would cause major damages to the coal mills. The firing of the boiler ceased under such condition and the operation engineer had to put the unit off-load eventually after the generator output of the unit dropped to a minimum level.

(b) For unit L10, which consists of a steam turbine and a gas turbine, the generator output dropped and rebounded very substantially during the incident, and the steam turbine of the unit stopped due to a protection operated to prevent its damage. With the steam turbine tripped but the gas turbine still running, the unit load gradually decreased to a minimum level and after an alarm of the generator operated, the operation engineer had to put the unit off-load.

4.5.2 The actions taken by the operation engineers in response to the severe disturbance to the generating units during the incident were assessed and found to be appropriate. They were necessary to safeguard the generating equipment from damage while not imposing additional stress to the system. For example, after the coal mills of L7 tripped, the operation engineer exercised his knowledge and judgment to allow the unit to continuously generate electricity safely for about 19 minutes, even though the generator output dropped gradually from 200 MW at 00:45 hours and 10 MW at 01:04 hours, using the residual steam in the boiler. If the operation engineer had tripped the unit immediately at about 200 MW after all coal mills stopped, it would cause another disturbance to the system and exacerbate the situation.

4.5.3 The under-frequency load-shedding scheme operated as designed and successfully arrested the frequency drop and maintained the integrity of the power system. The decision of the engineers in System Control Centre not to restore the distribution cable circuits switched off by the under-frequency load-shedding scheme until the first interconnector circuit had been restored as well as the subsequent process of supply restoration to the affected distribution cable circuits were assessed and found to be appropriate.

4.6 Resources and Quality of Work

4.6.1 At HK Electric, we strive to develop and maintain our own expertise for maintenance of our equipment. The operation and maintenance of the transmission system is under the responsibility of a dedicated team of trained staff and managed by experienced senior engineers. All operations, maintenance and commissioning works related to transmission apparatus are conducted or supervised by our own internal resources or OEM supervisors.

4.6.2 For the GIS refurbishment, the work was carried out by in-house experienced resources under the full-time on-site supervision of OEM personnel from the manufacturer.

4.6.3 For the engineering staff, they are required to go through a series of training and on-job practices and pass relevant interviews conducted by assessment panels before they are allowed to work on the corresponding system.

4.6.4 According to our investigation, the refurbishment work was carried out according to procedures and had met the quality requirements. During the post-fault inspections and testing on the refurbished GIS, no abnormalities were found. It was concluded that the incident was not related to either adequacy of resources or quality of refurbishment work.

5 Incident Causation

Based on the investigation findings, we attributed the incident to the following causes:

For the 275-kV fault

5.1 The EMS circuit diagrams did not record the spare cable circuit

Unlike standby cable circuits, spare cable circuits are not readily available for services. Since spare cable circuits are not designed to be used in daily operation of the power network, they were not specifically marked in the EMS circuit diagrams but were only updated in the detailed transmission schematic drawing. There were no specific requirements to explicitly include the spare cable circuits in EMS circuit diagrams due to their non-operational nature nor guidance on the function and limitation of the EMS diagrams. As a result, the affected spare cable circuit was not shown in those diagrams commonly used for GIS refurbishment work. Also, the automatic computer programme is not designed to check the connection of spare cable circuits.

5.2 On-site labels were insufficient to indicate whether a spare cable circuit is connected to the switchgear.

Generic “spare” labels without any other details were displayed at site for the GIS concerned as per past common practices. These labels were designed to indicate the function of the GIS but could not sufficiently indicate or differentiate between a spare GIS with or without cable circuit connected.

The above two factors in aggregate did not provide sufficient indications to the engineer in charge to alert him that the GIS was with a spare cable circuit connected and hence significantly limited the risk analysis related to the energisation of the associated cable isolator. Otherwise, the engineer in charge could have taken these into consideration in the risk analysis before preparing for the commissioning operation.

5.3 The engineer in charge was unable to identify whether the GIS was connected to a spare cable circuit in his on-site inspection

On-site inspection to find out the actual configuration of the equipment is a critical step in the preparation of the commissioning procedure after refurbishment of the switchgear. Unfortunately, the bottom of each cable connection tank is fully concealed by a fire-rated steel enclosure and a corrugated pipe, making the engineer in charge unable to clearly see any cable connected to the GIS during his inspection. Having seen no cable connections, the engineer in charge concluded based on the site labels, the EMS Diagrams and his past experiences that the GIS was not connected to any cable circuit.

5.4 No compulsory counter-check requirements for commissioning of refurbished GIS

In HK Electric, counter-check requirements have been adopted for high-risk or critical tasks involving GIS. For GIS refurbishment, all critical tasks had been counter-checked by an independent qualified engineer. However, for commissioning, as the refurbishment did not involve replacement of insulation parts and network change, the commissioning procedure was not counter-checked by another qualified engineer at site. This incident could have been avoided if another qualified engineer had been deployed to conduct an independent site inspection to confirm the correctness and suitability of the commissioning procedure.

<u>For the Power Interruption</u>

5.5 Consequential Power Swing and Under-Voltage affected generating units at Lamma Power Station

The consequential power swing and severe under-voltage caused by the fault affected the generating units at Lamma Power Station and units L7 and L10 had to be shut down manually due to tripping of auxiliary or main equipment and there was insufficient generation to meet customers’ demand.

The manual shutdown was inevitable to safeguard the generating equipment from damage. The action was considered to be proper and necessary in order to avoid the risk of a worse case of prolonged outages of the generation units having more serious impacts on customers.

6 Recommendations and Improvement Measures

In view of the above, the following remedial actions were formulated in respect of a number of areas, including among others, site labels and circuit diagrams, site arrangement of spare cable circuits, training of engineers, commissioning of transmission equipment, fault ride-through capability of generating units. Some of these measures, including disconnection of the four spare transmission cable circuits and improvement of site labels and update of EMS circuit diagrams have already been implemented and completed.

6.1 Site Labels and Circuit Diagrams

6.1.1 Site labels showing details of the spare transmission cable circuits were immediately added at sites (see Figures 4 to 7 in Appendix 2) to differentiate these spare GIS bays with a cable circuit connected from other spare GIS bays without cable circuit connected. Labels for all four spare circuits were updated.

6.1.2 The EMS circuit diagrams were also updated (see Figure 3 in Appendix 2) to include spare cable circuit connected to the GIS with remarks to alert engineers in System Control Centre and other site engineers.

6.1.3 Consistency among the detailed transmission schematic drawings in our geographical information system, the EMS circuit diagrams and site labels were checked within a week after the incident and no further discrepancies were found.

6.1.4 Instruction and guidelines for updating site identification labels, the detailed transmission schematic drawings, single line diagram and EMS circuit diagrams will be established by end June 2023. In addition, the usage of each type of the above diagrams and their limitations will also be included in the instruction.

6.1.5 Although no more spare cable circuits will be connected to the transmission system after this incident, a mechanism will be established to check the presence of spare cable circuits among drawings to supplement the automatic computer programme for checking the connection consistency of cable circuits among various circuit diagrams, which shall be completed by July 2023.

6.2 Site Arrangement of Spare Cable Circuits

6.2.1 Immediate checking of spare GIS bays in our whole transmission network has been completed. Four spare cable circuits in our transmission system were identified, all were reserved after network re-configuration and were kept for contingency use or for future network reinforcement/expansion. Two of the circuits are 275-kV spare cable circuits at CPX and two are 132-kV spare cable circuits connected to Kennedy Road 132-kV Switching Station and Apleichau 132-kV Switching Station.

6.2.2 Internal inspection of the four GIS bays with spare cable connections as mentioned above was also completed and the spare cable circuits have all been disconnected from the corresponding GISs.

6.2.3 Complete segregation of spare cable circuits from our GIS will be completed by July 2023 upon delivery of the required modification materials from the switchgear OEM as an additional precautionary measure to prevent inadvertent energisation of the spare cable circuits in future.

6.2.4 Guideline to detail the physical connection arrangement and labelling format of spare GIS bays will be established by June 2023.

6.2.5 The site labelling, switchgear arrangement and relevant drawings of distribution spare cable circuits will also be checked and the requirements will be aligned with transmission spare cable circuits as much as possible. The guidelines on handling spare distribution cable circuits will also be established. This will be completed by Q3 2023.

6.3 Training of Engineers

6.3.1 The engineer in charge concerned had been suspended for all work-related authorisation in our Transmission and Distribution network. He has been taken away from operational work and placed in a unit to provide logistics support until he has regained confidence and has passed the interviews by relevant assessment panels before resuming his normal operational duties.

6.3.2 Coaching and site training of our engineers, in particular, when handling new transmission apparatuses/configurations will be enhanced. Guidelines on the limitations and purposes of each type of transmission diagram will also be established. Preparation of the guidelines and the training will be implemented by Q3 2023.

6.4 Risk Assessment and Enhanced Procedures for Commissioning of Transmission Equipment

6.4.1 Immediately after the incident, all relevant transmission refurbishment works have been temporarily suspended until the guidelines have been formulated. In addition, additional resources had been deployed to check critical infrastructure in transmission network to ensure reliability and stability of supply.

6.4.2 The commissioning procedures of transmission equipment after various types of works, including the checking and approval process as well as the selection criteria of dedicated commissioning circuit will be further enhanced. In addition, the setting of backup protection system(s) to provide faster system protection during commissioning will also be formulated to cater for unforeseeable circumstances. All these will be completed by Q3 2023.

6.4.3 Counter-check requirements have been adopted for all commissioning of GIS immediately, whether it is a new or refurbished one. Another qualified engineer will be deployed to check the commissioning procedure prepared by the engineer in charge and inspect the site to confirm the correctness and suitability of the procedure.

6.4.4 The critical steps in works on transmission system which required counter-checks will be holistically reviewed and confirmation of the presence or absence of spare cable circuits will be included as one of such steps. The review will be completed and relevant instructions will be issued by June 2023.

6.5 Fault Ride-through Capability of Generating Units

6.5.1 Arrange dual-firing operation of coal-fired units, i.e., putting fuel oil burners in service in addition to the coal mills being operated, in the future when there is any critical switching operation in 275-kV system and any risk similar to the incident.

6.5.2 We note that units L7 and L8, and L10 and L11, have similar design but their behaviours during this incident differed from their sister units, i.e., L7 and L10 had to be shut down, but L8 and L11 were affected to a lesser extent and survived. The OEMs of both L7 and L10 for the mechanical portion and electrical & instrumentation portion have been requested to investigate the difference in responses during the incident.

6.5.3 We have asked the OEM to provide recommendations for improvement of both coal-fired and gas-fired generating units for riding through similar severe fluctuations of system voltage. We target to finalise the improvement plan by end 2023.

6.6 Customer Emergency Services Centre

6.6.1 We will comprehensively review the manpower arrangement, equipment and work flow of the Customer Emergency Services Centre and explore other possible means to effectively disseminate information on major power abnormalities to customers by Q3 2023.

6.7 Advisory Service

6.7.1 We will engage advisory service by June 2023 to review the incident and propose improvements of various management systems such as the drawing updating system, quality control system of transmission work, counter-check requirements of critical steps, qualification and training system, etc. We target to complete the review in three months and all recommendations will be implemented by end 2023.

Appendix 1 - Post-incident Public Communications

Within a week of the incident, we had arranged one voice message, three website banner messages, four media statements as well as a media briefing to keep our customers and the public informed about the incident and updated about our follow up actions.

On 19 April 2023 (within 24 hours of incident)

A.1.1 Automatic Voice Message in response to Hotline Calls (19 April 2023)

To handle the large number of calls to our Customer Emergency Services Centre (CSCE) immediately after the power interruption, the Interactive Voice Response System (IVRS) was activated at 01:08 hours. Customers who called would automatically receive the following pre-recorded voice message:

"Some customers may have experienced a power interruption due to a fault in our supply system. We are making arrangement to restore electricity supply as soon as possible. We apologise for any inconvenience caused.".

A.1.2 Company Website Banner 1 (19 April 2023)

Considering that customers may visit the company's website to check for information in the event of an emergency, a prominent message was uploaded onto our website banner at 01:56 hours (banner 1), advising customers that electricity supply had been fully restored following a power interruption that affected some customers. Customers were advised to contact us if their supply had not been restored.

A.1.3 Media Statement 1 and Company Website Banner 2 (19 April 2023)

A media statement 1 was issued to media organisations at 03:12 hours through WhatsApp, followed by email. The duration of the power interruption was mentioned and customers were reminded to arrange registered electricians to reset their sensitive equipment if necessary and a telephone number was included for further enquiries.

A new company website banner 2, with identical contents as media statement 1, was uploaded onto the company website at 03:15 hours (Chinese) and 03:56 hours (English) to replace company website banner 1.

A.1.4 Media Statement 2 and Company Website Banner 3 (19 April 2023)

A follow-up media statement 2 was issued to the media at 16:29 hours through WhatsApp, followed by email, on the cause and locations of the power interruption. It also clarified earlier reports claiming that the incident was caused by malfunctioning power generating units at Lamma Power Station. An apology was issued again.

A further company website banner 3, with identical contents to this media statement 2, was uploaded onto the website at 16:32 hours to replace company website banner 2.

On 20 April 2023 (within 48 hours of incident)

A.2.1 Media Briefing (20 April 2023)

A media briefing was conducted by HK Electric's Operations Director, Mr. Francis Cheng, and General Manager (Transmission and Distribution), Mr. S.T. Ip, at 22:00 hours at the company headquarters, sharing the findings of the initial investigation and the company's follow-up measures. The briefing was televised live by media organisations.

A.2.2 Media Statement 3 (20 April 2023)

A media statement 3 in the form of a press release was issued to media organisations at 22:46 hours immediately after the above media briefing to recap the contents of the briefing. It was also uploaded onto the corporate website for the public's information.

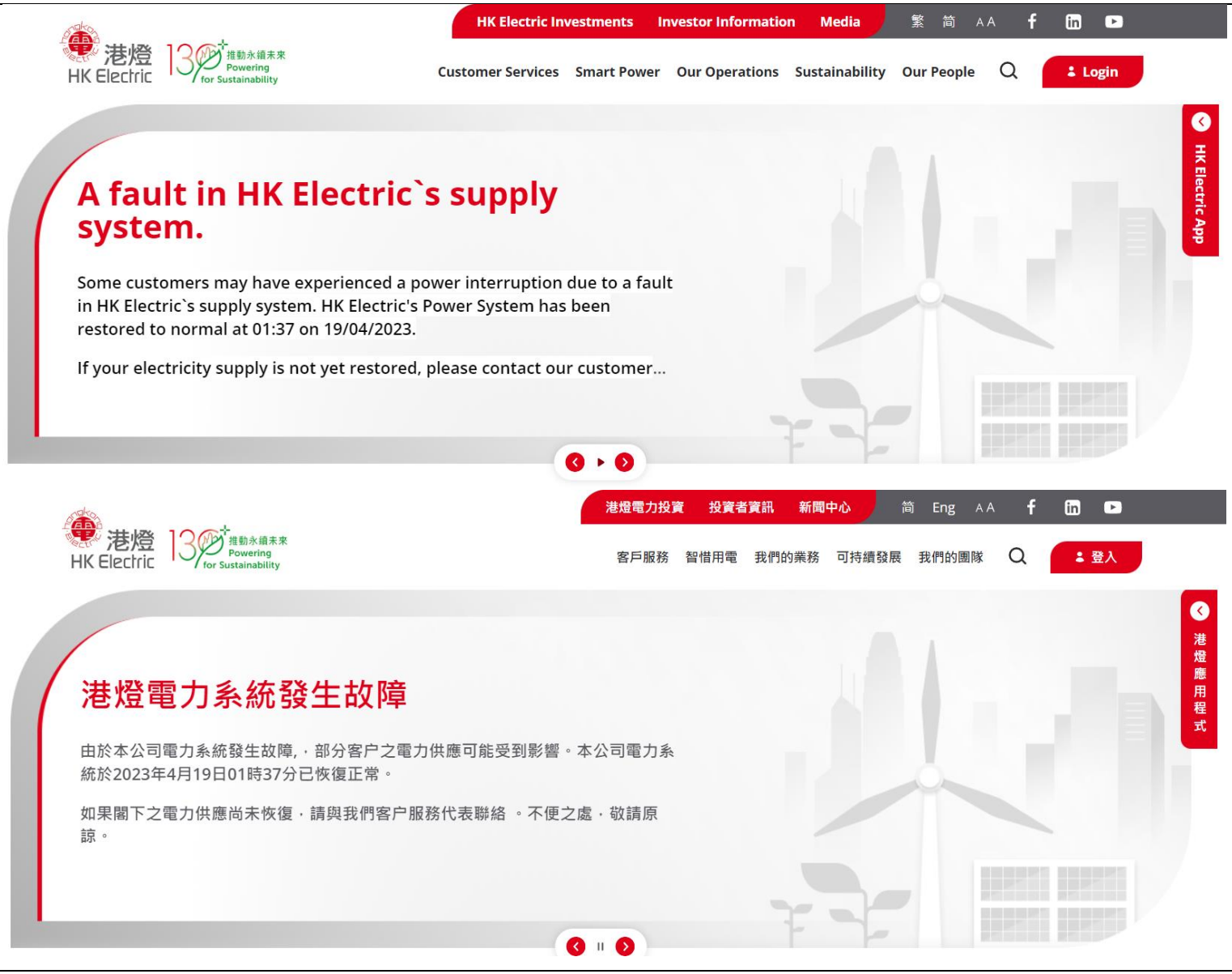
After 20 April 2023

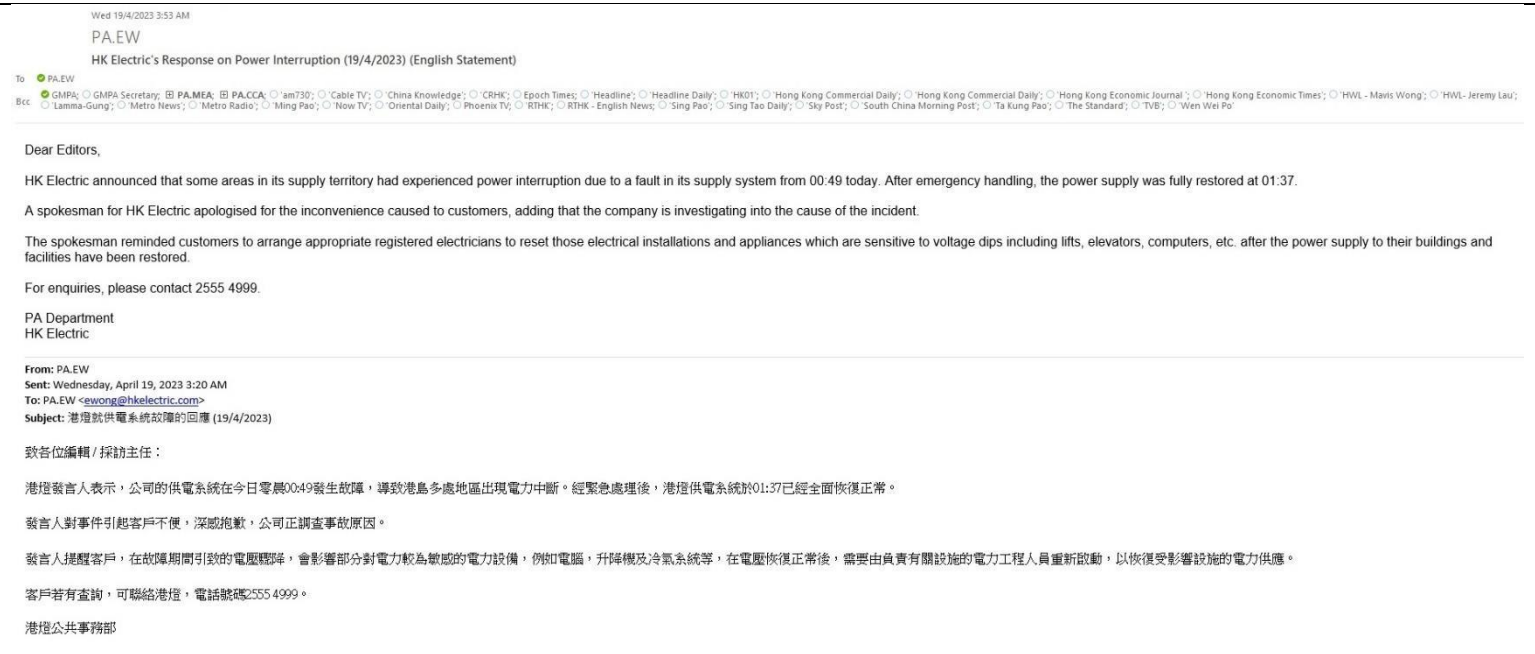
A.3.1 Media Statement 4 (24 April 2023)

A media statement 4 in the form of a press release was issued at 20:43 hours to clarify erroneous allegations against the performance incentives the company would be given in respect of power interruption duration, and that the incident involved was a spare cable not used in the system for "standby" purpose.

Company website banner 1

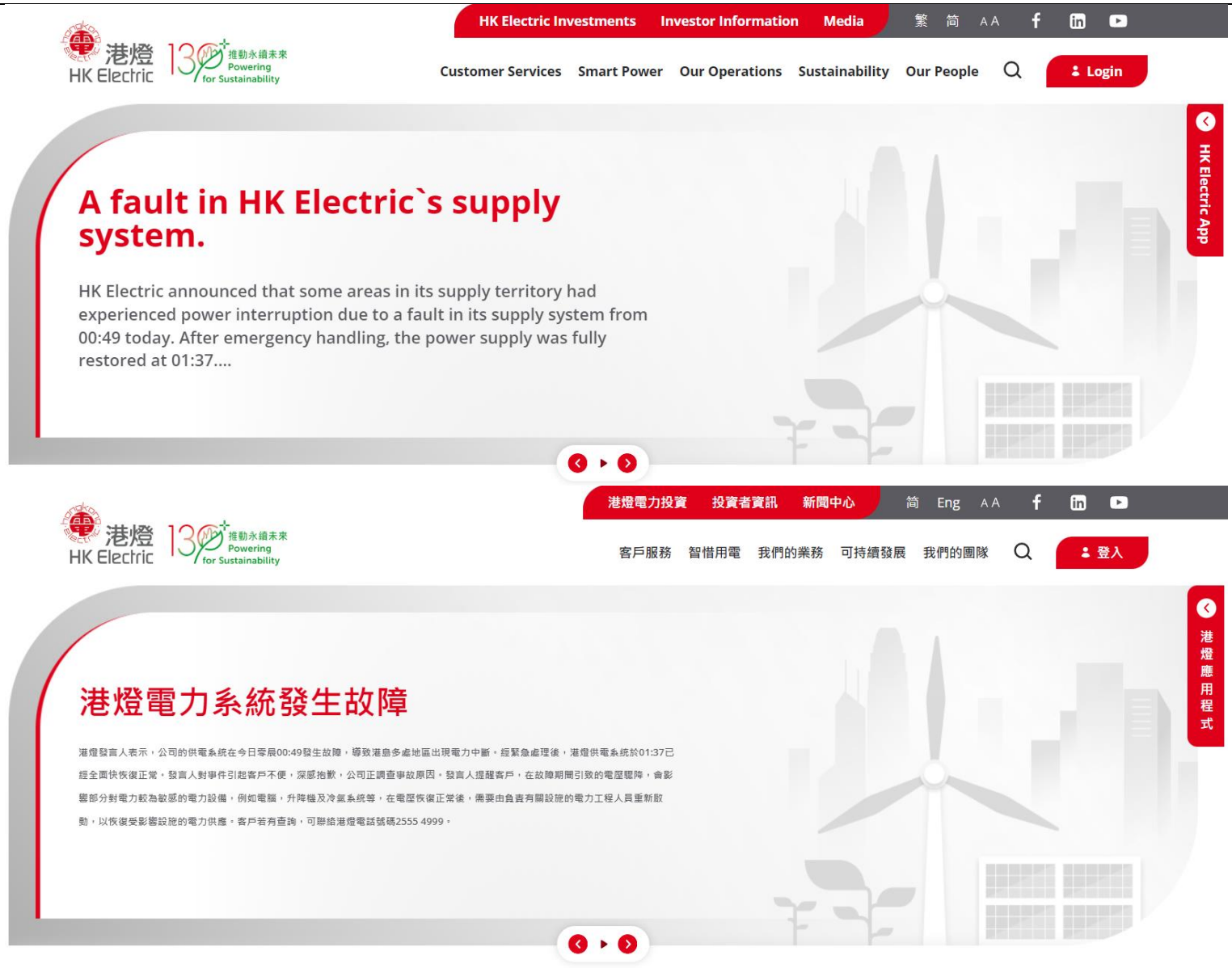
Date: 19 April 2023
Publish time - 01:56 hrs



Media statement 1 (WhatsApp/ email) Date: 19 April 2023 Publish time - 03:12 hrs	 Wed 19/4/2023 3:53 AM PA.EW HK Electric's Response on Power Interruption (19/4/2023) (English Statement) To PA.EW Bcc GMPA; GMPA Secretary; PA.MEA; PA.CCA; 'am730'; 'Cable TV'; 'China Knowledge'; 'CRHK'; Epoch Times; 'Headline'; 'Headline Daily'; 'HK01'; 'Hong Kong Commercial Daily'; 'Hong Kong Commercial Daily'; 'Hong Kong Economic Journal '; 'Hong Kong Economic Times'; 'HWL - Mavis Wong'; 'HWL- Jeremy Lau'; 'Lamma-Gung'; 'Metro News'; 'Metro Radio'; 'Ming Pao'; 'Now TV'; 'Oriental Daily'; Phoenix TV; 'RTHK'; RTHK - English News; 'Sing Pao'; 'Sing Tao Daily'; 'Sky Post'; 'South China Morning Post'; 'Ta Kung Pao'; 'The Standard'; 'TVB'; 'Wen Wei Po' Dear Editors, HK Electric announced that some areas in its supply territory had experienced power interruption due to a fault in its supply system from 00:49 today. After emergency handling, the power supply was fully restored at 01:37. A spokesman for HK Electric apologised for the inconvenience caused to customers, adding that the company is investigating into the cause of the incident. The spokesman reminded customers to arrange appropriate registered electricians to reset those electrical installations and appliances which are sensitive to voltage dips including lifts, elevators, computers, etc. after the power supply to their buildings and facilities have been restored. For enquiries, please contact 2555 4999. PA Department HK Electric **From:** PA.EW **Sent:** Wednesday, April 19, 2023 3:20 AM **To:** PA.EW <ewong@hkelectric.com> **Subject:** 港燈就供電系統故障的回應 (19/4/2023) 致各位編輯 / 採訪主任： 港燈發言人表示，公司的供電系統在今日零晨00:49發生故障，導致港島多處地區出現電力中斷。經緊急處理後，港燈供電系統於01:37已經全面恢復正常。 發言人對事件引起客戶不便，深感抱歉，公司正調查事故原因。 發言人提醒客戶，在故障期間引致的電壓驟降，會影響部分對電力較為敏感的電力設備，例如電腦，升降機及冷氣系統等，在電壓恢復正常後，需要由負責有關設施的電力工程人員重新啟動，以恢復受影響設施的電力供應。 客戶若有查詢，可聯絡港燈，電話號碼2555 4999。 港燈公共事務部

Company website banner 2

Date: 19 April 2023
Publish time -
Chi: 03:15 hrs
Eng: 03:56 hrs



Media statement 2 (whatsApp/ email)

Date: 19 April 2023
Publish time - 16:29 hrs

Wed 19/4/2023 4:34 PM

PA.EW

港燈就供電系統故障作進一步回應 (19/4/2023 - 16:30)

To PA.EW

Bcc GMPA; GMPA Secretary; PA.MEA; PA.CCA; 'wendytb@ckah.com'; 'winnie.cheong@ckah.com'; Grace Ng; 'samhung@hkej.com'; 'tampc@rthk.org.hk'; 'am730'; 'Cable TV'; 'China Knowledge'; 'CRHK'; Epoch Times; 'Headline'; 'Headline Daily'; 'HK01'; 'Hong Kong Commercial Daily'; 'Hong Kong Commercial Daily'; 'Hong Kong Economic Journal'; 'Hong Kong Economic Times'; 'HWL - Mavis Wong'; 'HWL - Jeremy Lau'; 'Iamma-Gung'; 'Metro News'; 'Metro Radio'; 'Ming Pao'; 'Now TV'; 'Oriental Daily'; Phoenix TV; 'RTHK'; RTHK - English News; 'Sing Pao'; 'Sing Tao Daily'; 'Sky Post'; 'South China Morning Post'; 'Ta Kung Pao'; 'The Standard'; 'TVB'; 'Wen Wei Po'; 'AA Stocks'; 'AA Stocks'; 'AA Stocks (Main)'; 'Bloomberg'; 'Bloomberg2'; 'BloombergEnergy'; 'Dealreporter'; 'ET Net'; 'etnet'; 'European Pressphoto Agency b.v.'; 'Finet'; 'Infocast'; 'infocast2'; 'InfraAsia'; 'Quamnet'; 'Reuters'; 'Reuters2'; 'Reuters3'; 'Wall Street Journal'; 'WSJ'; 'WSJ2'

致各位編輯 / 採訪主任：

就港燈供電系統較早時發生的故障事宜，公司發言人補充表示，港燈的供電系統在凌晨進行線路保養維修時，有設備發生故障，導致港島多處地區在00:49出現電力中斷。

受影響的客戶主要散布於南區鴨脷洲、田灣一帶，東區杏花邨、太古和筲箕灣一帶，灣仔摩理臣山和摩頓台一帶，以至中區薄扶林一帶等多處。

經過緊急處理後，港燈的供電於01:37已經全面恢復正常。

發言人對事件引起客戶不便，深感抱歉，公司正調查故障原因，並會適時向政府監管部門提交詳細報告。

對於有消息指今次供電故障是由於港燈在南丫島有機組出現問題引致，發言人強調，港燈在南丫發電廠內的機組雖然也受電壓波動影響，但已在短時間內相繼回復正常運作。供電系統亦在處理早前的故障後，繼續保持穩定的電力供應。

港燈公共事務部

Dear Editors,

HK Electric announced that the incident early today was due to equipment fault in its supply system during circuit maintenance, causing a wide-area power interruption at 00:49 on Hong Kong Island.

The incident mainly affected some customers in Ap Lei Chau and Tin Wan in the Southern District; Heng Fa Chuen, Tai Koo and Shau Kei Wan in the Eastern District; Morrison Hill and Moreton Terrace in the Wan Chai District, as well as Pok Fu Lam and Central District.

After emergency handling, the power supply was fully restored at 01:37.

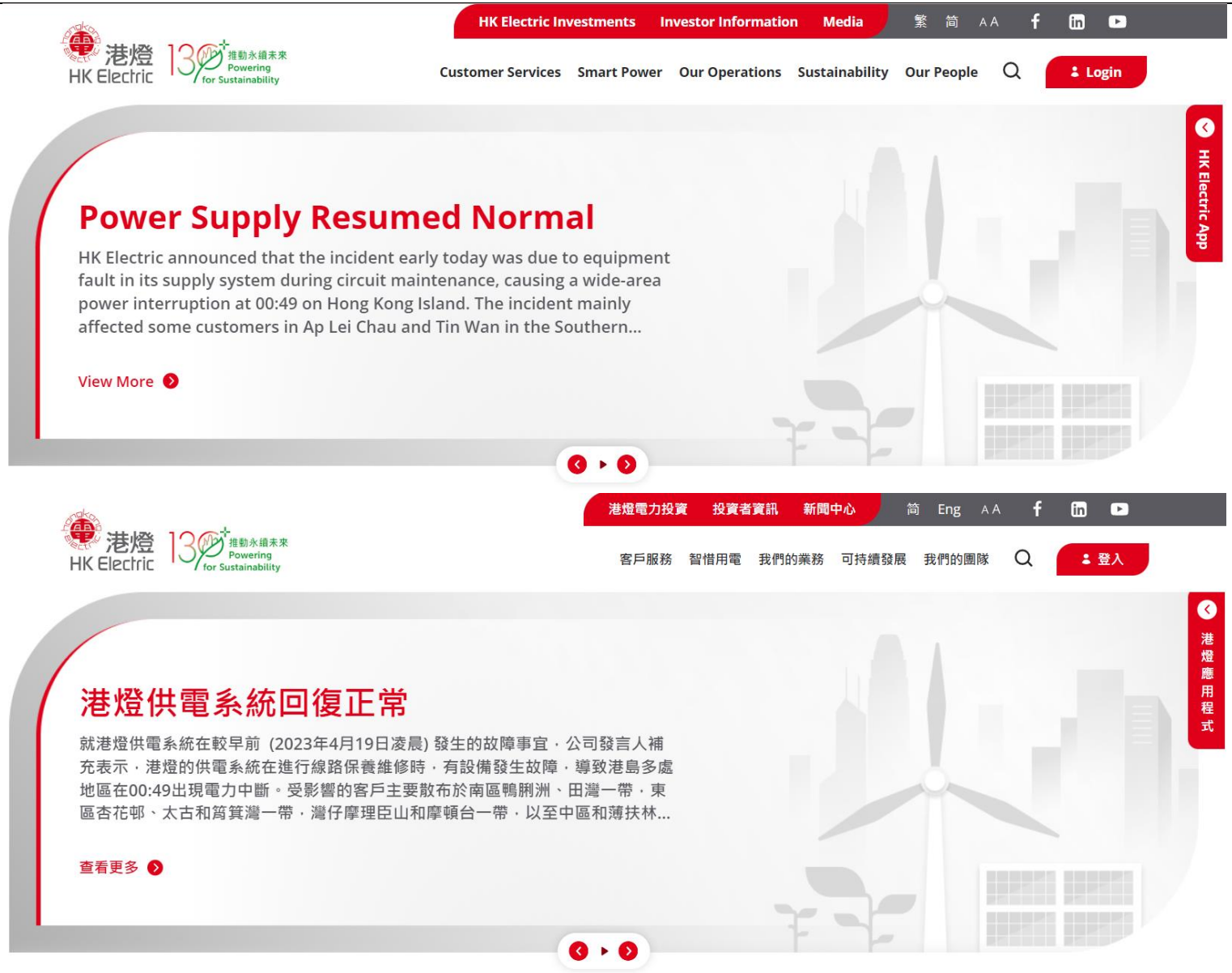
A spokesperson for HK Electric apologised for the inconvenience caused to customers, adding that the Company is investigating the root cause of the fault and will file a timely report to the Government.

Regarding those reports claiming that our power generating units at Lamma had malfunctioned causing the incident, the spokesperson clarified that some units had also been affected by the voltage fluctuation but they were all back in normal operation within a short period. And the supply system remains stable and reliable after emergency handling of the earlier incident.

Public Affairs Department
HK Electric

Company Website banner 3

Date: 19 April 2023
Publish time - 16:32 hrs



Media statement 3

Date: 20 April 2023
Publish time -
22: 46 hrs

Thu 20/4/2023 10:46 PM

PA.EW

港燈新聞稿 -「港燈一條後備電纜觸發電力中斷」

To PA.EW

GMPA; GMPA Secretary; PA.MEA; PA.CCA; 'am730'; 'Cable TV'; 'China Knowledge'; 'CRHK'; Epoch Times; 'Headline'; 'Headline Daily'; 'HK01'; 'Hong Kong Commercial Daily'; 'Hong Kong Commercial Daily'; 'Hong Kong Economic Journal '; 'Hong Kong Economic Times'; 'HWL - Mavis Wong'; 'HWL- Jeremy Lau'; 'Lamma-Gung'; 'Metro News'; 'Metro Radio'; 'Ming Pao'; 'Now TV'; 'Oriental Daily'; Phoenix TV; 'RTHK'; RTHK - English News; 'Sing Pao'; 'Sing Tao Daily'; 'Sky Post'; 'South China Morning Post'; 'Ta Kung Pao'; 'The Standard'; 'TVB'; 'Wen Wei Po'; 'Asian Power Magazine'; 'Cable TV'; 'China Daily, Sophie He'; 'CRHK'; 'Headline Daily'; 'HK Television Network, Cecilia Kwok'; 'HK01'; 'HK01Roger'; 'Hong Kong Business Magazine'; 'Hong Kong Economic Journal, Grace Lee'; 'Hong Kong Economic Times (Sub)'; 'Hong Kong Economic Times, Wendy Chan'; 'Metro Finance'; 'Ming Pao'; 'Ming Pao Web, Cannis Chow'; 'Ming Pao, Bill Ko'; 'Ming Pao, Jason Liu'; 'Now TV'; 'Oriental Daily / The Sun'; 'RTHK'; 'RTHK2'; 'Sammy Phoenix'; 'Sing Pao'; 'Sing Tao Daily'; 'South China Morning Post'; 'South China Morning Post, Eric Ng'; 'Ta Kung Pao'; 'TVB'; 'Wen Wei Po'; 'Wen Wei Po'; 'AA Stocks'; 'AA Stocks'; 'AA Stocks (Main)'; 'Bloomberg'; 'Bloomberg2'; 'BloombergEnergy'; 'Dealreporter'; 'FT Net'; 'etnet'; 'European Pressphoto Agency b.v.'; 'Finet'; 'Infocast'; 'infocast2'; 'InfraAsia'; 'Quamnet'; 'Reuters'; 'Reuters2'; 'Reuters3'; 'Wall Street Journal'; 'WSJ'; 'WSJ2'

Bcc

You replied to this message on 24/4/2023 8:33 PM.

prc_power outage_20230420_final.pdf
294 KB

輯先生/女士：

現隨電郵附上香港電燈有限公司於今天（4月20日）發出的新聞稿乙份，標題為「港燈一條後備電纜觸發電力中斷」，以供報道。

如有查詢，請與公共事務部經理（傳媒關係）黃綺玲聯絡，電話：2843 3229 ， 或電郵：media@hkelectric.com。

香港電燈有限公司
The Hongkong Electric Co., Ltd.

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www.hkelectric.com

港燈 HK Electric 130+ 推動永續未來 Powering for Sustainability

Press Release
20 April 2023

Power Interruption Triggered by a Spare Cable

A fault in HK Electric's power system in the early morning of 19 April 2023 resulted in power interruption to some customers in many parts of Hong Kong Island. From the Company's preliminary investigation, it is believed that the incident was related to an unrecorded spare cable and on-site operation procedures. This cable was accidentally connected to the power system after switchgear maintenance causing a short circuit. This triggered the automatic protection mechanism in the power supply system to operate and affected electricity supply.

The power interruption took place at 00:49 and the power supply was fully restored in 48 minutes.

The generating units in Lamma Power Station also experienced voltage fluctuation but resumed normal operation shortly.

HK Electric's Operations Director, Mr. Francis Cheng, pointed out that HK Electric all along has been delivering world-class supply reliability, and there has been no major power interruption for more than twenty years. This incident is most regrettable, he said.

Mr. Cheng explained that the incident was a rare one involving a "spare cable". HK Electric is taking the incident seriously and is conducting a thorough investigation. Meanwhile, the Company has immediately taken a series of precautionary measures to prevent similar incidents. He sincerely apologised again for the inconvenience caused to customers.

The incident happened during circuit maintenance at the Cyberport Switching Station in the early hours of yesterday. The power supply equipment in the Switching Station is a core part of the 275,000-volt (275-kV) transmission system.

At the time HK Electric's engineering personnel were carrying out equipment maintenance. During the course of re-commissioning of the concerned switchgear, they accidentally connected a "spare cable" to the system, causing short circuit and substantial voltage fluctuation which triggered the self-protection mechanism of the power supply system. It took a longer time to isolate this cable, which did not have its individual protection device, hence causing chain reactions in the system and affected the power supply to some customers in a number of districts on Hong Kong Island.

HK Electric's General Manager (Transmission & Distribution), Mr. Ip Sung-tai, noted that just like many other power companies in the world, HK Electric's power supply system has a self-protection mechanism designed to immediately isolate any faulty equipment from the grid in order to protect the entire power supply system and other important electric supply facilities.

Preliminary investigations revealed that the relevant cable became a "spare cable" after a network reconfiguration many years ago. For over ten years it was connected to the system but remained in a de-energised state. Both the circuit diagram and site identification labels did not indicate the presence of such spare cable, hence the commissioning procedures did not take this cable into account. As a result, during the re-commissioning test, the spare cable was accidentally energised resulting in a short circuit.

Mr. Ip pointed out that it has all along been the Company's practice to carry out commissioning work of the power supply system at night, when the power consumption is relatively low, in order to minimise any impact to the general public in case of an incident. Under the supervision of the system control centre, our maintenance team had carried out risk assessment and followed the commissioning procedures prior to commencing the relevant works.

He also said that upon an initial investigation, there was another "spare cable" in the same station and all related maintenance works has been suspended immediately. HK Electric's engineering team will confirm the accuracy of the circuit diagram and add remarks on the information of the "spare cables" to alert other engineering personnel in future works. On-site notices will also be placed.

Following this incident, HK Electric has taken various measures immediately, including deployment of additional manpower to ensure the stability and reliability of power supply, and a comprehensive review of the circuit diagrams of HK Electric's power supply system for accuracy. The Company will also review the preparatory measures and procedures for maintenance work to prevent similar incidents from happening in the future.

HK Electric is fully committed to the review of this incident. A detailed report to the government will be submitted in 4 weeks as required, and improvements and preventive measures will be proposed for the future.

- END -

香港電燈有限公司
The Hongkong Electric Co., Ltd.

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www.hkelectric.com

港燈 HK Electric 130 推動永續未來 Powering for Sustainability

新聞稿
2023 年 4 月 20 日

港燈一條後備電纜觸發電力中斷

港燈供電系統在 2023 年 4 月 19 日凌晨出現故障，導致港島多處地區的部分客戶出現電力中斷。公司初步相信故障與舊有檔案和現場操作程序有關，導致供電系統在進行保養維修後，意外地接駁上不在紀錄的後備電纜，引發短路，繼而觸動供電系統內的自動保護機制，影響供電系統。

停電事故發生在零時 49 分，並在 48 分鐘內全面恢復電力供應。

港燈南丫發電廠內的機組雖然也受電壓波動影響，但已在短時間內相繼回復正常運作。

港燈營運董事鄭祖瀛指出，港燈供電可靠性一直位於世界前列位置，過去二十多年來沒有發生大規模停電事故，對今次的停電事故深表遺憾。

他表示今次是個別事件，有關事故十分罕見，涉及一條「後備電纜」。港燈會以一貫嚴肅和認真的態度處理，亦會深入研究，查找系統有否其他需要改善的地方。公司已即時採取一系列預防措施，避免同類事件再發生，並再次就事件造成客戶不便，表心致歉。

事發於昨日凌晨，涉事地點是位於南區數碼港的電力開關站，該電站內的供電設備，屬 27 萬 5 千伏 (275 kV) 骨幹輸電系統。

港燈工程人員當時正對輸電系統的設備進行保養維修工程。他們在進行調試時，意外把一條「後備電纜」通電，引發電線短路及電壓大幅波動，並觸動系統的自動保護機制。該條後備電纜沒有獨立的保護裝置，有關短路故障需要比較長的時間去隔離，因而引發系統內出現連鎖反應，影響港島多處地區部分客戶的電力供應。

輸配電科總經理葉崇泰表示，一如全世界其他電力公司，港燈供電系統設有自動保護裝置，主要目的是在有任何故障發生時，可以第一時間隔離懷疑有問題的設備，保障整個供電系統的安全和保護其他供電設備。

經初步調查後，發現短路故障涉及的「後備電纜」，是因早年進行電網線路改造後，變為「後備電纜」，過去十多年來一直接駁在系統上，維持在不通電的狀態，現場亦沒有標示有一條「後備電纜」。而工程人員當日使用的電路圖資料，亦沒有紀錄這條「後備電纜」，所以現場施工程序亦沒有涵蓋對這條電纜的處理方法。結果在維修保養後，在調試過程中意外將後備電纜通電，引起短路故障。

葉崇泰指出，港燈一直選擇在夜間對供電系統進行線路調試，目的是趁整體用電需求比較低的情況下進行，以減少一旦發生事故時，對公眾可能帶來的影響。保養維修組同事在進行工作前均有進行風險評估及依足調試程序，在系統控制中心監督下進行，惟由於上述原因導致今次事故。

他又表示，經初步檢視，發現在同一電力開關站內另有一條「後備電纜」，已即時暫停有關維修工作，工程人員再三確認有關電路圖準確無誤後，會在「後備電纜」的資料上加上備註，並增加現場標示，提醒工程人員日後工作時要特別留意。

因應今次故障，港燈已即時採取多項措施，包括加派人手確保供電穩定和可靠，全面檢視港燈供電系統電路圖的準確性。同時亦會檢討在維修工作施工前的準備措施和程序，避免同類事情再次發生。

港燈將全力跟進故障後的檢討工作，並會按政府要求在 4 星期內提交詳細報告，以及提出改善及預防方法。

- 完 -

Media statement 4

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PA.EW

港燈新聞稿 -「港燈就供電系統故障最新回應」

To PA.EW

Bcc Grace Ng; 'info@inmediahk.net'; GMPA; GMPA Secretary; PA.MEA; PA.CCA; 'Elaine Wong'; 'am730'; 'Cable TV'; 'China Knowledge'; 'CRHK'; Epoch Times; 'Headline'; 'Headline Daily'; 'HK01'; 'Hong Kong Commercial Daily'; 'Hong Kong Commercial Daily'; 'Hong Kong Economic Journal'; 'Hong Kong Economic Times'; 'HWL - Mawis Wong'; 'HWL- Jeremy Lau'; 'Lamma-Gung'; 'Metro News'; 'Metro Radio'; 'Ming Pao'; 'Now TV'; 'Oriental Daily'; Phoenix TV; 'RTHK'; RTHK - English News; 'Sing Pao'; 'Sing Tao Daily'; 'Sky Post'; 'South China Morning Post'; 'Ta Kung Pao'; 'The Standard'; 'TVB'; 'Wen Wei Po'; 'AA Stocks'; 'AA Stocks'; 'AA Stocks (Main)'; 'Bloomberg'; 'Bloomberg2'; 'BloombergEnergy'; 'Dealreporter'; 'ET Net'; 'etnet'; European Pressphoto Agency b.v.; 'Finet'; 'Infocast'; 'Infocast2'; 'InfraAsia'; 'Quamnet'; 'Reuters'; 'Reuters2'; 'Reuters3'; 'Wall Street Journal'; 'WSJ'; 'WSJ2'; 'Apple Business'; 'Cable TV'; 'China Daily, Li Tao'; 'CRHK'; 'Headline Daily'; 'HK Television Network, Cecilia Kwok'; 'HK01'; 'HK01Roger'; 'Hong Kong Business Magazine'; 'Hong Kong Economic Journal, Grace Lee'; 'Hong Kong Economic Times (Sub)'; 'Hong Kong Economic Times, Wendy Chan'; 'Metro Finance'; 'MetroDaily2'; 'Ming Pao'; 'Ming Pao Web, Cannis Chow'; 'Ming Pao, Bill Ko'; 'Ming Pao, Jason Liu'; 'Now TV'; 'Oriental Daily / The Sun'; 'RTHK'; 'RTHK2'; 'Sammy Phoenix'; 'Sing Pao'; 'Sing Tao Daily'; 'Sing Tao Daily, Johnny Sing'; 'South China Morning Post'; 'South China Morning Post, Eric Ng'; 'Ta Kung Pao'; 'TVB'; 'Wen Wei Po'

You replied to this message on 24/4/2023 10:31 PM.

20230424_prc_HKElectric_PowerInterruption.pdf
323 KB

編輯先生/女士：

現隨電郵附上香港電燈有限公司於今天（4月24日）發出的新聞稿乙份，標題為「港燈就供電系統故障最新回應」，以供報道。

如有查詢，請與公共事務部經理（傳媒關係）黃綺玲聯絡，電話：2843 3229 ， 或電郵：media@hkelectric.com。

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港燈 HK Electric 130 推動永續未來 Powering for Sustainability

Press Release
24 April 2023

HK Electric's Latest Response on Power Interruption Incident

In response to recent media enquiries and reports, HK Electric has the following clarifications to make:

- In 2021, HK Electric had no major power interruption incidents that required immediate reporting to the Electrical and Mechanical Services Department. There were 162 power interruption incidents which affected isolated areas during the year, and most of them were caused by external factors affecting our cables, and equipment failures, etc. For incidents involving low-voltage distribution cables, which are mostly in old districts or relatively remote areas and which could not be handled from our control room like those in high-voltage power transmission and distribution systems, engineering personnel have to attend to the scene in person, hence taking a longer time to restore power supply. Under the circumstances, engineers and technicians have to race against time to restore power supply to the affected customers the soonest possible, and there is no question of the Company making use of small-scale power outage incidents to lower the average time for supply restoration as suggested by some while commenting on the incident.

- Customer performance incentives/ penalties scheme, covering the Average Supply Availability Index ("ASAI"), was introduced to the Scheme of Control Agreement (SCA) in 2009. The scheme was further enhanced in 2019 with, among other initiatives, the "Average Grid Supply Restoration Time" ("Average GSRT") metric introduced. The aim is to enhance the level of supply reliability and shorten the time for supply restoration after a power interruption incident occurred, benefitting even the customers at remote districts. The provisions were added mainly to improve the service quality of the power companies to customers.

- We noticed recent comments querying our preliminary findings released last week which reported that an unrecorded spare cable had been energised accidentally. In fact, the relevant cable became a "spare cable" after a network reconfiguration many years ago. Though the cable had been connected to our system for more than ten years, it was never used in the system for "standby" purpose. It was accidentally energised during the re-commissioning test in this incident. Until the incident, the cable had been in a de-energised state, hence no individual protection device is required. As to why this cable was not featured in our circuit diagram, this is something we aim to find out in our investigation. At the same time, we are doing a comprehensive review of our supply system targeting to formulate a series of improvement measures to prevent similar incidents from occurring in future.

- HK Electric has suspended the relevant work-related authorisation of the engineering staff involved in the power interruption incident. The related staff are also subject to a detailed investigation.

The Company will submit a detailed report to the Government in 4 weeks as required. We sincerely apologise again for the inconvenience caused to customers.

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港燈 HK Electric 130 推動永續未來 Powering for Sustainability

新聞稿
2023 年 4 月 24 日

港燈就供電系統故障最新回應

回應傳媒近日的查詢及報道，港燈發言人澄清如下：

- 港燈在 2021 年沒有重大停電事故需即時通報機電署；全年共有 162 宗涉及範圍相對較小的停電事故，絕大部分涉及電纜受外來因素影響或設備故障等。當中涉及低壓配電設備的事故，由於不能如涉及高壓輸配電系統般可以遙控處理，需要工程人員到肇事環境親身處理，所需復電時間較長。由於低壓配電設備多位於舊區或較偏遠地區，工程人員更需爭分奪秒去盡早恢復供電，並不存在以小範圍停電事故拉低恢復供電時間平均數的說法。

- 事實上，《管制計劃協議》在 2009 年起開始引入客戶表現獎勵／罰款機制，當時已經引入「平均服務可用指數」(Average Supply Availability Index，簡稱 "ASAI")。其後在 2019 年對機制作出改善，引入「平均電網供電復電時間」(Average Grid Supply Restoration Time，簡稱 "平均GSRT" 或 "Average GSRT")。希望藉有關安排提升供電可靠度，一旦遇上事故，盡量縮短客戶的恢復供電時間，即使較遙遠地區的客戶也可惠及。條文主要為提升供電機構對客戶的服務質素而增加。

- 至於有評論質疑港燈稀少故是由於意外按駁一條沒有紀錄的「後備電纜」所致，查實涉事的「後備電纜」，早年因進行電網線路改造，變為「後備電纜」。該條「後備電纜」儘管過去十多年來一直按駁在系統上，但是屬一條不在系統內使用的「後備電纜」，並非備用（standby）電纜，而該電纜在設備調試過程中意外通電。由於維持在不通電的狀態，該條「後備電纜」並沒有配置獨立的保護裝置。至於為何這條「後備電纜」沒有顯示在涉事電路圖上，我們期望在今次調查中找出原因，並正就供電系統作全面檢視，制定一系列改善措施，避免同類事件再發生。

- 港燈已暫停負責涉事工地員工的工作授權的權限，有關員工正接受詳細調查。

公司會按規定在 4 個星期內向監管機構提交詳細調查報告，並再次就事件引起客戶不便，衷心致歉。

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Appendix 2 – Figures

Figure 1. Cross section of CPX 275-kV Gas Insulated Switchgear (GIS)

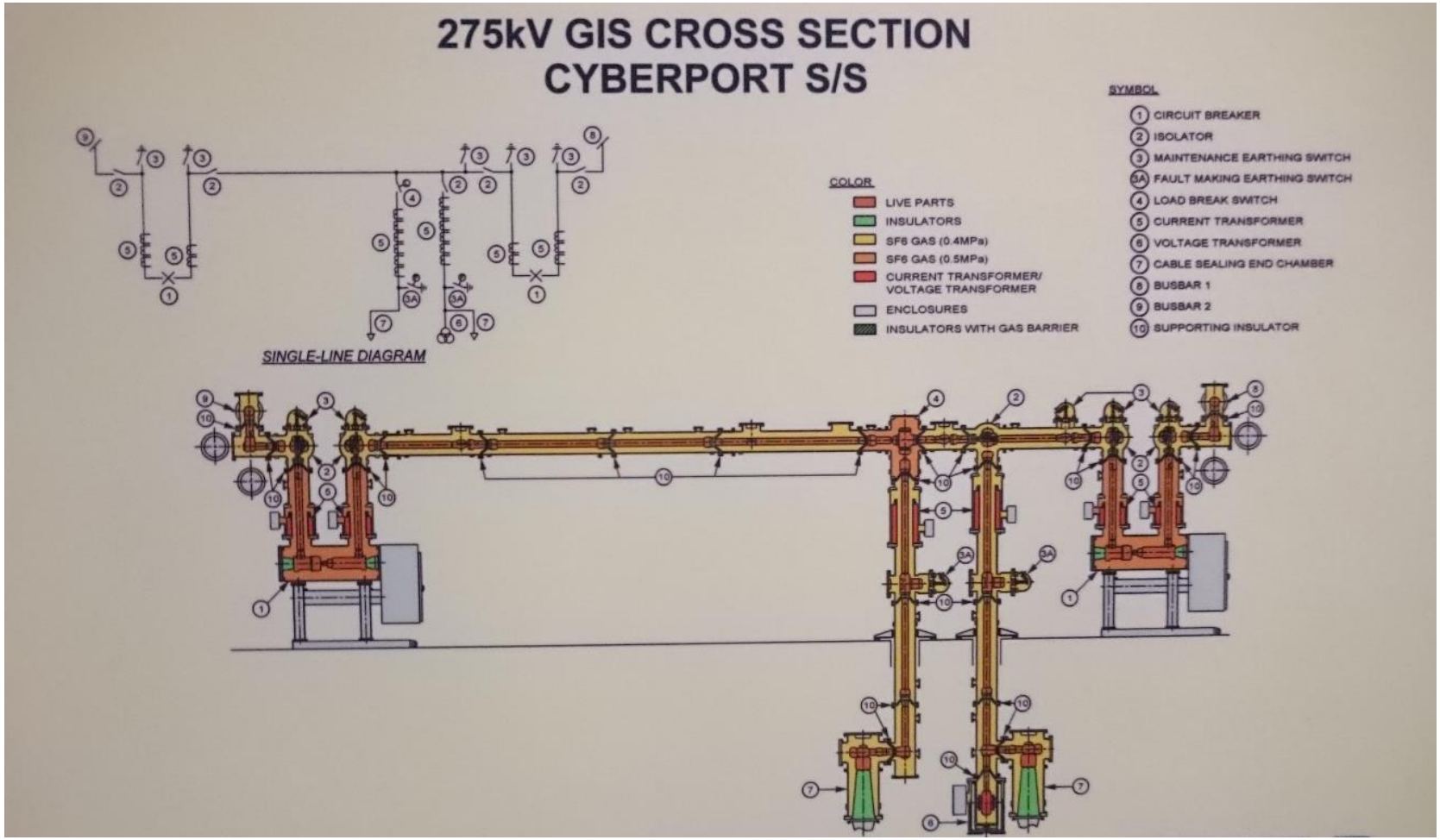

Figure 2. Scope of Refurbishment Work and EMS Circuit Diagram

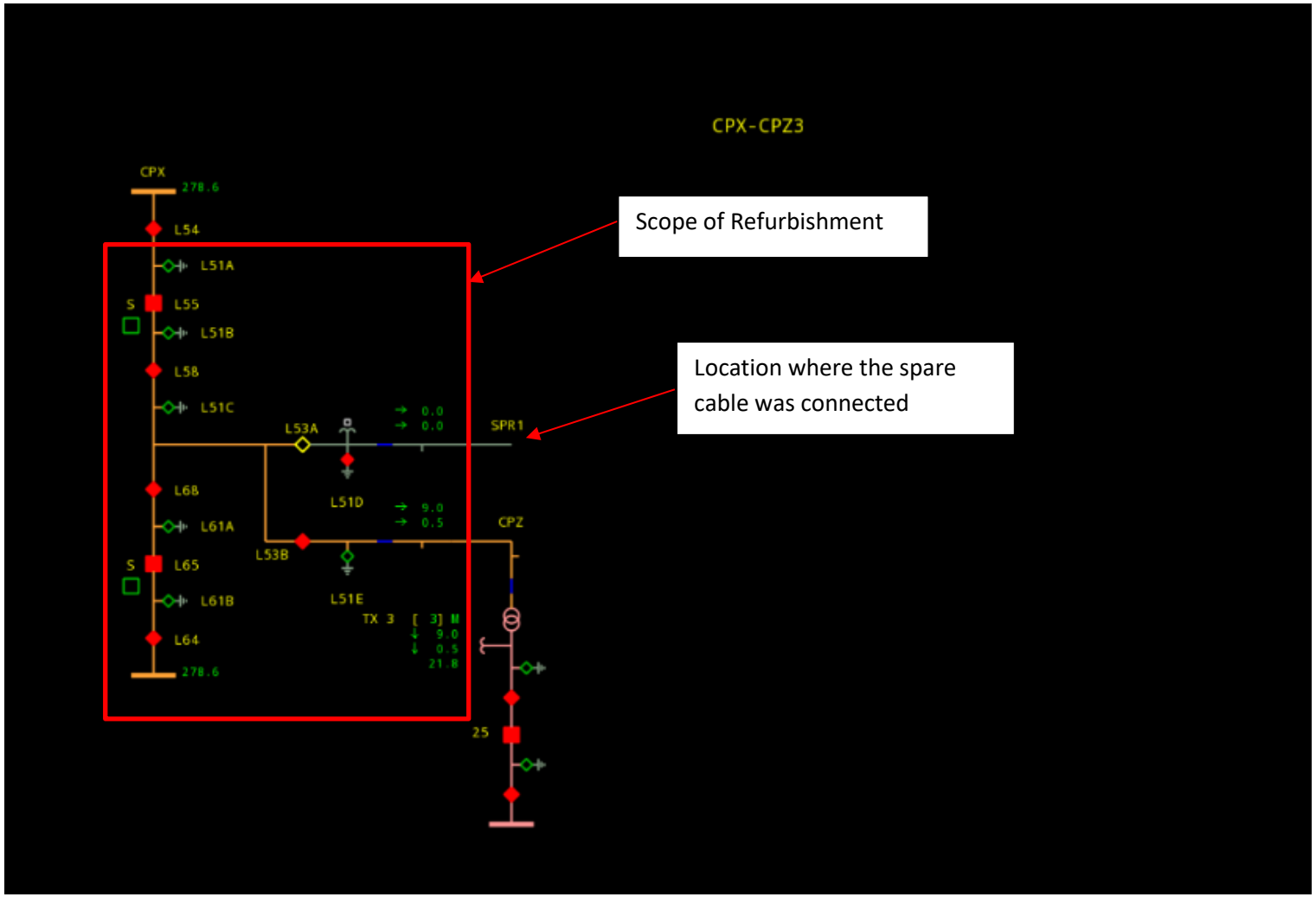

Figure 3. Updated EMS Circuit Diagram

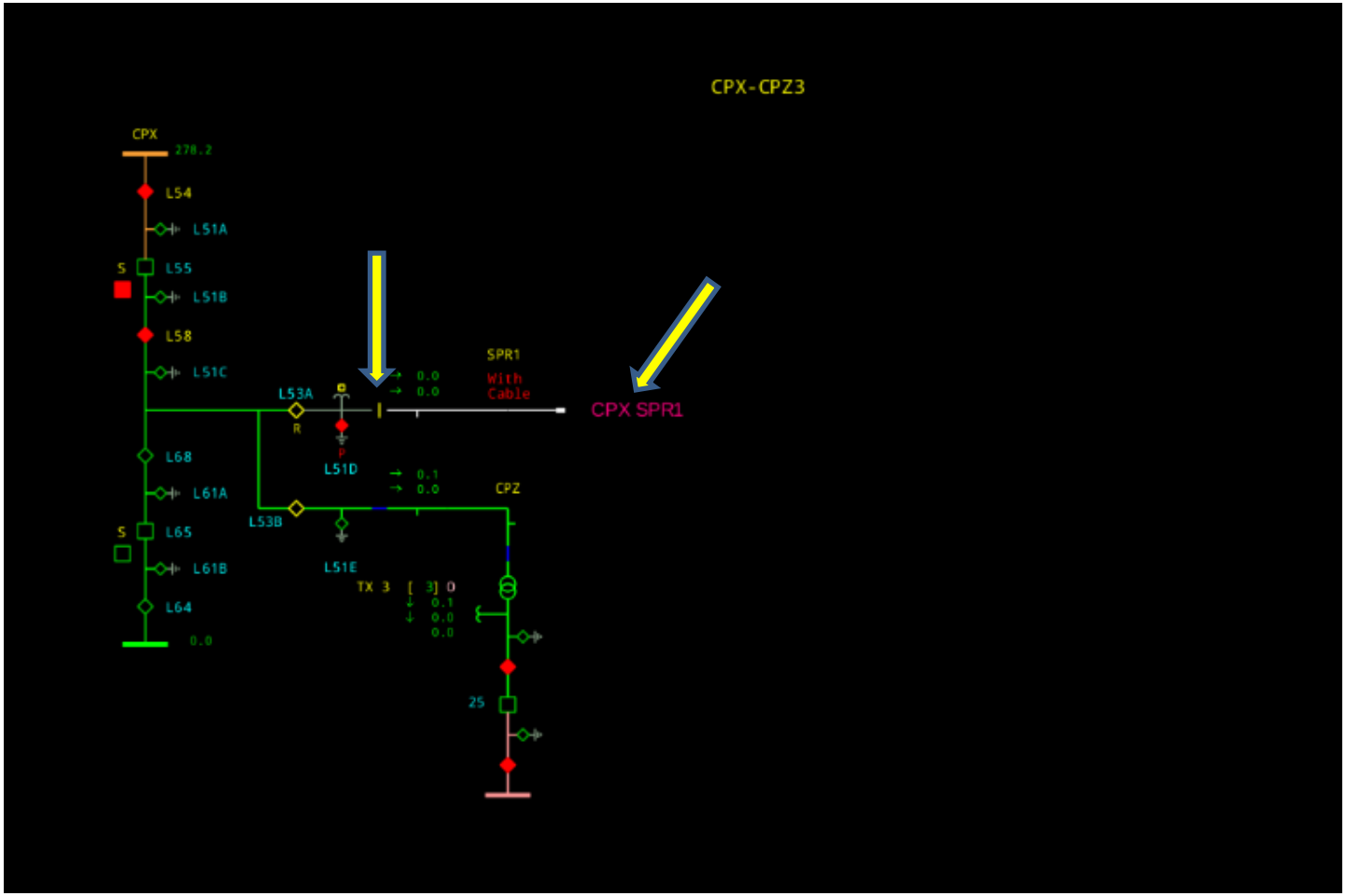

Figure 4. Wordings of New Labels with Additional Information on Local Control Panel at CPX

Figure 5. New Labels with Additional Information on Cable Connection Tank at CPX

Figure 6. Wordings of New Labels with Additional Information on Cable Connection Tank at CPX

Figure 7. New Label on the Cable Connection Tank at Apleichau 132-kV Switching Station