GOVERNMENT OF PUERTO RICO
PUERTO RICO PUBLIC SERVICE REGULATORY BOARD
PUERTO RICO ENERGY BUREAU

IN RE:
TECHNICAL INVESTIGATION REPORT REGARDING JULY 16, 2026 COSTA SUR DISTURBANCE

CASE NO.: NEPR-MI-2026-0008

SUBJECT: LUMA's Motion to Submit Technical Investigation Report Regarding Costa Sur Disturbance of July 16, 2026

MOTION TO SUBMIT TECHNICAL INVESTIGATION REPORT REGARDING JULY 16, 2026 COSTA SUR DISTURBANCE

TO THE HONORABLE PUERTO RICO ENERGY BUREAU:

COME NOW LUMA Energy, LLC and LUMA Energy ServCo, LLC (jointly "LUMA") and respectfully state and request the following:

1. On July 16, 2026, a disturbance occurred at the Costa Sur Steam Plant, affecting approximately 117,000 clients. LUMA, in its capacity as Operator of the Puerto Rico Transmission and Distribution System ("T&D System") pursuant to the Transmission and Distribution Operation and Maintenance Agreement[1], prepared a Technical Investigation Report documenting the event, which is attached hereto as Exhibit 1 and incorporated by reference.

2. The Technical Report was prepared in accordance with applicable industry standards, accepted analytical practices and methodologies, and based on a comprehensive assessment of all available information, including information gathered through Digital Fault

[1] LUMA Energy, LLC, LUMA Energy ServCo, LLC, the Puerto Rico Electric Power Authority and the Puerto Rico Public-Private Partnerships Authority, *Transmission and Distribution System Operation and Management Agreement* (June 22, 2020); *Puerto Rico Transmission and Distribution System Operation and Maintenance Supplemental Terms Agreement* (June 22, 2020) (together herein referred to as the "T&D OMA") https://docs.pr.gov/files/P3-PublicaPrivadas/Projects/Projects/TD%20-%20LUMA/OM%20Agreement/executed-consolidated-om-agreement-td.pdf

Recorders, protection relay records, optical sensor measurements, SCADA information, and field inspections.

3. On July 16, 2026, the Costa Sur facility experienced two separate and unrelated electrical disturbances approximately 17 seconds apart. Although the faults took place seconds apart, the investigation confirms that they were independent events, each arising from different equipment and each cleared as intended by the protection systems in place.

4. The first fault occurred on the 230 kV transmission line ("TL") connecting Costa Sur to Mayagüez. A surge arrester, an important protective device that shields equipment from voltage spikes, failed near the Costa Sur end of the line. Protective relays at both terminals immediately detected the issue and opened the necessary breakers, removing the line from service and preventing broader impacts to the T&D System. Later inspections showed the surge arrester had deteriorated over time and LUMA proceeded with its replacement. During this event, Costa Sur Unit 6 ("CS6") remained stable and unaffected.

5. Sixteen seconds after the initial fault, a separate surge arrester, located on the high-voltage side of the CS6 generator transformer (within Genera PR LLC's demarcated area of responsibility), failed. This triggered a differential protection system, which correctly opened the breaker connected to CS6, disconnecting the unit from the grid.

6. Because Costa Sur Unit 5 ("CS5") had experienced problems earlier in the day, the overall grid was already operating under stress. When CS6 tripped offline due to the transformer fault, it removed a significant amount of generation at a moment when the Energy System could least afford it. As a result, the CS6 trip caused system frequency to drop quickly, triggering automatic underfrequency load-shedding protections. These protections activated exactly as designed to prevent a system-wide collapse.

7. Although CS6 disconnected from the system as designed, its extended unavailability was neither the result of the initial fault in TL 50400 nor of any other condition in the T&D System. Rather, the unit's prolonged outage was attributable exclusively to internal mechanical conditions within CS6 and to the broader limitations in available generation capacity across the Energy System. These unit-specific and system-level generation constraints, wholly independent of the T&D System, prevented CS6 from returning to service following the July 16 event.

8. The root cause of both faults was confirmed to be deteriorated surge arrester assemblies, one set within LUMA's demarcated area of responsibility and another within Genera's demarcated area of responsibility. Both sets have since been replaced, and the protection systems operated as intended. There was no incorrect operation and no electrical interaction between the two faults. The disconnection of CS6 and subsequent load shed event were exclusively related to the activation of protection schemes because of the fault in the CS6 generator transformer. No T&D System condition was present when CS6 tripped. Finally, CS6 remained offline after July 16 due to separate internal mechanical failures unrelated to the T&D System.

9. Exhibit 1 is being submitted in redacted form because it contains: (1) personal identifiers, which appear at the cover page; and (2) Critical Energy Infrastructure Information (CEII), which appears at pages i-iv and 1-23. LUMA is submitting today a redacted public version of Exhibit 1. In compliance with the Energy Bureau's Policy on Management of Confidential Information, CEPR-MI-2016-0009, issued on August 31, 2016, as amended on September 21, 2016, under separate cover and expeditiously, within the next ten (10) days, LUMA will submit a memorandum of law in support of its request to file Exhibit 1 redacted.

WHEREFORE, LUMA respectfully requests that the Energy Bureau take notice of the filing of the Technical Investigation Report attached hereto as **Exhibit 1**, together with any other relief deemed just and proper.

RESPECTFULLY SUBMITTED.

In Guaynabo, Puerto Rico, on the 20th day of August 2026.

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Exhibit 1

Technical Investigation Report Costa Sur 230 kV Disturbances at Line 50400 and Costa Sur #6

20:15:05 and 20:15:21 – July 16, 2026

Prepared by

[redacted]

Outage Investigations Supervisor, Reliability
LUMA Energy Servco, LLC
San Juan, Puerto Rico
(08-05-2026)

LUMA

Version History

Version	Date	Revision
01	07-21-2026	Preliminary report -First Issue
02	07-30-2026	Final Report - Draft
03	08-05-2026	Final Report – R.1 with CS6 trip cause

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CRITICAL ENERGY INFRASTRUCTURE INFORMATION (CEII)

This document contains privileged legal analysis and Critical Energy Infrastructure Information (CEII) protected from disclosure under:

- 6 U.S.C. §§ 671–674
- 18 C.F.R. § 388.113 (2020)
- Puerto Rico Energy Bureau Policy CEPR-MI-2016-0009 (as amended)

It is provided exclusively for internal LUMA Energy Servco, LLC legal counsel, authorized regulatory personnel, and individuals with a legitimate need to know.
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2

Executive Summary

On July 16, 2026, two independent electrical disturbances occurred at the Costa Sur Steam Plant affecting the 230 kV transmission line 50400 from Costa Sur Steam Plant (Costa Sur) to Mayagüez Transmission Center (Mayagüez) and Costa Sur Generation Unit 6 (CS6). High-resolution digital fault recorder data, relay events and targets, optical sensor measurements, and SCADA recordings confirm that the events were electrically separate, originated in different protection zones, and were cleared correctly by the respective protection systems. LUMA formally requested operational records from Genera, including video documentation and internal sequence-of-events logs to support a complete reconstruction of the events. These records were not provided. In the absence of this information, the investigation relied exclusively on validated instrumentation data and field inspections, which delayed the ability to confirm certain initiating components.

The first disturbance on July 16 was a close-in phase-to-ground fault on Line 50400 at the Costa Sur terminal. Protective relays at both Costa Sur and Mayagüez operated immediately and isolated the line. LUMA conducted field inspections and diagnostic testing of equipment within its ownership boundary. [redacted]

After the July 16 Line 50400 fault cleared, CS6 remained electrically and mechanically stable for more than sixteen seconds, confirming that the transmission event did not impose abnormal electrical stress on the unit. This short-duration, correctly cleared, transient fault is fundamentally different from the prolonged generation-wide disturbance caused earlier in the day by internal issues on Costa Sur Unit 5 (CS5), which lasted several minutes and placed the island's generation fleet—including CS6—under sustained mechanical and electrical stress.

The second disturbance was caused by the failure of the phase-C surge arrester located on the grounded 230 kV high-voltage interface of the CS6 generator step-up transformer within Genera's demarcation boundary. The unit differential protection detected the fault immediately and tripped circuit breaker (CB) [redacted] to isolate CS6. LUMA inspected the equipment within its ownership boundary and found no defects. Although the failed surge arrester was within Genera's demarcation boundary, the structure was located inside the yard surrounded by energized LUMA-owned equipment. Based on risk assessment and the need to safely secure the surrounding energized facilities, extensive coordination and work permits were required before LUMA personnel could access the area. Once those authorizations were completed, LUMA performed the inspection and installed the replacement surge arresters on August 1, 2026.

CS6 tripped on July 16, while the islanded grid was operating in the Alert operational state with limited generation capacity due to earlier instability caused by internal issues at CS5. Thus, the removal of CS6 generation from the islanded system caused a rapid frequency decline that activated the automatic

underfrequency load-shedding (UFLS) scheme protections which operated at their programmed stages and prevented a cascading collapse.

During the frequency recovery period, manual switching actions occurred inside the Costa Sur plant without authorization or communication to LUMA's Transmission Operations Center:

- [redacted] on the high-voltage side of the [redacted] was manually opened de-energizing the transformer and temporarily removing the existent transmission path from the 230 kV source to the 115 kV system.
- [redacted] was manually closed to restore the transformer.
- [redacted] which serves both the [redacted] in the same bay, was also manually closed.

These operations temporarily altered the configuration of the Costa Sur 230 kV and 115 kV systems during a vulnerable underfrequency period. The system did not experience further disturbances because Line 50400 did not have a permanent fault, Costa Sur's generation share was not predominant at the time, and the temporary loss of the 230/115 kV Transformer #1 occurred during a period of reduced loading from Costa Sur while all other 230 kV transmission lines remained in service. Under different conditions, particularly if Costa Sur had been supplying a higher percentage of island generation or if the Line 50400 fault had been permanent, these switching actions could have caused significant system imbalance and contributed to a widespread outage.

On July 17, it was reported that while off-line, CS6 experienced a separate and unrelated internal boiler piping failure during a test conducted by Genera. Relay targets and differential protection behavior from July 16 confirm that the generator did not experience an internal fault during the electrical disturbances, as the [redacted] protection did not operate. July 17 internal mechanical failure of CS6 was independent of the July 16 electrical events.

Overall, on July 16, protection systems operated correctly throughout both disturbances. The transmission fault on Line 50400 was cleared immediately, the generator transformer-zone fault was isolated instantly, and UFLS protections operated as designed. The detailed analysis presented in this report documents the electrical behavior associated with each disturbance, the operational conditions surrounding the events, and the subsequent system recovery sequence.

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1 Introduction

This report reconstructs the electrical disturbances at Costa Sur on July 16, 2026. Two independent faults occurred in the 230 kV yard during the evening peak, separated by over sixteen seconds and cleared by different protection zones.

The first fault was a failed phase-C surge arrester on Line 50400 between Costa Sur and Mayagüez. Protection at both terminals operated immediately, isolating the line. With Line 50400 de-energized, CS6 maintained stable operation for more than sixteen seconds.

Another, unrelated fault then developed at the phase-C surge arrester on the 230 kV side of the CS6 generator step-up transformer within Genera's ownership. The unit differential protection ([redacted]) detected and cleared it instantly.

After CS6 tripped, system frequency declined and entered automatic underfrequency load-shedding stages to avoid system instability. During the underfrequency event, manual switching actions occurred inside Costa Sur without TOC authorization. [redacted] on the high-voltage side of the [redacted] transformer was manually opened and re-closed, and breaker [redacted]—shared between the transformer and Line 50400—was also manually closed. These actions temporarily changed the 230 kV and 115 kV configurations but did not create further disturbances, as CS5 was already out of service and the line fault was not permanent. They are included here as part of the full event sequence.

The following sections provide a detailed analysis supported by DFR data, protection relay records, optical sensor measurements, SCADA information, and field inspections. The objective is to present an accurate, evidence-based account of the July 16 events and the subsequent system conditions.

2 Event Summary

Outage Name	Costa Sur Dual Independent Fault Events – July 16, 2026 (Line 50400 SLG Fault and Separate CS6 230 kV-Side Disturbance)
Event Number	OE2607-060 and OE2607-061
Outage Date	July 16, 2026
Outage Time	20:15:05 (Line 50400 single line-to-ground fault) 20:15:21 (Fault at CS6 230 kV side with L50400 open) 20:15:34 (Costa Sur [redacted] de-energized by Genera)
Location	Costa Sur Steam Plant
Clients	117,000

3 Before the Events Initiated at 20:15:05

This section outlines the system conditions and ongoing disturbances present before the independent faults at 20:15 on July 16, 2026. These conditions did not cause the faults but significantly shaped the electrical environment in which they occurred.

3.1 Costa Sur #5 Loss of Load & Trip Caused Two System Disturbances

Several hours before the independent faults on Line 50400 and the CS6 230 kV surge arresters, the system experienced two major disturbances originating from CS5. Although separate from the later events, these disturbances caused instability, underfrequency excursions, tripping of renewable generators and sustained mechanical and electrical stress across the generation fleet, including CS6.

At 12:50, CS5 experienced a rapid loss of control attributed to reported internal Genera operational issues. The sudden loss of generation caused system frequency to fall below 59.5 Hz, leading to trips of renewable units and pushing frequency downward until underfrequency load shedding activated and system recovery began. Throughout this instability, all generating units, including CS6, operated under prolonged disturbance conditions. CS5 remained unstable, with significant output oscillations, and Aguirre Unit 2 (AG2) experienced the largest operational impact, with wide swings in power output while attempting to remain synchronized.

At 12:59, system frequency reached 60.3 Hz shortly before CS5 tripped offline, removing approximately 115 MW and initiating another underfrequency event with renewable trips. Subsequent renewable generator reentry five minutes later produced additional frequency swings.

These extended CS5-related disturbances resulted in more than 10 minutes of elevated current loading, repeated frequency fluctuations, and sustained dynamic stress across generators and transformers, unlike the short, isolated and independent faults that occurred later at 20:15.

Figure 3-1:Prolonged UF load shed event CS5 loss of control and trip

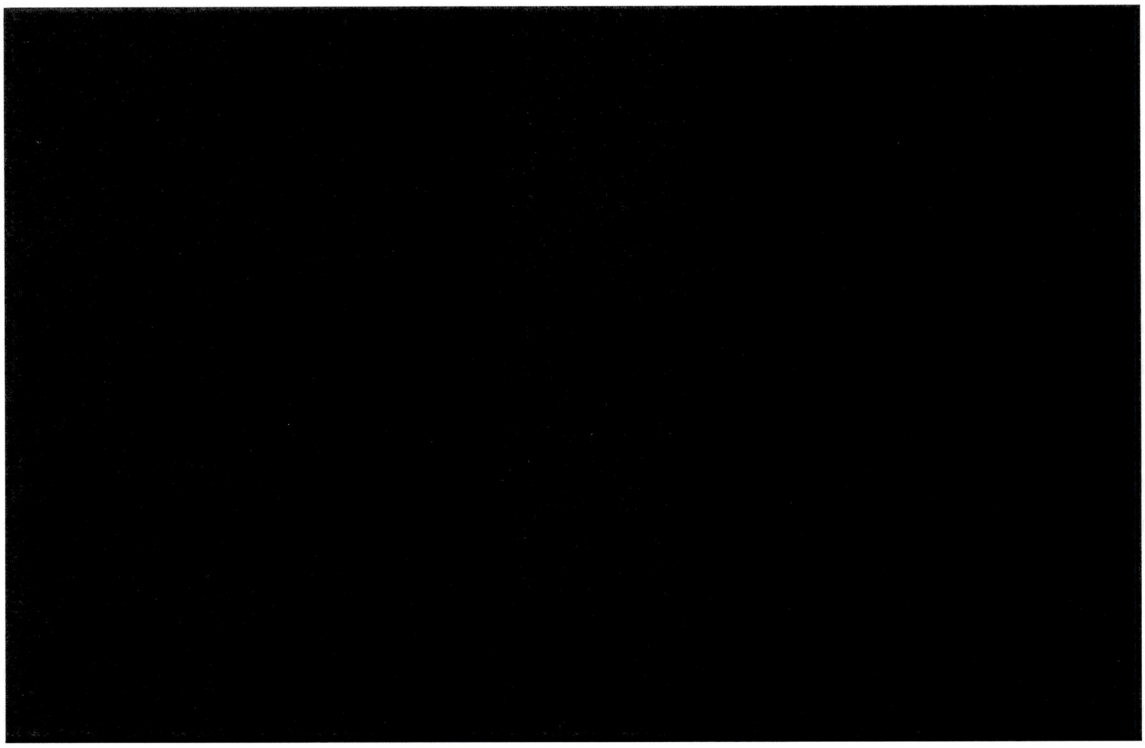


Figure 3-2: CS5 control loss in green and trip event caused system generation unbalance. Note AG2 in aqua

3.2 System Before the Faults at L50400 and Costa Sur Unit #6

Prior to the two independent events at Costa Sur, system generation totaled about 2,968 MW. EcoEléctrica (578 MW) and Costa Sur (338 MW) supplied roughly 916 MW, or about 31% of available generation. These levels describe the system's operating state at the time and did not influence the subsequent independent faults that occurred later in the Costa Sur 230 kV yard.

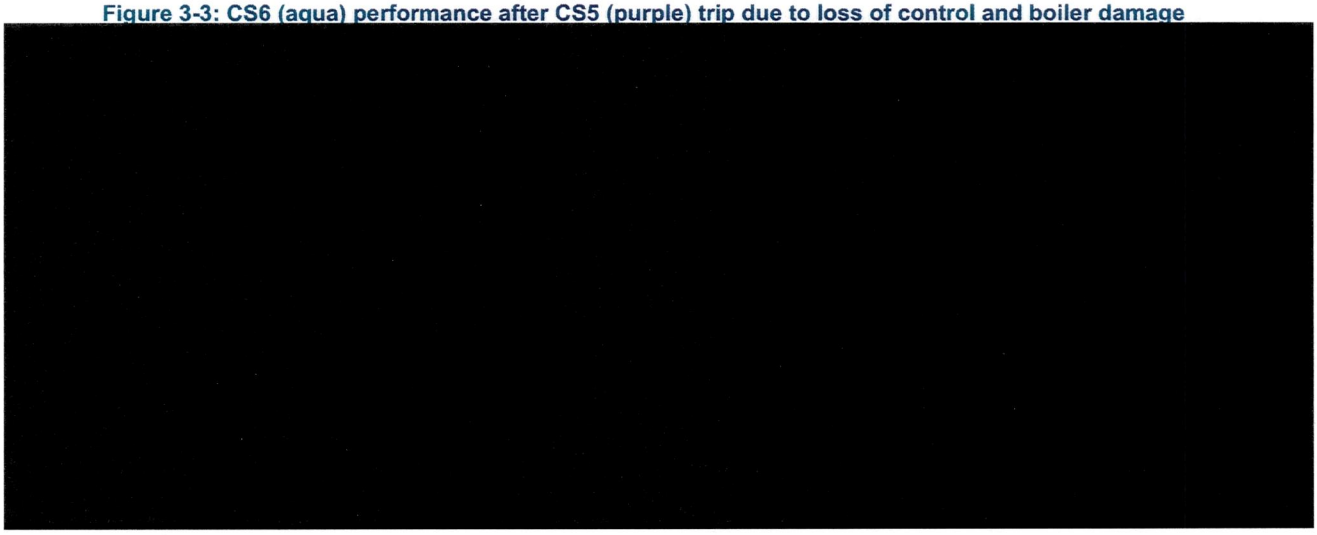
3.2.1 Costa Sur Unit #6

Before the July 16 disturbances, Costa Sur units and the broader transmission system were already operating under stress due to earlier instability from CS5. Prior to the first CS5 event, CS5 and CS6 were producing a combined output near 518 MW. After CS5's loss of generation due to internal control issues, CS6 increased output to roughly 338 MW to help stabilize system frequency and compensate for the deficit. The CS5 230 kV circuit breakers [redacted] were open before the 20:15 faults.

230/115 kV transformer #2 at Costa Sur was out of service, but it's CB [redacted]—located in the same bay as CS5—remained closed to maintain bus continuity in the breaker-and-a-half configuration. [redacted] was in service with 115 kV CB [redacted] open.

CS6 remained stable and electrically balanced in the period leading to the events at 20:15. CB [redacted]22, associated with CS6 protection and outgoing circuits, was already open due to a planned operational replacement following mechanical issues identified during the April 16, 2026, event. Its status did not contribute to any abnormal conditions before or during the faults.

Figure 3-3: CS6 (aqua) performance after CS5 (purple) trip due to loss of control and boiler damage

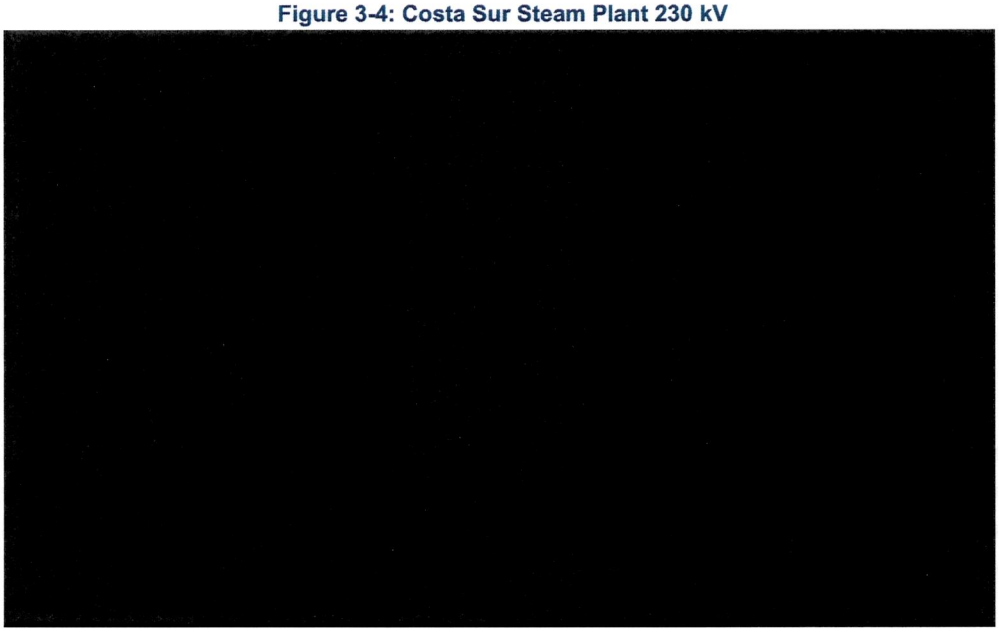


3.2.2 230 kV Line 50400 from Costa Sur to Mayagüez

230 kV line 50400 was carrying approximately 422 amperes. The line reclosing scheme does not permit automatic reclosing from the Costa Sur side; instead, the selector switch operates in synch-check mode allowing Costa Sur to close and synchronize only after the Mayagüez terminal is energized. The programmed synch-check window is ten seconds, with a ten-second reset interval. Therefore, Line 50400 at Costa Sur could not have re-closed during the CS6 event more than sixteen seconds apart from the trip.

The Mayagüez terminal has one of the optical sensors installed across the 230 kV system. In addition to traveling-wave fault location, these devices provide several modes of monitoring that extend beyond microsecond-scale transient detection to record frequency variations, long-duration system behavior, and disturbance evolution across multiple time scales. Their architecture allows the same hardware to capture both immediate fault-location functions and broader system diagnostic analysis across the island.

Figure 3-4: Costa Sur Steam Plant 230 kV



4 Sequence of Events

This section provides a chronological reconstruction of the events that occurred on July 16, 2026. The timeline integrates information from the digital fault recorders (DFR), optical electric field sensors, protective relay events targets/logs, field reports, and operational sequence-of-events data. Camera records, control logs, and local SCADA sequence-of-events data from Costa Sur – Genera facility were not available. As a result, the analysis reflects only the data sources that were accessible.

Cross-comparison of the available independent sources shows consistent alignment in timestamps, voltage and current magnitudes, and protection system responses, providing a reliable representation of system conditions throughout the disturbance. See chapters 3 and 5 for details.

Table 4-1 Timeline of Events (HH:MM:SS.000)

Time	T-T0	Description
12:50:51.57	-07:24:13.49	CS5 generator, carrying 250 MW, experienced a loss of load due to reported internal Genera control issues, reducing output to 51 MW. This caused an underfrequency disturbance, triggering the automatic load-shedding protection scheme. During this event, all generators, including CS6, experienced a prolonged disturbance lasting more than 10 minutes in total.
12:56:20.00	-07:18:45:06	As system frequency recovered from the load-shed event, CS5 tripped at 115 MW due to boiler failure. A new underfrequency disturbance occurred, followed approximately five minutes later by a frequency rise from renewable generation recovery.
20:15:05.06	T0	An incipient high-impedance [redacted] to-ground fault began developing at the surge arrester structure on the Costa Sur 230 kV terminal of line 50400 to Mayagüez T.C.
20:15:05.13	00:00:00.07	The fault at line 50400 evolved into a solid C-to-ground fault and was detected immediately by line protection.
20:15:05.23	00:00:00.17	Circuit breakers [redacted] at Costa Sur and [redacted] in Mayagüez opened to clear the transient fault from the system.
20:15:06.33	00:00:01.27	CS6 generator returned to normal balanced load. System frequency returned to normal at 60.07 Hz.
20:15:17.86	00:00:12.80	System frequency increased to a maximum of 60.23 Hz, remaining within normal operational limits.
20:15:21.95	00:00:16.89	With line 50400 breakers still open, a [redacted] to-ground surge arrester fault occurred on the grounded 230 kV high-voltage interface of CS6 belonging to Genera, within the unit differential protection zone.
20:15:22.05	00:00:16.99	The fault at CS6 generator was cleared instantly by the unit differential protection, opening [redacted] as designed.

Time	T-T0	Description
Following the opening of [redacted] CS6 entered the deceleration process. As system frequency declined, DFR and [redacted] relay data showed that 24 kV [redacted] current momentarily dropped without a corresponding voltage change for approximately 0.3 seconds due to internal Genera issues within the generator zone. With CS6 generation offline, system frequency started to drop and entered an Emergency and subsequently "In extremis" (severe emergency) operational states.		
20:15:29.07	00:00:24.01	System frequency dropped below 59.2 Hz.
20:15:34.70	00:00:29.64	[redacted] of the [redacted] at Costa Sur was opened by Genera personnel, interrupting the 230 kV source feeding the transformer and temporarily isolating the 115 kV system from the remaining 230 kV generation. This action was not reported to LUMA.
20:15:35.36	00:00:30.30	System frequency reached its lowest point of 58.54 Hz. Automatic underfrequency load-shed protection scheme was activated to prevent a blackout and restore frequency balance.
20:18:30:17	00:03:25.11	[redacted] was manually closed by Genera without TOC authorization restoring the [redacted]r and normal load flow.
20:18:33.80	00:03:28.74	The Costa Sur operator closed [redacted] locally without authorization from the TOC or inspection of the line. Fortunately, the fault at line 50400 was not permanent and no consequences (damage to the remaining [redacted] closed to a fault) followed.
Given the existing generation shortfall, due to the previous CS5 broken boiler event, automatic load-shed restoration was delayed, and manual load-shed procedures had to be implemented.		
21:13:00.00	00:57:54.94	Automatic underfrequency loads were restored
23:41:00.00	03:25:54.94	Manual load shed finished. Loads were restored.
07-17-2026 During a Genera off-line operation, CS6 sustained major boiler-piping damage due to an internal issue. As the source of the July 16 trip was still unknown, the unit remained off-line and was never synchronized with the system. The generator itself had not suffered any damage during the July 16 fault. After July 17, the unit remained unavailable for repair with its estimated time for return (ETR) listed as to be determined (TBD).		
07-21-2026 LUMA personnel were at Costa Sur inspecting line 50400 equipment in service looking for the point of failure on July 16, 2026. At 16:33, a fault occurred on line 50400.		
16:33:21		Line 50400 trip due to a [redacted]to-ground fault. As LUMA personnel were in the field, the fault was localized and repairs were completed as listed in section 5.

5 Investigation and Analysis

Investigation and analysis for this fault is based on digital fault recorders data, relay events for line 50400, relay targets for CS6 generator, optical sensor data, LUMA SCADA alarms and field inspections reports.

5.1 Surge Arrester Fault at Line 50400 Costa Sur to Mayagüez

The investigation determined that the July 16 disturbance on Line 50400 was initiated by failure of the surge arrester assembly at the Costa Sur 230 kV terminal. Instrument data placed the fault electrically within the Costa Sur switchyard. A second disturbance on July 21 at the same electrical location provided visual confirmation when personnel observed a flash at the elevated surge arrester structure approximately [redacted] feet above ground.

Initial inspections showed no visible structural damage, and because breaker yard video footage requested from Genera was not available, the initiating component could not be visually confirmed until July 21. Although vegetation and possible insulation conditions identified during helicopter patrols did not match the characteristics of the recorded fault they were addressed independently.

[redacted]

Figure 5-1:Surge arrester structure at approximately [redacted] ft where July 21 fault flash was observed

[redacted]

5.1.1 Optical Electric Field Sensors

Optical electric-field sensors with microsecond-level traveling-wave accuracy, installed on Line 50400 (Mayagüez–Costa Sur) and Line 50200 (Costa Sur–Manatí), recorded a single line-to-ground fault on [redacted] accompanied by a full phase voltage collapse on that phase. Approximately five seconds prior to the fault, both the optical sensors and the DFRs from around the island registered a frequency ramping from 60.20 Hz to 60.07 Hz without any corresponding decrease in voltage or increase in fault current. This behavior is consistent with the development of an incipient electrical arc in the surge-arrester assembly. See Figure 5-2. The estimated fault location from both sensors at Costa Sur and Mayagüez confirmed that the event occurred near, or within, the Costa Sur 230 kV switchyard.

On July 21, the sensors detected a second fault—this time on [redacted]—at the same electrical location. Because personnel were present in the switchyard during this event, they observed a flash at the surge-arrester structure and confirmed that all three surge arresters associated with Line 50400 were damaged.

A comparison of the per-unit energy change recorded by both devices shows that the Costa Sur sensor detected a significantly higher per-unit disturbance than the Mayagüez-end sensor on line 50400. This behavior is consistent with a fault located electrically close to Costa Sur corroborating the traveling-wave data, the DFR records, and relay event data. The estimated event location on line 50400 was:

- [redacted]7 km ([redacted] mi) from the Costa Sur SP 230 kV terminal (bus [redacted])
- [redacted] km ([redacted] mi) from the Mayagüez TC 230 kV terminal (bus [redacted])
- GPS coordinates: [redacted], elevation [redacted] m
- Total line length: [redacted] km ([redacted] mi)

These results indicate an estimated traveling-wave propagation speed of [redacted], which is consistent with expected values for a 230 kV overhead transmission line.

Figure 5-2: Frequency performance during both 230 kV [redacted] faults seen by Aguirre

[redacted]

Figure 5-3: Optical Sensor Data from Costa Sur Line 50200

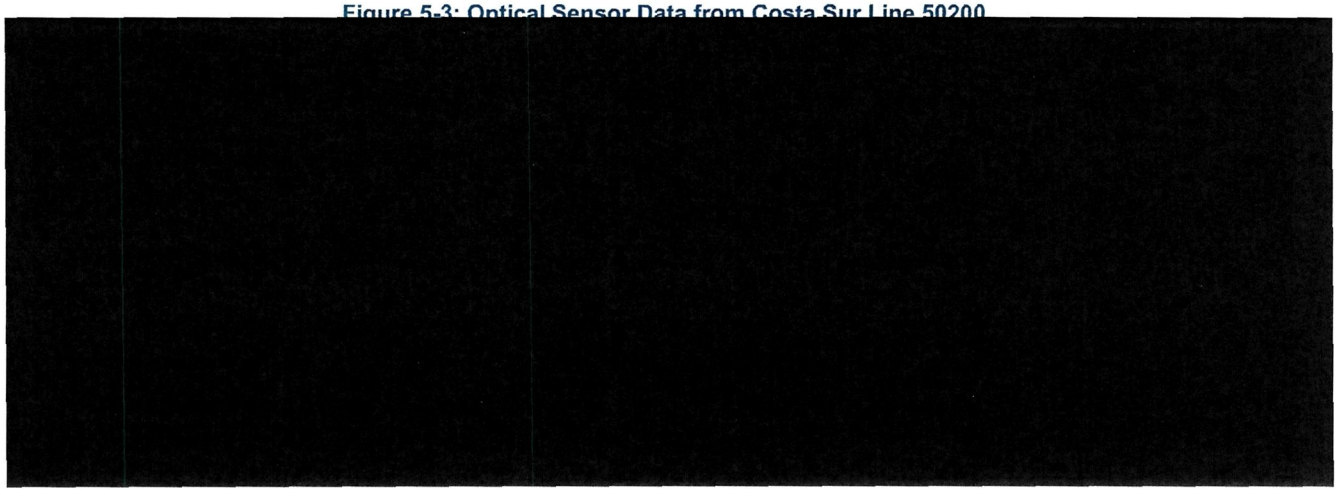
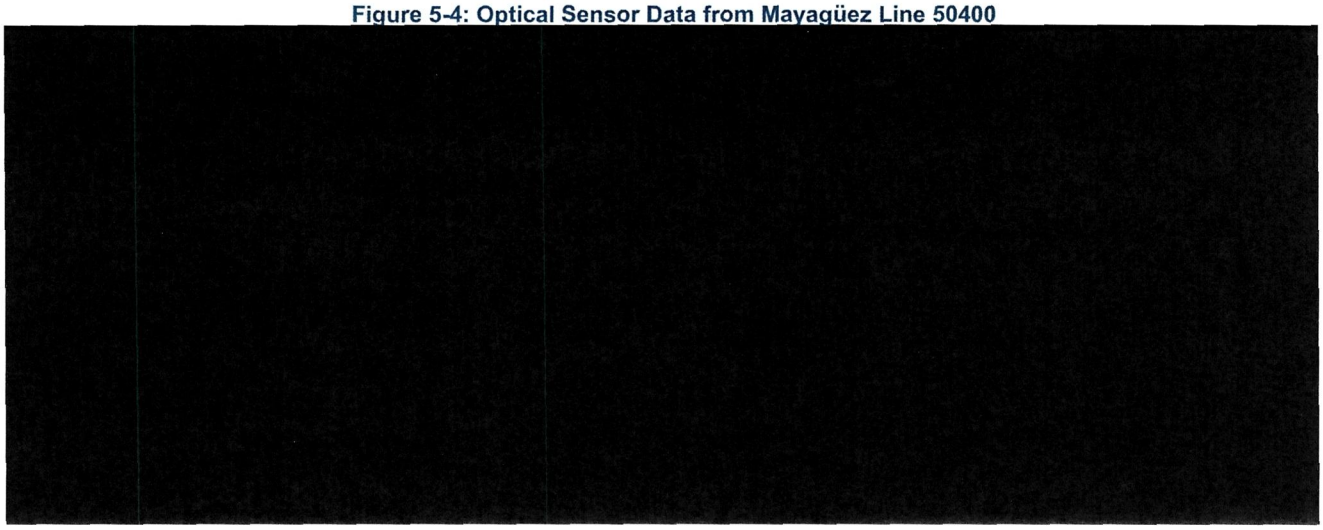


Figure 5-4: Optical Sensor Data from Mayagüez Line 50400



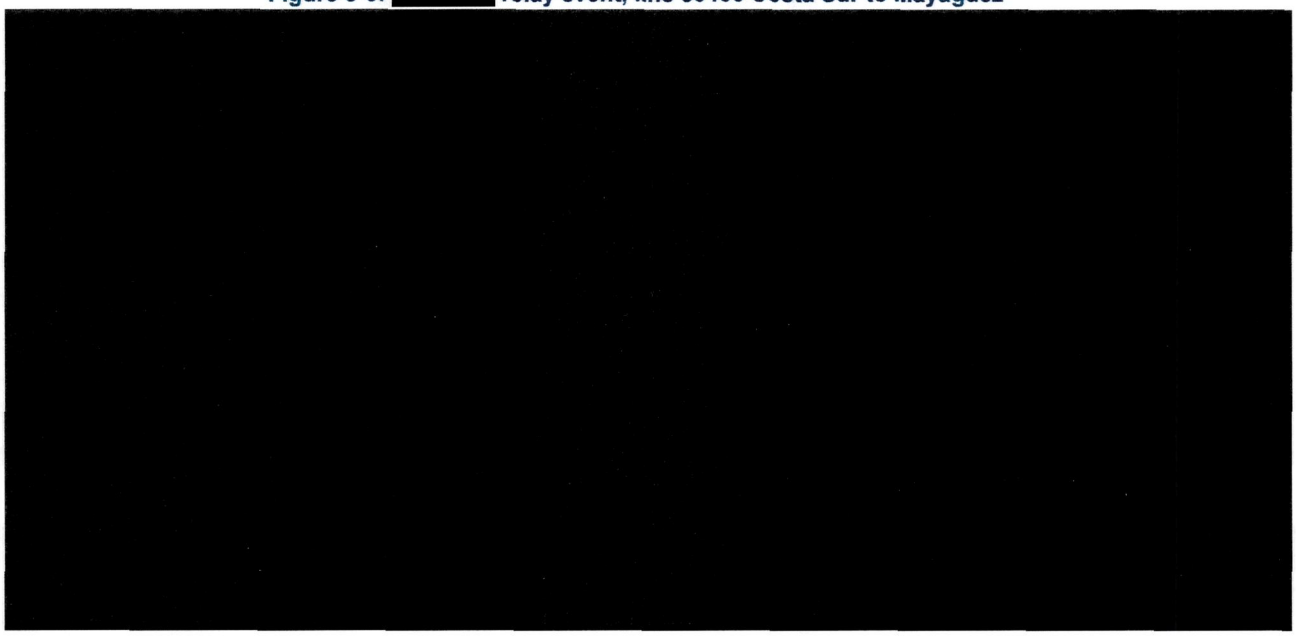
5.1.2 Line 50400 Relay Events

Figure 5-5 shows the relay event data from the relays at both the Costa Sur (local) and Mayagüez (remote) terminals. At the Costa Sur terminal, the maximum fault current measured was I, and CBs opened in seconds. The protection elements that operated included instantaneous directional ground overcurrent ( ), line differential ( ), and ground distance ( ). Breaker status indications confirm that the associated breakers opened correctly and remained open following the fault. Line 50400 did not attempt automatic reclosing from either terminal.

At the Mayagüez terminal, CBs operated in seconds and recorded a remote-end contribution of , which is consistent with a fault electrically close to the Costa Sur terminal. The line remained out of service after protection operation.

Prior to the disturbance, phase voltages at Costa Sur were approximately . During the fault, voltages dropped to , and , consistent with a solid phase-C-to-ground transient fault located at the Costa Sur terminal.

Figure 5-5: [redacted] relay event, line 50400 Costa Sur to Mayagüez

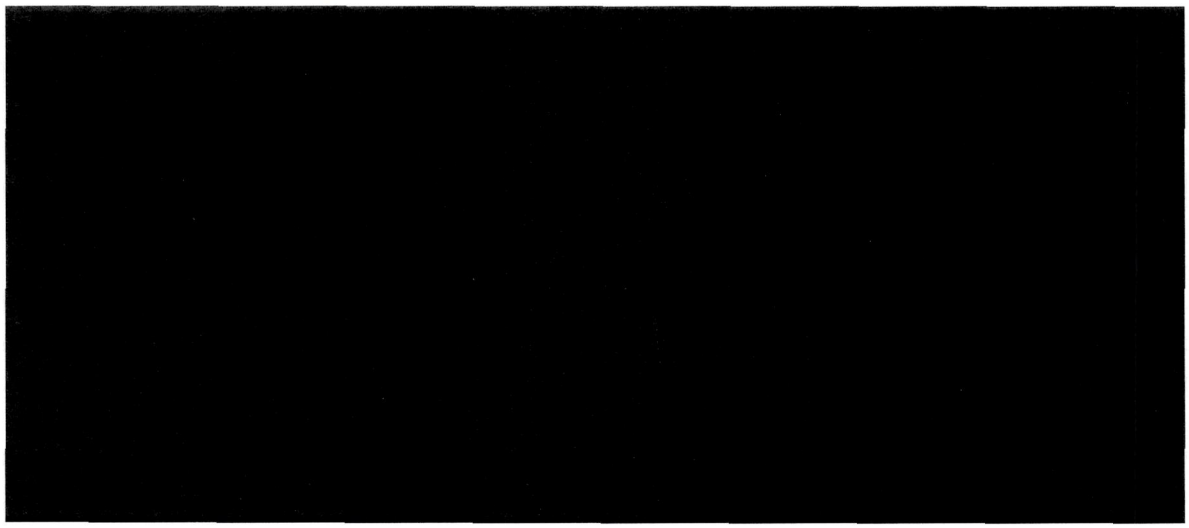


5.1.3 Line 50400 Event - Digital Fault Recorder Data

Digital fault recorder data from Costa Sur shows the line 50400, EcoEléctrica generation flowing through Line 51100 and the CS6 generator response during the transient fault at the 230 kV line 50400. See Figure 5-6. The DFR analog channels connected to the metering CTs of line 50400 registered significant saturation with peak current of [redacted] amperes on [redacted]

The Costa Sur DFR also recorded a system frequency decrease without a corresponding voltage drop or current increase in the milliseconds preceding the fault, which is consistent with the behavior during the development of an incipient surge-arrester failure. Short circuit current contribution from CS6, measured at the [redacted] generator terminals, reached [redacted] amperes on [redacted] and [redacted] amperes on [redacted]

Figure 5-6: Costa Sur DFR Record – Fault at line 50400



5.1.4 Costa Sur #6 Response After L50400 Fault

Digital fault recorder data in Figure 5-6 show that immediately after the transient fault on Line 50400, the CS6 generator responded as expected for a synchronous machine riding through a short-duration disturbance. The generator's load current stabilized at approximately [redacted] amperes on the [redacted] kV side, system frequency remained at 60.07 Hz, and the 230 kV bus voltage returned to its pre-fault value of approximately [redacted]. EcoEléctrica generation also remained stable, indicating that the disturbance did not propagate beyond the immediate fault location.

Because the fault at Line 50400 lasted only [redacted] seconds and cleared correctly, CS6 maintained normal electrical and mechanical operating conditions throughout the post-fault period. The unit continued steady operation for more than [redacted] seconds after the line fault cleared.

5.2 Surge Arrester Fault at Costa Sur #6 with L50400 open

Before evaluating the protection behavior and recorded fault signatures for CS6, the system configuration at the time of the event must be established. Line 50400 was fully isolated when the generator disturbance occurred; circuit breakers [redacted] at Costa Sur and [redacted] at Mayagüez remained open, and the line did not attempt reclosing. Because the line was deenergized, the earlier 0.07-second transmission fault did not impose any electrical stress or abnormal power flow on CS6. DFR data shows that the generator operated normally for more than [redacted] seconds after the line fault cleared, confirming that the later disturbance was independent of the Line [redacted] event and must be evaluated within the CS6 transformer protection zone.

Following the disturbance, and with no switchyard video available to provide visual confirmation of the initiating component, LUMA undertook a comprehensive inspection of all equipment within its ownership boundary to verify its condition. This included full maintenance of [redacted] even though the breaker had operated correctly and immediately during the event. Corona inspection and thermographic evaluation were not feasible during the post-event review, as both diagnostic techniques require the equipment to be energized to identify discharge activity or thermal irregularities. Because the transformer and associated high-voltage structures were de-energized at the time of inspection, these tests were performed later with satisfactory results. No defects were identified on LUMA-owned equipment related to CS6 fault on July 16, 2026.

The surge arresters associated with the CS6 transformer are located beyond [redacted], outside LUMA's demarcation point, and belong to Genera. After LUMA completed its inspections and communicated the results, both entities agreed to examine the surge arresters within Genera's ownership boundary. Joint field observations confirmed visible damage on the [redacted] arrester, as shown in Figure 5-7, and diagnostic testing showed that the surge arresters on Phases A and B also did not pass inspection. All three surge arresters were replaced on August 1, 2026.

The following sections describe the analysis of the [redacted] surge arrester fault occurring on the 230 kV side of the CS6 main power transformer, within the [redacted] unit differential protection zone and within Genera's demarcation.

5.2.1 Generator Main Power Transformer High Side Fault Characterization

The fault occurred at the failed [redacted] surge arrester located beyond [redacted] within Genera's ownership area. Instrument data showed a brief frequency rise immediately before fault current appeared, consistent with an incipient grounded-high-voltage arrester failure. Although the DFR captured an A–C disturbance at the [redacted] kV generator terminals, this reflected the magnetic response of the delta-connected winding to a single phase-to-ground fault on the 230 kV side. The delta winding blocks zero-sequence current, and the recorded [redacted] values across the 230 kV system confirm that the fault originated on the grounded 230 kV interface rather than inside the generator. Representative zero-sequence current magnitudes recorded at the Costa Sur 230 kV bus included:

- Line 50300 (Aguirre): [redacted] A
- 230/115 kV Transformer [redacted]: [redacted] A
- Line 50200 (Manatí): [redacted] A
- Line 51200 (Cambalache): [redacted] A

[redacted] fault contributions recorded across the system also align with a high-voltage [redacted] surge arrester failure on the grounded 230 kV interface. Representative values include:

- Aguirre (50300): [redacted] A
- Manatí (50200): [redacted] A
- 230/115 kV Transformer #1: [redacted] A
- Cambalache (51200): [redacted] A

Protection behavior aligned with the confirmed fault location. The unit differential protection ([redacted]) detected the high-voltage surge arrester failure and tripped [redacted] while the generator differential protection ([redacted] did not operate, confirming that the generator itself remained electrically healthy. The loss of approximately 338 MW from CS6 occurred while CS5 was already out of service, producing a system-wide frequency decline. The underfrequency load-shedding (UFLS) scheme operated at the 59.2 Hz and 58.6 Hz stages, stabilizing frequency at a minimum recorded value of 58.54 Hz and preventing broader system instability.

Figure 5-7: CS6 Genera's Side 230 kV Faulted Surge Arrester

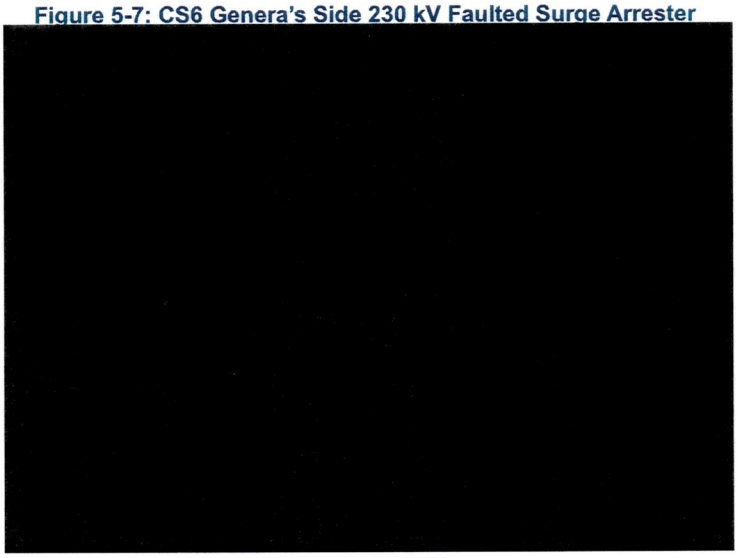
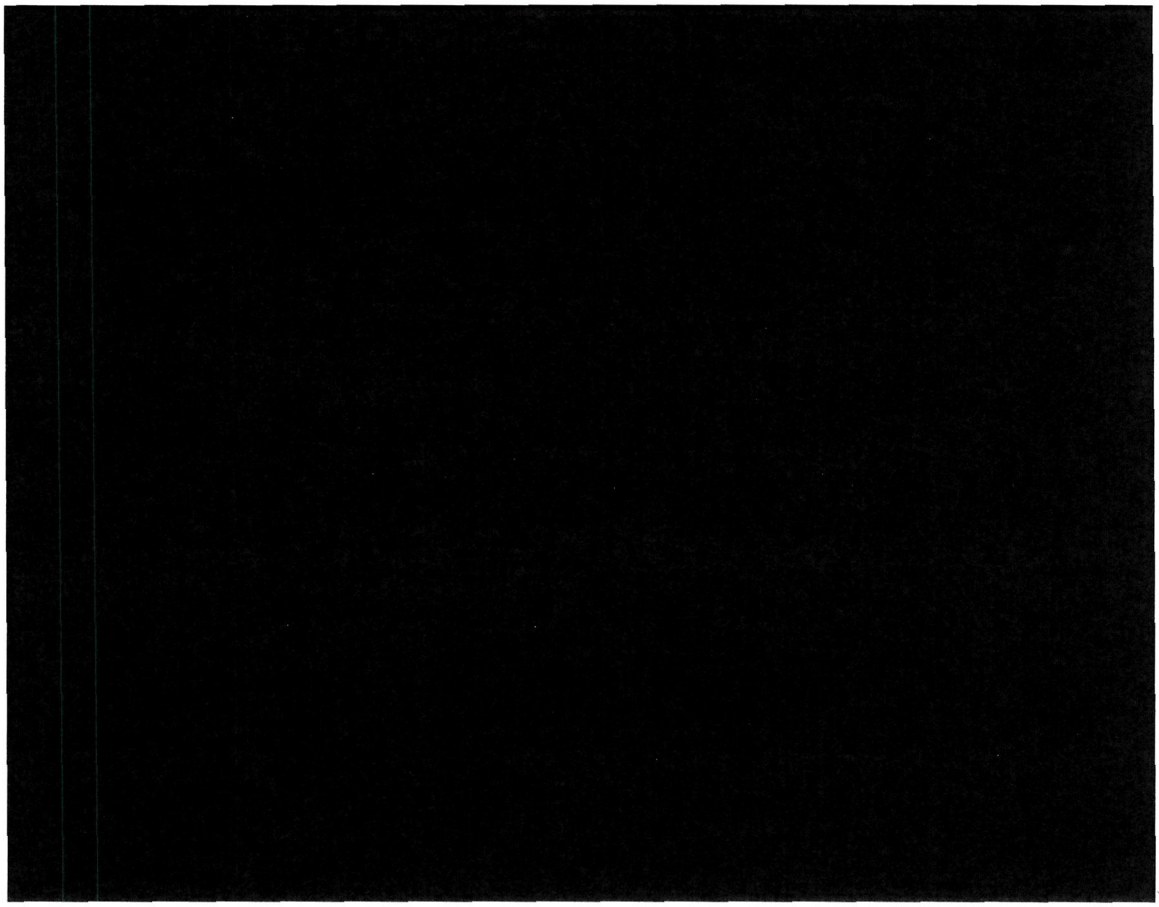


Figure 5-8: CS6 Fault - 230 kV Side with L50400 Open and UFLS Event



5.2.1.1 CS6 Behavior at 24 kV with 230 kV CB# [redacted] Open – CS6 Isolated from the System

The generator's contribution to the 230 kV phase-C fault measured at the [redacted]V terminals was [redacted]. The unit differential protection ([redacted]) cleared the fault in approximately 0.08 seconds. Once [redacted] opened, CS6 began its natural de-energization sequence. During this rundown, the [redacted] current, which had not contributed fault current, momentarily showed no measurable current for approximately 0.31 seconds, while [redacted] followed the expected deceleration profile.

After this interval, the generator currents stabilized at [redacted]. The brief loss of phase-B current occurred after [redacted] opened and cannot be attributed to the 230 kV fault. This condition must be reviewed by Genera, since the behavior appears in both the [redacted] event provided by Genera and the DFR recording for the CS6. Both devices measuring channels are connected to the 24 kV. See figures 5-9 and 5-10.

Figure 5-9: DFR record of 24 kV side [redacted] of CS6 lost current at [redacted] after [redacted] opened

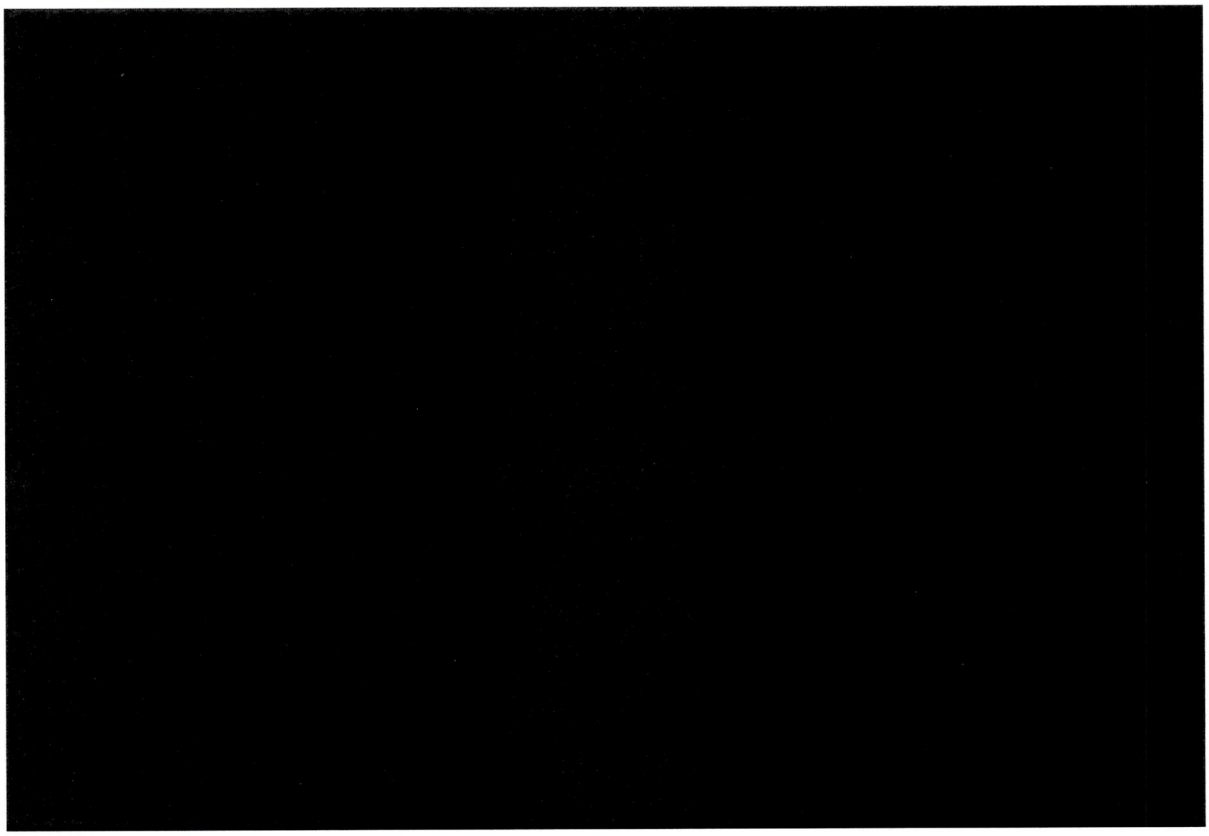
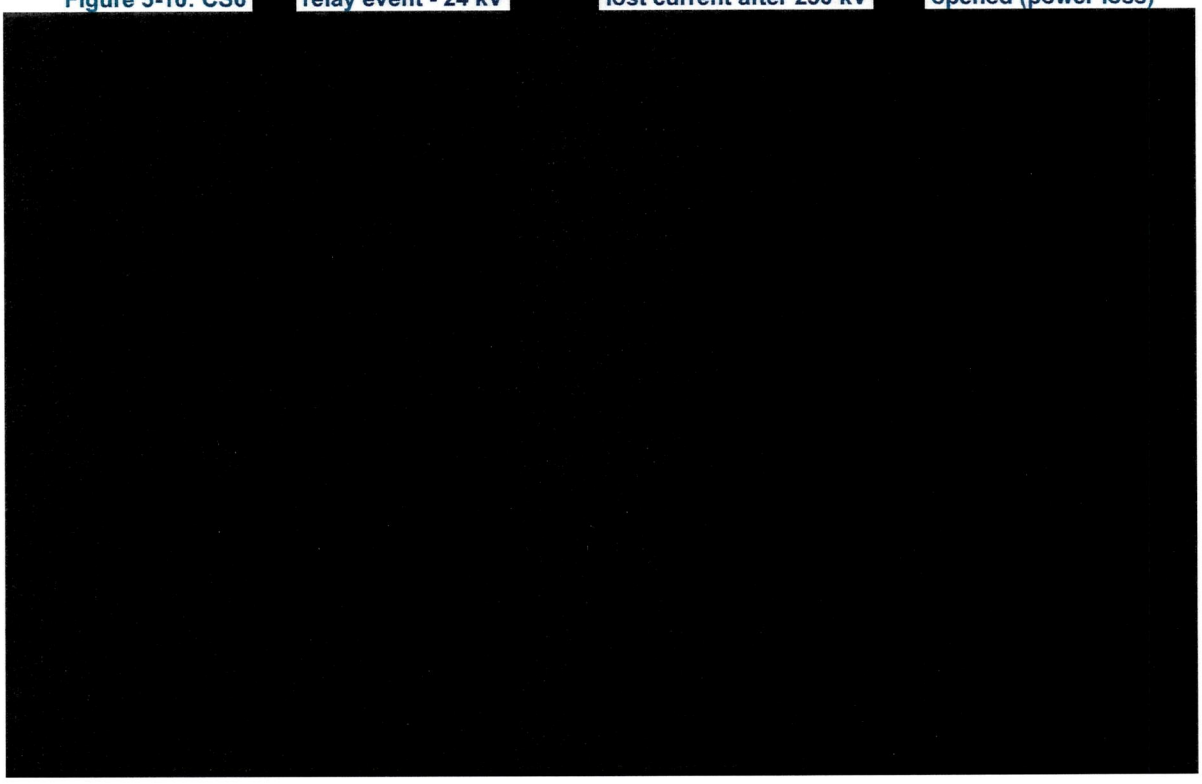


Figure 5-10: CS6 [redacted] relay event - 24 kV [redacted] lost current after 230 kV [redacted] opened (power loss)



5.2.2 Relay Behavior on L50400 – Induced CT Currents with Breakers Open

When the 230 kV surge-arrester failure occurred at the grounded high-side of the CS6 step-up transformer on the Genera side, Line 50400 had already been removed from service for 16 seconds due to an earlier and unrelated surge-arrester failure at the Costa Sur terminal of Line 50400. These two failures involved different surge arresters on different equipment operated by different entities. They were independent events with no operational or electrical connection.

At the time of the CS6 fault, Line 50400 was fully de-energized, with circuit breakers [redacted] at Costa Sur and [redacted] at Mayagüez open. The digital fault recorder in Figure 5-9 confirms that [redacted] at both terminals registered zero current throughout the duration of the CS6 surge-arrester failure, demonstrating that Line 50400 was electrically inactive and not involved in the Genera-side fault.

Despite the absence of primary current on the line, the differential protection associated with Line 50400 operated. This behavior aligns with a well-recognized phenomenon in high-voltage substations, where high-energy external faults induce CT secondary currents into adjacent circuits through CT cross-coupling. The CS6 surge-arrester failure produced a rapid rise in ground potential and substantial short-circuit current within the Costa Sur switchyard. Under such conditions, ground-return currents may propagate through the grounding grid, buried conductors, bonding meshes, cable raceways, and structural steel. Costa Sur has previously documented grounding-grid performance issues, and remediation is ongoing; these conditions influence how fault-related currents couple into nearby CT circuits.

Relay event records shown in Figures 5-11 and 5-12 confirm that all relay-monitored breaker inputs associated with Line 50400 were in their open state during the CS6 surge-arrester failure. At the Costa Sur terminal, relay inputs [redacted] (breaker [redacted]) and [redacted] (breaker [redacted]) both indicated [redacted] open. At the Mayagüez terminal, relay inputs [redacted] (breaker 50480) and [redacted] (breaker [redacted] likewise indicated [redacted] open. These relay records also show the induced CT secondary currents arriving at the protection system. Because differential protection compares currents at both terminals, the discrepancy between the zero current measured at Mayagüez and the induced current detected at Costa Sur caused the instantaneous differential element to operate. This operation was driven by the external CS6 surge arrester fault and did not reflect any fault condition on Line 50400.

Post-event inspections at Costa Sur did not identify any new grounding anomalies beyond those previously documented and already under remediation. The relay actions were consistent with induced CT secondary currents generated through CT cross-coupling during a high-energy external fault.

In summary, Line 50400 was electrically isolated before the CS6 surge-arrester failure occurred, with breakers [redacted] and [redacted] open and relay inputs [redacted] and [redacted] at both terminals confirming the open status. DFR recordings verified zero current on all phases, and relay event data demonstrated induced CT secondary currents leading to the differential trip. The protection operation resulted exclusively from the external surge-arrester failure at the CS6 transformer high-side terminal and not from any condition associated with Line 50400 or its earlier, separate surge-arrester failure.

Figure 5-11:Costa Sur [redacted] Relay Trip with CBs [redacted] Already Open

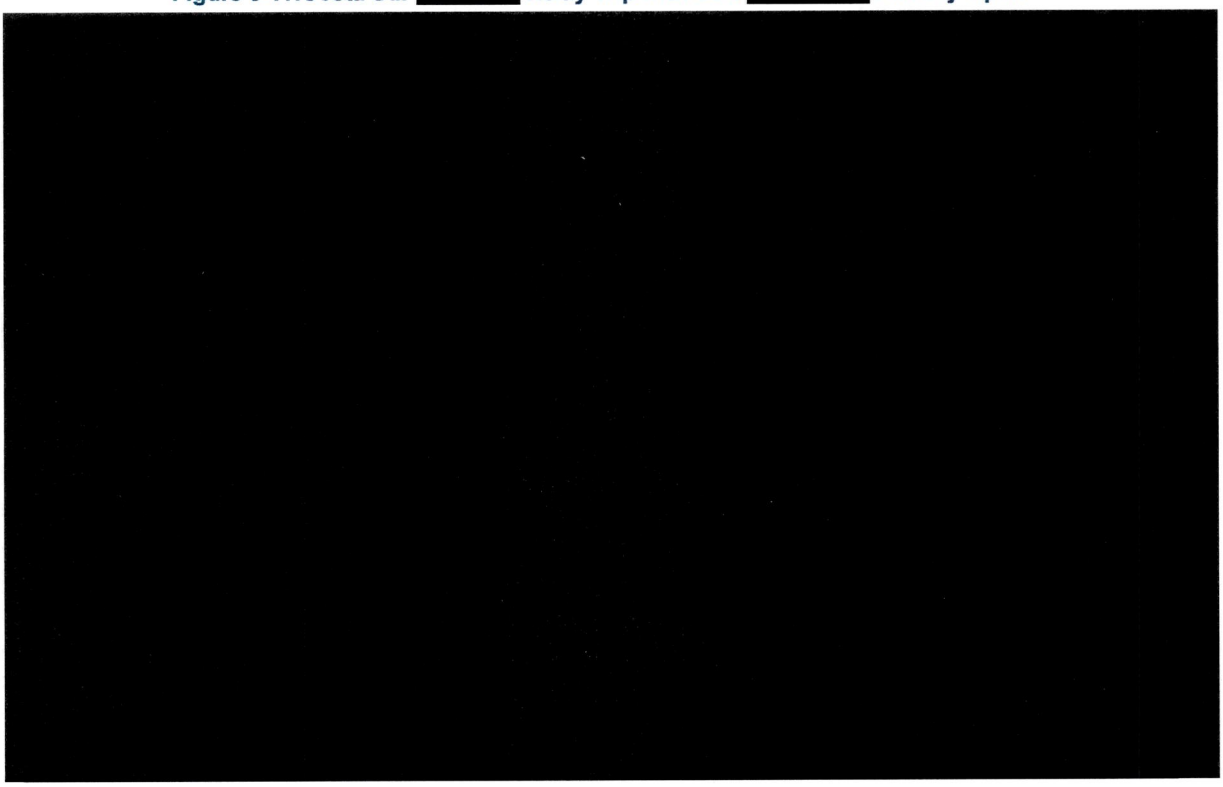
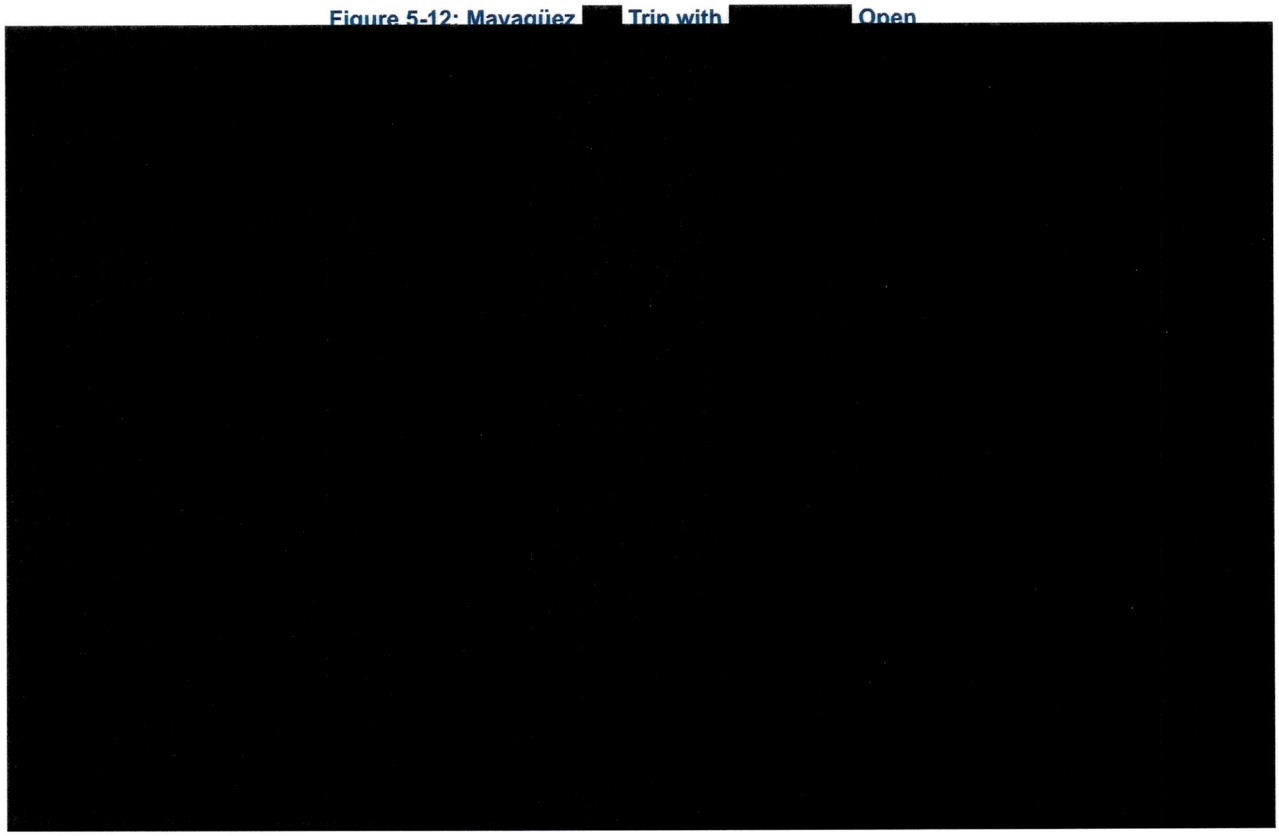


Figure 5-12: Mayagüez [redacted] Trip with [redacted] Open



5.3 Unauthorized Switching Actions - CBs [redacted] and [redacted] at Costa Sur

Because LUMA does not have remote operational control of transmission breakers located inside Genera-operated facilities, all switching activities at these locations require prior TOC authorization and proper documentation. During the July 16 event, TOC had SCADA visibility only of the closing of [redacted] and received no indication or notification regarding the opening or subsequent closing of [redacted] These actions were discovered only during post-event analysis when it became apparent that power flow through the [redacted] had fallen to zero. At the time of the event, the [redacted] at Costa Sur was the only active transmission path supplying the 115 kV system from the 230 kV generation source. During field verification conducted on July 24, LUMA crews confirmed that no log entries existed in the plant logbook for either [redacted] or [redacted] for the July 16 disturbance. Protection systems were reviewed and confirmed not to have operated; most notably, the 115 kV transformer low-side [redacted] remained closed throughout the event. This establishes that the loss of transformer power flow resulted from a strictly manual operator action performed without TOC authorization. The most technically consistent explanation is that the operator attempted to carry out the generator post-trip lockout procedure on [redacted] to prevent inadvertent reclosing and motoring of the generator, but the process appears to have been applied to [redacted] which is not a generator breaker.

Following the trip of CS6, the sudden loss of 338 MW placed the island system in the *In Extremis* (severe emergency) operational state due to underfrequency condition. As an isolated electrical system with limited inertia and no external interconnections, Puerto Rico is uniquely vulnerable to cascading collapse when large generating units trip. The system was not in a balanced state; it was actively struggling toward recovery, and automatic underfrequency load shedding was operating during the period in which [redacted] was manipulated. Approximately 13 seconds after the generator trip, DFR recordings show system indicators trending toward stabilization, with the following measurements:

- 230 kV PT – 131 kV
- System frequency – 58.62 Hz
- L51100 – 1,400 A.
- [redacted] – 550 A
- L36900 – 151 A
- L37100 – 430 A
- L50300 – 96 A
- L50200 – 395 A

At 20:15:34.7, approximately 12.67 seconds after the CS6 trip, [redacted] was opened by the Genera operator. Because [redacted] was already open due to the earlier protection operation on Line 50400, opening [redacted] interrupted the only remaining transmission path from the 230 kV source to the 115 kV system through [redacted] causing its power output to fall to zero. [redacted]

At 20:18:30.17, [redacted] was manually closed, restoring transformer power flow. A brief inrush current was recorded, followed by normal stabilization. Figures 5-12 and 5-13 illustrate the interruption and restoration sequence, including the corresponding load shift observed on the 115 kV Line 36900. At

20:18:34.27, [redacted] was closed, energizing Line 50400. The re-energization did not result in any protection operation because the fault condition on Line 50400 was not permanent.

Although the unauthorized switching actions did not produce additional disturbances under the specific conditions of July 16, they represent a serious deviation from established operational protocols with significant risk implications for an islanded grid.

Historical blackout events in Puerto Rico have originated from disturbances at Costa Sur during periods of high generation output. On this occasion, Costa Sur was generating at reduced levels, and underfrequency load shedding was already mitigating system instability. Under different circumstances—such as higher output at Costa Sur, greater system loading, or a sustained fault on Line 50400—the operator-initiated interruption of transformer power flow, or its subsequent re-energization, could have imposed higher electrical stress on transmission equipment and substantially increased the likelihood of cascading system instability or widespread outage. These considerations are essential for regulatory review, as they underscore the systemic risks associated with unauthorized manual switching during critical events within an islanded, vulnerability-prone electrical system.

Figure 5-13: [redacted] Transformer circuit breaker [redacted] Opened and Closed by Genera

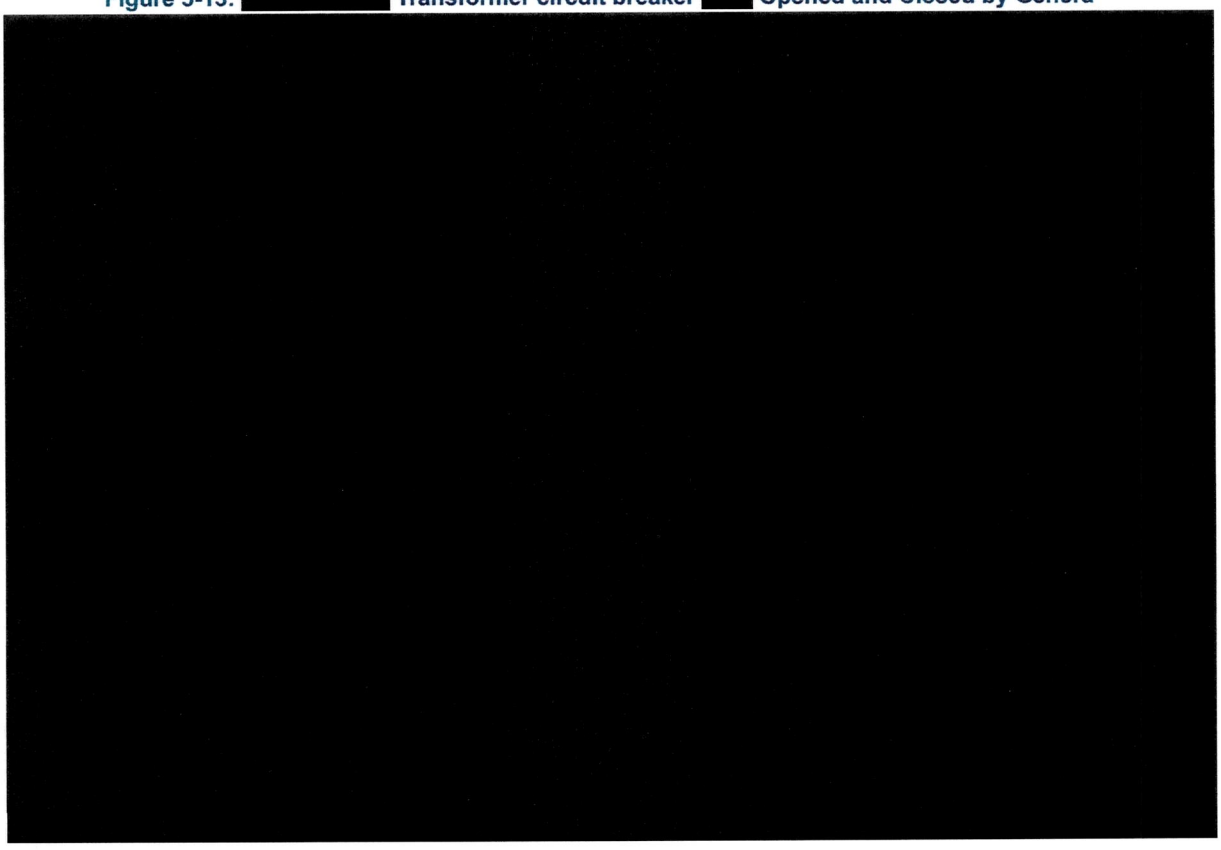
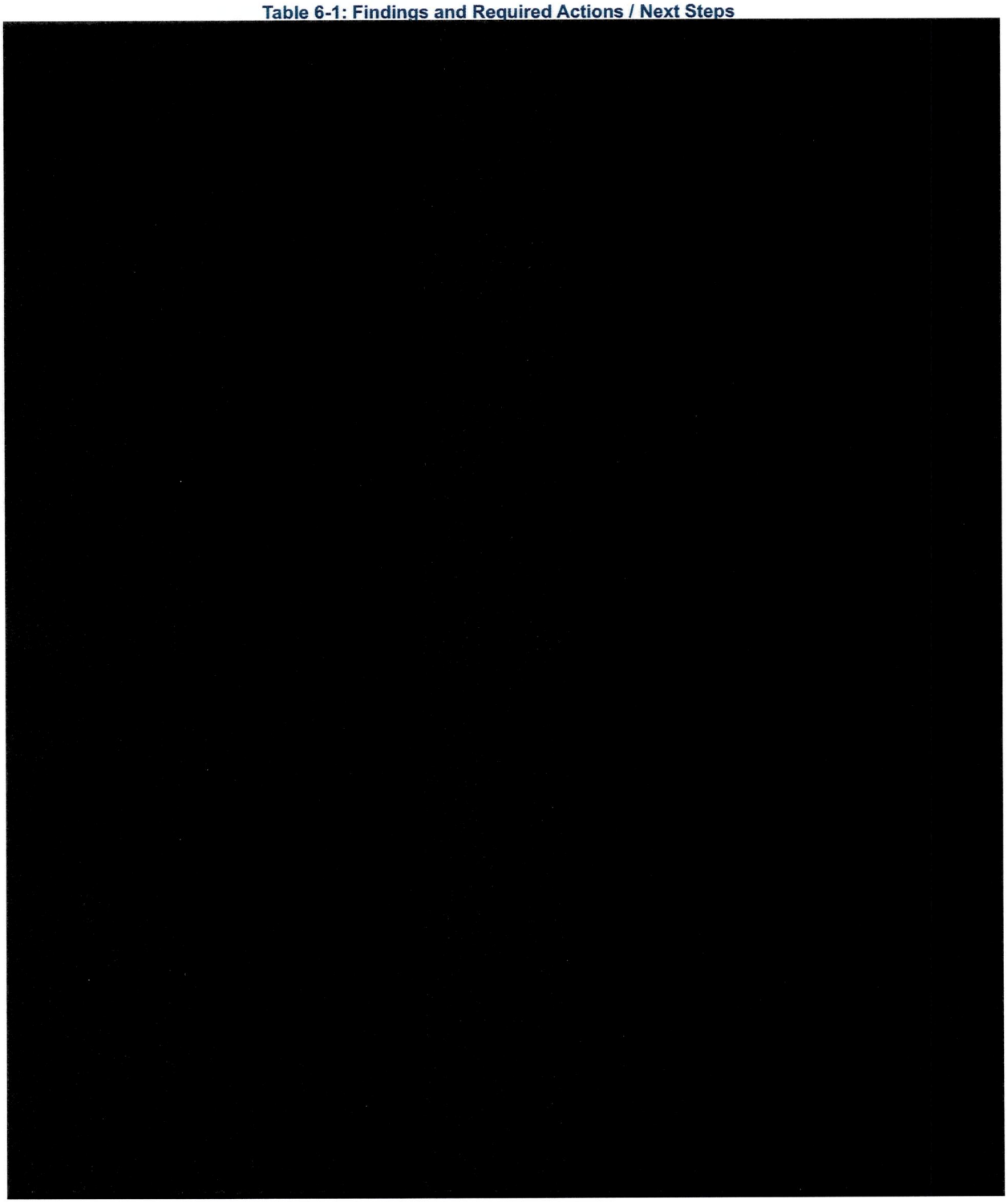


Figure 5-14: SCADA measurements during Costa Sur [redacted] de-energization by Genera

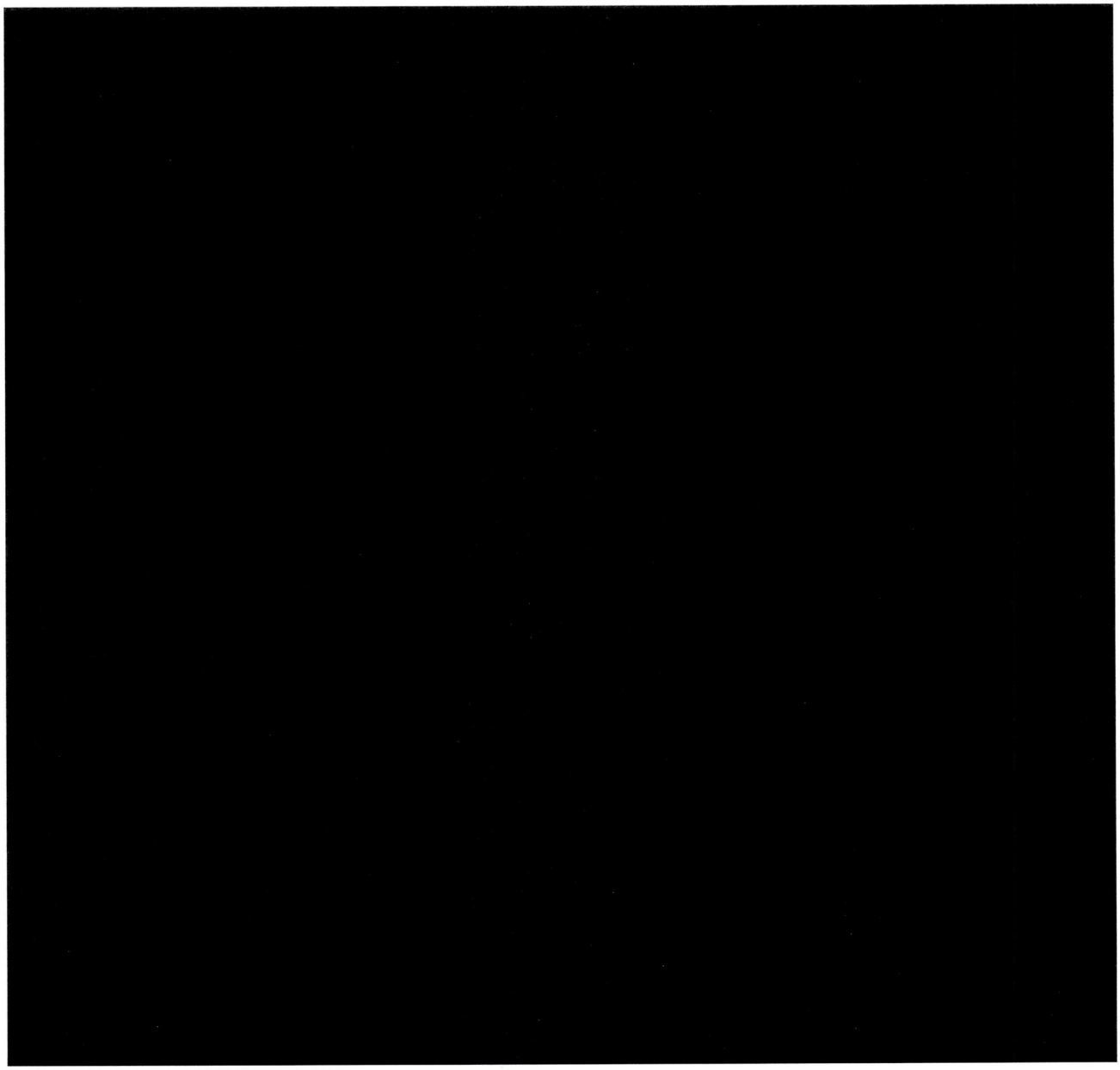
6 Findings and Next Steps

Table 6-1: Findings and Required Actions / Next Steps



Num.	Finding	Required Action / Next Steps
[redacted]		

7 Root Cause



8 Conclusion

[redacted]