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

IN RE: INTERRUPCIÓN DE SERVICIO ELÉCTRICO DE 6 DE ABRIL DE 2022

CASE NO. NEPR-IN-2022-0002

SUBJECT:

Submission in Compliance with Request for Information on April 6th Incident

MOTION SUBMITTING PRELIMINARY REPORT ON APRIL 6TH INCIDENT

TO THE HONORABLE PUERTO RICO ENERGY BUREAU:

COME now **LUMA Energy, LLC** ("ManagementCo") and **LUMA Energy ServCo, LLC** ("ServCo") (jointly referred to as the "Operator" or "LUMA"), and respectfully state and request the following:

1. On April 6th 2022, a failure in the electric system led to a fire at the Costa Sur transmission substation, which resulted in a power outage of the entire electrical system (hereinafter, the "April 6th Incident").

2. On April 8th 2022, this Honorable Puerto Rico Energy Bureau ("Energy Bureau") issued a Resolution and Order whereby it initiated a confidential investigation of the April 6th Incident ("April 8th Order").

3. The April 8th Order instructs LUMA to submit on or before April 12th, 2022, at noon, a preliminary report on the causes of the April 6th Incident and the corrective actions taken by LUMA (the "Preliminary Report").

4. Further, the April 8th Order instructs LUMA to submit on or before April 18th 2022, at noon, a final report on the April 6th Incident with the following information (the "Final Report"):

i. a summary of the incident including, but not limited to, a chronological description of the events and their effect, if any, on the Puerto Rico Electric Power Authority's ("PREPA") generation fleet, other energy producers, and the transmission and distribution system, as well as investigative, corrective, or other actions taken by LUMA and PREPA;

ii. any information received, obtained, or gathered in the course of investigative, corrective, or other efforts undertaken by LUMA and/or PREPA, its agents, attorneys, or consultants to determine the cause of the incident and its effect, if any, on PREPA's generation fleet and the transmission and distribution system;

iii. Any document produced, prepared, or received by LUMA and/or PREPA, its agents, attorneys, or consultants in the course of investigative, corrective, or any other efforts undertaken to determine the cause of the incident including, but not limited to, the root cause report of the incident and its effect, if any, on PREPA's generation fleet and the transmission and distribution system;

iv. Repercussions, consequences, or effects that clients and the electricity system will face in the short or long term because of the incident; and

v. Any information, in digital or tangible format regarding the incident in possession of LUMA and/or PREPA, which includes, but is not limited to, data, graphs, maps, videos, audios, photos, reports, or documents related to

the Incident and its effect on the electric service, the generation fleet, and the electricity transmission and distribution system of Puerto Rico.

5. Earlier today, LUMA filed a *Request for a Brief Extension of Time to Comply with April 8th Resolution and Order on April 6th Incident Investigation*. Therein, LUMA requested the Energy Bureau a brief extension until the end of the day today to submit the Preliminary Report in compliance with the April 8th Order.

6. In compliance with the April 8th Order, and to be transparent with its customers and regulators about its operations, LUMA hereby submits the Preliminary Report of the April 6th Incident. *See* Exhibit 1. The Preliminary Report includes the information that LUMA has gathered thus far and preliminary findings and assessments of the April 6th Incident. By Sunday, April 10th, 2022, at 3:00 p.m., because of its utility workers' hard work and professionalism, LUMA, working in conjunction with PREPA, had restored power to nearly all customers – or ninety-nine percent (99%) of the total customers affected by the outage.

7. The Preliminary Report filed as Exhibit 1 to this Motion, includes the following:

i. Summary Information on the April 6th Incident;

ii. Incident chronology;

iii. Investigation;

iv. Damaged Equipment; and

v. Summary of Completed Actions and Next Steps.

8. Large-scale events like the April 6th Incident are uncommon. The significant outage event deeply frustrated and impacted many of LUMA's customers. LUMA, in its role as the operator of the transmission and distribution system, believes it is critical that a transparent and

scientific investigatory process is followed to protect the integrity of the analysis and credibility of any conclusions. Multiple steps need to occur as part of this investigatory process in order to understand the event in its entirety and reduce the probability of such events occurring in the future.

9. As detailed in the filing, LUMA is conducting a thorough investigation of the April 6th Incident, including an independent forensic review of the failed equipment. To this end, is engaging the National Electric Energy Testing, Research & Applications Center ("NEETRAC") for a forensic assessment of the defective equipment and the equipment manufacturer to support the investigation. The preliminary analysis points to the failure of a circuit breaker in the 230 kV switchyard at the Costa Sur transmission substation. It is respectfully submitted that, given the nature of the April 6th Incident, LUMA is still in the process of collecting data from multiple internal and external sources that require verification. Therefore, LUMA wishes to note that the information presented in the Preliminary Report is subject to change as additional details become available. Since the April 6th Incident, LUMA has focused diligently on safety, restoring service to customers, restoring system stability, and assuring the continuation of service within operating parameters.

WHEREFORE, LUMA respectfully requests that the Energy Bureau **take notice** of the aforementioned and **accept** the Preliminary Report of the April 6th Incident that is being filed as Exhibit 1 to this Motion.

RESPECTFULLY SUBMITTED.

We hereby certify that we filed this motion using the electronic filing system of this Energy Bureau and that we will send an electronic copy of this motion to the attorney for PREPA, Bolaños-Lugo, kbolanos@diazvaz.law.

In San Juan, Puerto Rico, this 12th day of April 2022.

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Exhibit 1
Incident Preliminary Report

Costa Sur Substation Initial Facts from April 6, 2022 Incident

In the interests of protecting the electric infrastructure of Puerto Rico, portions of this document are protected from disclosure as Critical Energy Infrastructure Information ("CEII"), in accordance with 6 U.S.C. §§671-674; ;18 C.F.R. §388.113 (2020), and pursuant to the Puerto Rico Energy Bureau's Policy on Management of Confidential Information, CEPR-MI-2016-0009, issued on August 31, 2016, as amended by the Resolution dated September 16, 2016.

VERSION HISTORY:

Version	Date	Description
0.0	4/12/2022	Preliminary Report

Incident Summary

Name: 06APR2022 Major Outage Event –
Costa Sur Substation's 230 kV Circuit Breaker Failure

Date: April 06, 2022

Time: 20:42

Location: Costa Sur Substation – 230 kV Switchyard

Description: Oil-circuit breaker number 0082 failed at closing during an attempt to connect Costa Sur Steam Plant's Unit #5 to the grid. The fault was cleared by the protective relaying system. A series of faults, caused by the subsequent ball of burning oil and flying debris, were cleared in the initial eight (8) seconds of the event. The disconnection of the generation at Costa Sur SP and EcoEléctrica triggered a complete system collapse. The island lost power 19 seconds after the initial fault was recorded.

Resumen Del Evento

Nombre: Evento Mayor del 06ABR2022 –
Fallo de interruptor en el patio de 230 kV en Costa Sur

Fecha: 06 de abril de 2022

Hora: 20:42

Localización: Subestación de Costa Sur - Patio Interruptores 230 kV

Descripción: Durante la conexión a la red eléctrica de la unidad de generación número 5 en la planta de generación de Costa Sur, el interruptor de aceite número 0082 falló en la operación de cierre. La falta original fue despejada por el sistema de relés de protección. La consecuente nube de aceite en llamas y los pedazos de material despedidos por el fallo ocasionaron una serie de faltas durante los ocho (8) segundos iniciales del evento. La desconexión de las plantas de Costa Sur y EcoEléctrica fue seguida por un colapso del sistema eléctrico de Puerto Rico. La isla sufrió un apagón general 19 segundos después de la falta inicial.

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List of Acronyms

- Circuit Switch Disconnects (CS)
- Costa Sur Steam Plant (SP)
- National Electric Energy Testing, Research & Applications Center (NEETRAC)
- Oil-Circuit Breaker (OCB)

1.0 Introduction

On the evening of Wednesday, April 6th, 2022, Puerto Rico's electric system suffered an island-wide blackout that left hundreds of thousands of people without power for several days. While the root cause is not known at this time and is still being investigated, the catastrophic failure of a circuit breaker and fault in the 230 kV switchyard at the Costa Sur Substation led to subsequent cascading series of outage events which impacted the entire island.

While uncommon, when large-scale events like this occur, LUMA, in its role as the operator of the transmission and distribution system, believes it is critical that a transparent and scientific investigatory process is followed to protect the integrity of the analysis and credibility of any conclusions. Multiple steps need to occur as part of this investigatory process in order to understand the event in its entirety to reduce the probability of such events occurring in the future. This investigative process must be undertaken without compromising safety and within the practical limitations posed by the nature of the incident and its aftereffects. Understandably, these factors will shape and affect the collection of evidence. In addition, as part of this investigation process, information will be collected from various sources in addition to the site. LUMA and independent parties will analyze all of the evidence to the fullest extent possible in an effort to determine the root cause(s) and formulate future corrective actions.

Conducting a rigorous investigation, and adopting corrective actions, is especially important given the fragility of the entire electric system. To help address the fragile nature of the electric grid, and to help prevent such events in the future, it is more important than ever that all parties – LUMA and PREPA - work together, and with a sense of urgency, collaboration and partnership if we are to effectively repair, rebuild, and strengthen all critical aspects of the electric grid.

With respect to this investigation, this is only the initial phase of a multiphase approach. LUMA is still in the process of collecting various pieces of data from multiple internal and external sources that require verification. While the information presented in this report is preliminary and subject to revision as additional details become available, we are committed to being fully transparent with our regulators, the government, and our customers about findings as the investigation is completed.

Event Summary

At 20:42 on Wednesday, April 6th, 2022, a fault occurred in the 230 kV switchyard of the Costa Sur Substation. Phase B of Oil-Circuit Breaker (OCB) #0082 suffered a catastrophic failure.

OCB #0082 connects to Costa Sur Steam Plant (SP) Generation Unit #5. While synchronizing Unit #5 to the grid and during the circuit breaker's closing operation, the circuit breaker experienced a failure followed by a ball of fire and flying debris that damaged Bus #6. The failure affected three adjacent circuit breakers and several portions of the substation's lattice structures.

Due to the circuit breaker's failure, the 230 kV circuits at Costa Sur Substation needed to open to clear the fault, which disconnected EcoEléctrica from the grid and resulted in subsequent outage events that cascaded into a full blackout of Puerto Rico's electrical system.

By 03:00 on Sunday, April 10th, 99% of customers impacted by this event had been restored.

Preliminary Findings

This preliminary report for the Puerto Rico Energy Bureau includes the findings to date.

Preventing future large-scale outages demands a clear and transparent explanation of the causes that contribute to such events. LUMA has prioritized the analysis of this event and is actively working to determine the root cause(s) and the improvement(s) needed to mitigate similar incidents from occurring in the future including any identified corrective short- and long-term actions.

We understand that any electrical outage no matter its magnitude or reason is very frustrating for our customers. The event which began on April 6th was especially impactful on our customers and all of us at LUMA, working with PREPA, are determined to conduct a thorough investigation to minimize the risk of such events in the future. In addition, LUMA is committed to not only being transparent about the causes of such events, but to working together with PREPA and other partners to take the necessary actions to build an energy system that our 1.5 million customers can rely on.

Figure 1-1 Photo of Damaged Oil-Circuit Breaker #0082

2.0 Summary of Customers Restored

Table 2-1 below summarizes the number of customers restored after the incident.

Table 2-1 Estimated Number of Customers Restored

Time, Date	Customers Restored	Percent Restored
21:00, Thursday, April 7	348,939	23.8%
21:00, Friday, April 8	798,912	54.4%
21:00, Saturday, April 9	1,218,691	83.5%
00:00, Sunday, April 10	1,386,294	95%
03:00, Sunday, April 10	1,452,397	99%

3.0 Investigation of Power System's Outage

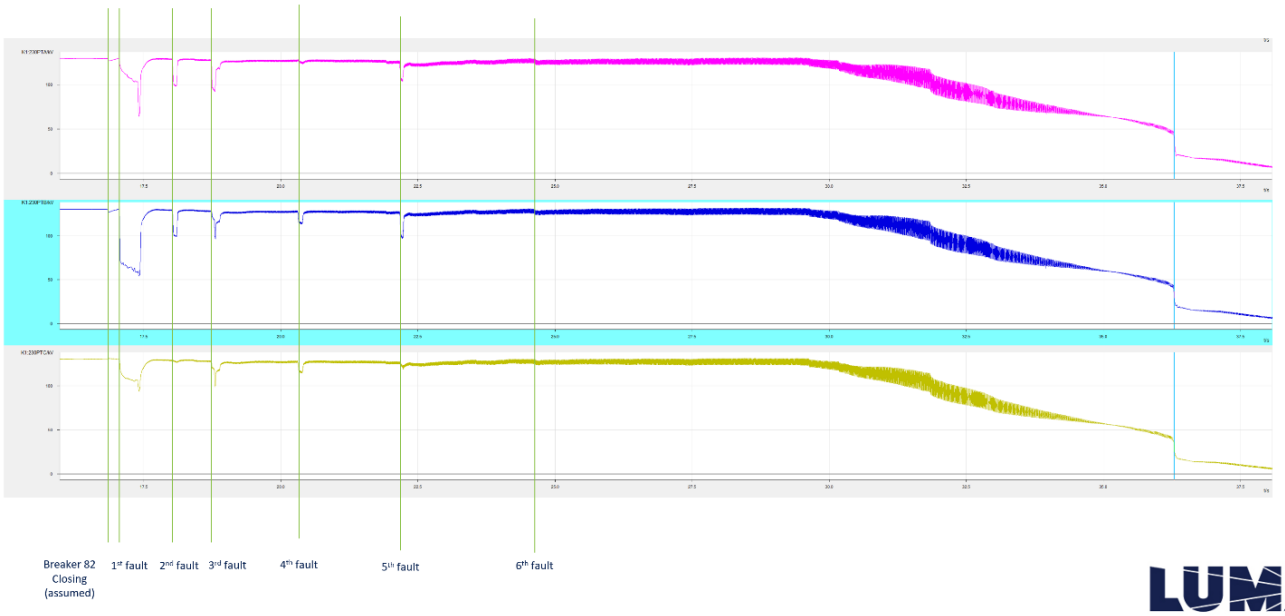
3.1 Operations Timeline

The following timeline details the system's collapse. The information is subject to revision once all available records are collected and studied. Due to different time sources, some items may be revised.

Figure 3-1 Sequence of Events up to Fault 6 from Manatí FR-COM_5

Event	Time	Elapsed ms
Event start	20:42:56.840	
B-phase fault	20:42:57.052	212
AB fault	20:42:57.389	549
Fault clearing	20:42:57.431	591
2nd AB fault	20:42:58.024	1,184
2nd AB fault clearing	20:42:58.103	1,263
3rd C-phase fault	20:42:58.732	1,892
3rd C-phase fault clearing	20:42:58.797	1,957
Power swing occurring		
4th C-phase fault	20:43:00.306	3,466
4th C-phase fault cleared	20:43:00.397	3,557
5th AB fault	20:43:02.166	5,326
5th AB fault cleared	20:43:02.223	5,383
6th fault event (not sure if a fault)	20:43:04.635	7,795
6th fault event cleared	20:43:04.723	7,883
System collapsed	20:43:16.301	19,461

Figure 3-2 230 kV System Voltage Readings as seen by Manatí TC's Transient Recorder



3.2 Circuit Breaker Failure at Costa Sur Substation

OCB #0082 connects Costa Sur SP's Generation Unit #5. During a closing operation, while synchronizing Unit #5 to the grid, the circuit breaker experienced a catastrophic failure. Previously during the day, PREPA reported reset problems with the unit turbine's MARK VI control systems. Later, PREPA advised that the problems had been repaired.

Given the current preliminary status of the investigation, it is not confirmed yet if:

- The circuit breaker closed out of synchronization,
- An additional fault in the electrical system at Costa Sur SP occurred,
- The circuit breaker experienced a mechanical problem, or
- A combination of these.

From the videos recorded by the security cameras, evidence of a ground fault prior to the failure is apparent. As of this moment, the source of this fault has not been identified. The Bureau of Alcohol, Tobacco and Firearms and Explosives (ATF) indicated evidence of arcing from the poles to the circuit breaker's tank on #0082.

Figure 3-3 Security Cameras' Screenshots Showing Arcing Immediately Before the Failure

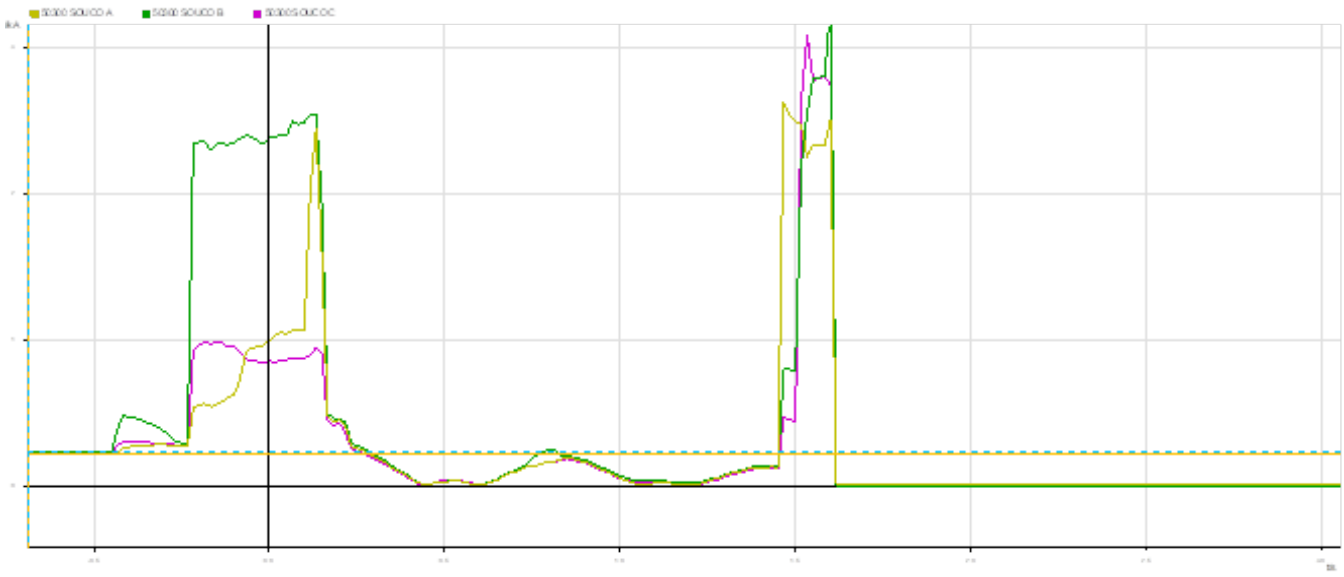
With respect to the issue of maintenance, PREPA maintenance records for OCB #0082 indicate the maintenance was current and had been serviced in March 2020. The recommendation from PREPA on the last report was to place the circuit breaker into service and the next breaker maintenance was planned for 2023, per industry standards. Since June 2021, LUMA Maintenance crews have completed 17 maintenance actions at the Costa Sur switchyards.

To better understand the causes of the April 6th outage, the National Electric Energy Testing, Research & Applications Center (NEETRAC) is being engaged for a forensic assessment of the circuit breaker, and the equipment manufacturer to support the investigation, as well as a third-party outage investigation company will be retained to oversee the process.

Based on available data, the failure of the circuit breaker started after the closing of the circuit breaker. As seen in the figure below, the B-phase current showed a higher current compared to A's and C's phase currents. After approximately 230 milliseconds (ms), the current increased drastically and it can be assumed this was the moment when the circuit breaker B's phase failure occurred. This fault event lasted for about 400 ms.

About 1.7 seconds (s) after the failure happened, a second fault was visible in the recorded data and lasted for approximately 160 ms. More events occurred during this time period and detailed data is needed to confirm the sequence of events.

Figure 3-4 230 kV Current Readings in Line 50300 Aguirre-Costa Sur as seen by Aguirre Planta's Transient Recorder



The following relays at Costa Sur SP operated during the event:

- **Digital relays** for lines 50400, 50200, and 51100.
- **Electromechanical relays:**
  - Breaker failure - CHC 11A OCB #0074 Target 1
  - Breaker failure - CHC 11A OCB #0082 Target 1 and Target 2
  - Breaker failure - CHC 11B OCB #50220 Target 1
  - Bus differential protection - PVD 11C Bus #6.
- **Generator relays GEN 5:**
  - BDD-15 unit differential 87A, 87B, and 87C
  - Sam 11B circuit breakers #0082-0012 62G5
  - GGP-53B (reverse power) TIME Target.

3.3 Additional Faults at Costa Sur SP

Lines from Costa Sur to EcoEléctrica, Manatí, and Mayagüez opened on both ends. Pending verification as to how the failure affected those lines.

3.4 Systemwide Events

LUMA is collecting information and initiating an event analysis of the system's collapse. Currently, generation data continues to be gathered. Once such data is made available, additional conclusions about the event will be possible.

Other generators like San Juan's SP and Palo Seco's SP opened with lockout.

The frequency remained stable during the first phase of the event. The frequency began to drop and load-shedding events attempted to stabilize the system. Further frequency drop required additional load shedding, but no additional load was available for shedding. After no further load-shedding activities could be utilized, the system collapsed about 19.5 s after the event started with the failure of the B-phase of OCB #0082 at Costa Sur's SP.

4.0 Damaged Equipment

The failure of OCB #0082 damaged the structure of Bus #6 and three additional circuit breakers.

The failure of OCB #0082 caused structural damages to Bus #6 and contaminated the support structures and high-voltage equipment to the left and right sides of the failure. The burning oil spill reached beyond the substation's fence, as seen in the front of the picture below.

Figure 4-1 Evidence of Burned Oil Reaching Beyond Substation's Fence

Costa Sur SP's 230 kV switchyard has a circuit breaker and a half configuration with five bays that include four gas circuit breakers and 11 oil circuit breakers circa 1969-1976.

LUMA has already begun a project to repair key portions of the substation in the near term. Tables 4-1, 4-2 and 4-3 indicate on a preliminary basis the series of actions that are being taken, including the equipment to be replaced, the equipment to be cleaned, and the equipment to be tested at the Costa Sur substation.

Table 4-1 Equipment to be Replaced

Item	How Many?	Spare Available?	Target Date
230 kV OCB #0082 (failed device)	1	Yes	06-10-2022
230 kV OCB #0074 (collateral damage)	1	Yes	06-10-2022
Potential transformers (synchronism) on Bay #6	2	Yes	04-14-2022
Potential transformers (bus bar)	3	Yes	06-10-2022
230 kV insulators	30 approximately	TBD	06-10-2022
230 kV gang-operated switches	12 approximately	TBD	06-10-2022
30' of copper bus bar with hardware (confirming measurements)	1	TBD	06-10-2022

Table 4-2 Equipment to be Cleaned

Item	Type of Cleaning	Target Date
Structural bay #6	Completely	06-10-2022
OCB #50320	In addition to complete maintenance procedure	06-10-2022
OCB #50220	In addition to complete maintenance procedure	06-10-2022

Table 4-3 Equipment to be Tested

Item	Type of test	Target Date
Bus bar #5	Megger, trip, and bus bar differential	04-08-2022
Ground grid	Resistivity test	04-10-2022
OCB #50320	Electrical and mechanical tests	06-10-2022
OCB #50220	Electrical and mechanical tests	06-10-2022

5.0 Completed Actions and Next Steps

LUMA continues to collect field data to determine the complete sequence of events and causes for each tripped circuit. LUMA is in contact with PREPA and other relevant parties including appropriate law enforcement agencies, to collect the data required to complete the analysis. It is premature to draw conclusions at this time regarding the root cause(s). The timeframe for a complete analysis of the collected data, including corrective actions and lessons learned, is anticipated to be approximately 30 to 45 days – or sooner if possible. The action items completed, as of April 10, 2022, are identified below.

5.1 Completed Steps: Costa Sur's Energization Plan

Figure 5-1 Single-line Diagram for 230 kV Switchyard at Costa Sur SP

CONFIDENTIAL, CRITICAL ENERGY INFRASTRUCTURE INFORMATION

Table 5-1 Completed Steps to Energize Costa Sur SP

Step	Details
1	• Clean affected structures from the oil spill and soot, which started the afternoon of Friday, April 8th. In parallel, open all circuit switch disconnects (CS) in Bay #5 (51120-0014-51320). Functionally test the circuit breakers in this bay. • Open all CS for OCB connected to Bus #5: #51220, #0086, #0084, and #54420. Test circuit breakers. Open OCB #0072 and its CS for testing. Open CS for OCB #0074. • Close CS and OCB #51320 to energize Bus #5 from Ponce TC via Line 51300. Close CS for OCB #0014 (A and B). Close OCB #0014. Energize #51100 to EcoEléctrica. • The EcoEléctrica energization is required to supply natural gas for Costa Sur's SP.
2	Test OCB #50420 and energize Line 50400 to Mayagüez.
3	Synchronization of potential transformers for Bank #1 and Generation Unit #5. Spares located and will be tested on Saturday, April 9th. After cleaning the structures is completed, the synchronization potential transformers will be replaced, OCB #0072 can energize the 230/115 kV Bank #1 at Costa Sur SP. The synchronization power transformer for generation Unit #5 will be replaced at the same time to mitigate future outages.
4	Test OCB #0086 and open CS for OCB #0022 and then Costa Sur Generation Unit #6 can be connected to the grid via Bus #5. After Unit #6's energization, EcoEléctrica will be able to connect to the grid as per the plan prepared by the Energy Control Center.
5	Lines 50300 to Aguirre and Line 50400 to Cambalache cleaned and energized on April 10th. Line 50200 to Manatí targeted for energization by April 11th. Circuit breaker switch being replaced.

Step 1 was completed by Friday evening, April 8th. Steps 2-5 were completed between Saturday, April 9th and early Monday, April 11th and included cleaning the structures required for the energization of the lines 50200, 50300, and 50400 plus Bank #1.

After the energization plan is complete, the remaining elements out of service will be OCB #0074, #0082, #50220, #50320, #0012, #0022, and #0032. Details for these elements are presented below in section 5.2.

5.2 Next Steps: Repairs and Restoration of Costa Sur SP

Removal of OCBs #0084 and #0074 initiates on Monday, April 11th. The environmental services company will empty the tanks in poles one and three of OCB #0084 and the tanks of OCB #0074 as the initial step with an estimated 10,000 gallons of oil being removed.

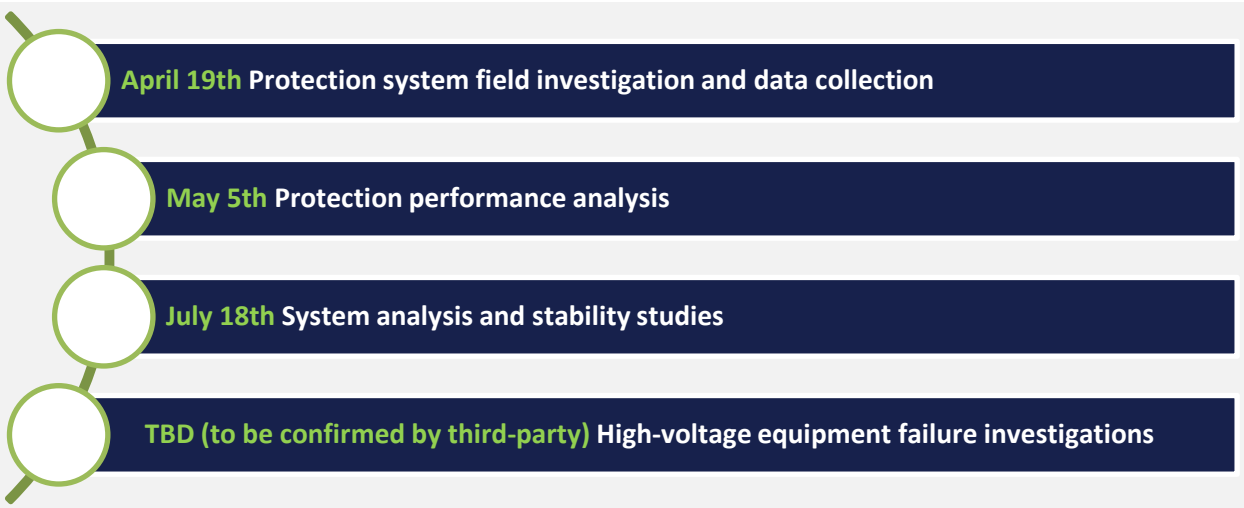
An engineering firm has provided the plan for the structural testing and engineering design for the reconstruction of the damaged bus and the replacement of OCBs #0082 and #0074.

5.3 Next Steps: Investigation Analysis

A detailed schedule has been developed with the studies required to complete a full-incident analysis. This schedule is contingent on the timely acquisition of all field data required, including PREPA and other generation plant data.

The current schedule consists of four (4) main milestones specified in Figure 5-2. The estimated schedule below assumes all data has been received from all parties including but not limited to LUMA, PREPA, and all generating plants. As stated, LUMA is committed to being fully transparent about the findings of the investigation, and to provide additional updates during each of phase of the investigation whenever possible.

Figure 5-2 Main Study Investigation Milestones with Dates



6.0 Summary

Since the April 6th outage event occurred, LUMA focused on safety, restoration of service to customers, and the electrical system's stability, including assuring the continuation of service within operating parameters. While a complete investigation will take time in order to process and review all relevant data, including expanding on the preliminary information provided in this document, LUMA is committed to completing this investigation as quickly as possible.

Currently, LUMA continues to collect all relevant data and analyze the situation to inform the investigation and continue with plans to rebuild and modernize the grid of Puerto Rico while working to prevent such incidents from occurring in the future.

When the investigation, including independent forensics analysis, is complete, LUMA is committed to being transparent with our customers and regulators about operations and the successes and challenges faced in delivering more reliable energy. LUMA will provide relevant data along with other information obtained resulting from its investigation of the incident.

LUMA will continue to communicate with the Energy Bureau with regard to the progress of the investigation.