CONFIDENTIAL

# Independent Engineering Report

## Costa Sur Steam Plant

Prepared for

Puerto Rico Electric Power Authority

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Final

October 8, 2021

Project 14495.001

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# ACRONYMS AND ABBREVIATIONS

| Acronym/Abbreviation | Definition/Clarification |
|---|---|
| 2017 Weston CERCLIS Volume I Report | Final Site Inspection Report Volume I of II (dated September 2017) for CERCLIS ID No.: PRD987376704 prepared by Roy F. Weston, Inc. |
| BFP | Boiler feedwater pump |
| Btu/kWh | British thermal unit per kilowatt hour |
| CAPEX | capital expenditures |
| Costa Sur | Costa Sur Steam Plant |
| CWA | Clean Water Act |
| EAF | Equivalent availability factor |
| ECHO | Enforcement and Compliance History Online [United States EPA] |
| EFOR | Equivalent forced outage rate |
| EMS | Energy management system |
| EPA | Environmental Protection Agency [United States] |
| EPCRA | Emergency Planning and Community Right to Know Act |
| EQB | Environmental Quality Board [Puerto Rico] |
| FD | Forced Draft |
| FY | Fiscal Year |
| GE | General Electric |
| GT | Gas turbine [operating on natural gas or No. 2 fuel oil] |
| gpm | Gallons per minute |
| HFO | Heavy fuel oil [No. 6 fuel oil, Bunker C fuel] |
| HP | High pressure |
| hp | Horse power |
| ID | Induced Draft |
| IP | Intermediate pressure |
| IRP | Integrated Resource Plan |
| klb/hr | Kilopounds per hour |
| kV | Kilovolt(s) |

| Acronym/Abbreviation | Definition/Clarification |
|---|---|
| kW \| kWh | Kilowatt(s) \| kilowatt hour(s) |
| MATS | Mercury and Air Toxics Standards |
| MCR | Maximum continuous rating |
| MW \| MWh | Megawatt \| megawatt hour(s) |
| NCF | Net capacity factor |
| NPDES | National Pollution Discharge Elimination System |
| O&M | Operations and Maintenance |
| Phase I ESA | Phase I Environmental Site Assessment |
| Plant | Costa Sur Steam Plant |
| PM | Particulate matter |
| PREPA | Puerto Rico Electric Power Authority |
| PRV | Pressure reducing valve |
| psig | Pounds per square inch, gage |
| RCRA | Resource Conservation Recovery Act |
| REC | Recognized Environmental Conditions |
| SPCC | Spill Prevention, Control, and Countermeasure |
| TRI | Toxic Release Inventory |

# EXECUTIVE SUMMARY

## OVERVIEW

The Puerto Rico Electric Power Authority (PREPA) is the electric power company responsible for generating, transmitting, and distributing electricity for the island of Puerto Rico. PREPA engaged Sargent & Lundy to perform an independent technical review of the Costa Sur Steam Plant ("Costa Sur" or the "Plant").

Costa Sur is located on the southern coast of Puerto Rico in Guayanilla and is owned and operated by PREPA. The Plant has two operational steam power generation units with a combined nameplate generation capacity of 820 megawatts (MW). There are four non-operational steam units that are no longer in service. Finally, there are two 21-MW black start capable gas turbine (GT) generators on site: GT #1.1 and GT #1.2.

On January 7, 2020, a 5.9 magnitude earthquake tripped Units 5 and 6. The earthquake greatly impacted the infrastructure of buildings and major equipment. Unit 5 returned to service on August 1, 2020 while Unit 6 was expected to return to service by the end of January 2021. As of October 2020, the Costa Sur station was at 35% capacity, and Unit 5 was experiencing a derate related to repairing the hydrogen cooler, which was expected to be resolved by the end of February 2021. The existing two black start capable GTs on site have been in a long-term outage and are currently being repaired. GT #1.1 is scheduled to be operable by November 2020 and the turbine for GT #1.2 has been replaced with a previously decommissioned turbine from the Central Hidro Gas Mayagüez Plant and is scheduled to be operable in early 2022.

This technical report includes an assessment of the plant design, operations and maintenance (O&M) activities, plant organization and personnel, technical performance, commercial arrangements and obligations, and provisions for environmental permitting. The review was based on information provided by PREPA and its advisors through January 2021 and onsite visits conducted in 2018 and 2020. Limited information was provided in August 2021 on the GT #1.2 replacement.

Sargent & Lundy understands that this review is being conducted in connection to the request for proposals (RFP) to manage, operate, maintain, asset manage, and decommission, as applicable, one or more of the base-load generation plants and gas turbine peaking plants located throughout the island of Puerto Rico, including Costa Sur.

## TECHNICAL REVIEW

Units 1 and 2 steam power generation units are retired[1] and were last operated in 2003. These units were commissioned in 1959 and 1960, respectively, and had a capacity of 50 MW each. These units are irreparable. Units 1 and 2 were declared decommissioned by PREPA's Governing Board and were expected to be demolished in 2021.

Units 3 and 4 were commissioned in 1962 and 1963, respectively. Each unit has a nameplate capacity of 85 MW. The units are no longer operated because they are unsafe for normal service. The boilers are tangentially-fired Combustion Engineering (“CE,” now General Electric [GE] Power) heavy fuel oil (HFO) boilers with an MCR rating of 487 klb/hr main steam flow at 1,550 psig and 1,000°F. Their GE steam turbines include an IP section designed for 1,000°F hot reheat steam. Condenser cooling uses once-through seawater cooling. The decommissioning plan for Units 3 and 4 are currently being evaluated by PREPA's Generation, Planning, and Finance Directorates. This decommissioning plan is expected to be presented to the Governing Board in 2021.

The two remaining operational steam Units, 5 and 6, are each rated at 410 MW; they began commercial operation in 1972 and 1973, respectively. Their boilers are tangentially-fired CE that were retrofitted in 2011 to burn natural gas but also still have the flexibility to burn a) a combination of natural gas and HFO or b) HFO only as originally designed. Fired with natural gas, they can meet their original maximum continuous rating (MCR) design conditions: 2,970 kilopounds per hour (klb/hr) main steam flow and outlet steam conditions of 2,620 psig[2] and 1,005°F. The boilers also have a reheat circuit designed to provide 2,371 klb/hr steam flow at 451 psig and 1,000°F to the intermediate pressure (IP) section of the GE turbines at the rated output of 410 MW.

Raw water is provided by four off-site PREPA wells and is used as the primary supply for the Plant’s water treating systems that generate demineralized water for the Plant’s steam cycle. Raw water backup is supplied from EcoEléctrica’s desalination plant. Either the primary or backup raw water source may be fed into the new mixed-bed demineralizer plant, which was installed in 2015. The new plant has three 400-gallons-per-minute (gpm) water treating trains that produce demineralized water for the facility. Units 5 and 6 have a combined daily average demineralized water makeup requirement of 300 gpm. The original 600-gpm mixed-bed demineralized water treatment plant is still functional and may be used as a backup. Seawater is used for the main condenser cooling system. The seawater is forwarded through once-through condensers for cooling by four 1,000-horsepower (hp) vertical circulating water pumps for Units 5 and 6. A

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[1] Removed from service and no longer considered for future generation
[2] Pounds per square inch, gage

single installed spare is available for the two units. The Units 5 and 6 electrical generators are 60-hertz General Electric 4C4W1 units rated for 24 kilovolts (kV) with continuous output ratings of 544 megavolt amperes at a power factor of 0.85. The electrical power is sent to three interconnected switchyards having operating voltages of 38 kV, 115 kV, and 230 kV.

In 2010, Foxboro completed a controls system upgrade on Units 5 and 6; additionally, GE completed an upgrade on the steam turbine controls to a Mark VI system.

In addition to the steam power generation units, two John Brown 21-MW GT generators were installed in 1972 and were being repaired. Each operates on No. 2 fuel oil and can be used for peaking operation or black start of the Costa Sur facility. They are owned, maintained, and operated by PREPA'S Hidro Power division. The GTs connect to the 115-kV switchyard. PREPA is also considering the replacement of these GTs with two new black-start GT generators, approximately 30 MW each. Each GT would be able to operate on natural gas or No. 2 fuel oil and will be designed for peaking operation or black start of the Costa Sur facility.

## EQUIPMENT CONDITION

Units 1 and 2 are retired and are no longer suitable for service. They have been abandoned in place. The two black start GTs at the Plant are in extended outages and are currently being repaired. Without these units available, the Plant does not currently have black start capability and must rely on external power for startup.

The boilers on Units 3 and 4 are at their end of life and are currently unsafe for normal operations. The boilers would require substantial investment to return pressure-containing parts to a condition for safe service. The Units 3 and 4 steam turbine generators and much of the balance-of-plant equipment and systems on the units may be salvageable but will require a thorough investigation to confirm remaining useful life. There are concerns because the exciters on both steam turbine generators are not operational, and the balance-of-plant equipment and systems have not been exercised or maintained for a significant period. Furthermore, the equipment has not been properly prepared for long-term storage. Units 3 and 4 have not been operated since 2016.

Unit 5 remained out of service for nearly seven months after the January 7, 2020 earthquake but is currently online and in operation; however, it is derated related to repairs of the hydrogen cooler, which was expected to be resolved by the end of February 2021. Unit 6 was scheduled to be online and back in service before the end of January 2021. The major impacts to the station caused by the earthquake were:

- Equipment was found misaligned

- Buckling on gusset plate connections
- Cracks on concrete pedestal of column and connections at various locations below the turbine deck
- Large storage tank foundation damage found at:
  - Demineralized Water Reserve Tank #1
  - Demineralized Water Tank #2
  - Raw Water Tank #3
- Various vertical/horizontal cracks on masonry walls throughout the Plant. Cracks below the turbine need to be further evaluated to determine their structural integrity.
- Concrete secondary containment was broken at piping sleeve section due to movement or vibration of piping.
- Insulation and refractory material compromised and broken down in various pipes, duct walls, conduits, and boiler walls.
- Damage to the main building.

In general, the condition of Units 5 and 6 is consistent with units of a comparable size and similar vintage. The Plant upgraded the Unit 5 and 6 plant and turbine control systems in 2010, and improvements are currently being made to the steam-cycle system for preventing water induction. Equipment is being replaced on these units and the Plant's common systems to improve reliability. Recent additions and/or replacements include the replacement of the demineralized water system, the addition of a new second natural gas pressure reducing station (for 2 x 100% redundancy) and rebuilds or repairs of the boiler feedwater pumps, condensate pumps, closed cooling water pumps and boiler circulating water pumps. Other systems that need modifications are the Unit 5 air dryers and boiler blowdown pumps and for both units the medium voltage switchgear, batteries, chargers, and uninterrupted power supplies. Recent boiler inspections on both units have indicated the need to closely monitor the condition of some internal components. It may be necessary to repair or replace key internal pressure parts in the near future. Some feedwater heaters on both units are bypassed due to leakage, and this limits Plant output. Corrosion control is on-going at the Plant and could be improved; however, Units 5 and 6 are overall in good condition similar to other units of a similar age.

## INFRASTRUCTURE AND INTERCONNECTIONS

The Plant receives regasified natural gas from the neighboring EcoEléctrica Natural Gas Power Plant and fuel oil from the adjacent Commonwealth Oil Refining Company, Inc. refinery. Liquefied natural gas is delivered to the unloading port at the EcoEléctrica power plant. It is stored in a 42-million-gallon thermally insulated tank at near atmospheric pressure and cryogenic conditions. The liquefied natural gas is drawn from the tank for regasification as required by the demand of Costa Sur and the EcoEléctrica power plant. It is delivered by EcoEléctrica to Costa Sur via pipeline in accordance with the Amended and Restated Natural Gas Sale and Purchase Agreement with Naturgy Aprovisionamientos S.A., which is valid through September 30, 2032. Process water for Costa Sur is drawn from off-site PREPA wells.

## OPERATIONS & MAINTENANCE

The two operational units, Units 5 and 6, load-follow 24 hours a day, 7 days a week as directed by PREPA dispatch. They normally are directed to operate at minimum load through the night and around 75% load during the day. The Plant is manned by three shifts of operations personnel daily and single shifts of maintenance and administrative staff on weekdays. Extended hours and additional personnel are used during outages. Units 5 and 6 have regular outages every 12 to 18 months for maintenance and environmental reasons, per an EPA consent decree and PREPA direction. There are no service agreements with manufacturers, but GE is normally used for boiler and turbine inspections and parts. The Plant has extensive workshop capability and is mostly self-reliant for repairs of equipment. Rebuilds of motors, generators, and rotors are done by specialty shops. On-site simulators for the boilers, steam turbines, and demineralized water system are used for training and troubleshooting.

## PERFORMANCE BENCHMARK

Sargent & Lundy reviewed the performance data that PREPA provided against the information gathered for this assessment report through site meetings, phone calls, walkdowns, and electronic exchanges. The data reflect the limited use of GT #1.1 and #1.2 since they have been out of service for extended periods the past few years. The data shows reduced capacity factors for Units 5 and 6 in 2017, 2018, and 2020, likely due in large part to hurricane- and earthquake-related limitations outside of the Plant boundaries and outside of their control. The units are in relatively good condition and have availability that could be used, but they have only been dispatched with capacity factors in the 40%–60% range the past few years. This could be due in part to the increasing trend seen in their heat rates, which were both near 11,900 Btu/kWh in 2019. Maintenance activities are expected to incrementally improve the heat rates of the units. Sargent & Lundy recommends a study to be conducted to identify additional steps to improve their heat rates to their average 2014 value or less, which was 10,800 Btu/kWh.

## FINANCIAL REVIEW

Sargent & Lundy compiled the historical O&M and capital expenditures (CAPEX) for Costa Sur from reported PREPA data and fiscal plan forecasts for the fiscal years 2015 through 2020. We compared these values with O&M and CAPEX for existing units in operation in North America of similar configurations and operating profiles. Sargent & Lundy has determined that the Costa Sur costs are within the typical range of costs for similar units.

## ENVIRONMENTAL AND REGULATORY

Sargent & Lundy performed a limited environmental review of publicly available information and information provided by PREPA to determine the compliance status for Costa Sur. Sargent & Lundy did not find any compliance-related issues that would prevent renewal of the existing permits or impact near-term operation of the facility. However, the items listed below were identified as having unknown or potential compliance implications for Costa Sur.

- **Water and Wastewater**
    - EPA's CWA inspection report dated August 16, 2017 identified one reported exceedance of copper in Outfalls 002 and 003 for the monitoring period of October 2016. According to PREPA, there has been no follow up from EPA since the inspection.
    - Violations during the third quarter 2018 to third quarter 2020 are identified in ECHO as "reportable noncompliance." Sargent & Lundy has not been provided information concerning those violations.
    - ECHO identifies two "unresolved" violation notices from 2018 and 2020. The 2018 violation is related to nitrate monitoring reporting, and the 2020 violation is related to coliform monitoring.

## RECOMMENDATIONS AND CONCLUSIONS

Sargent & Lundy recommended that Units 3 and 4 at Costa Sur be removed from service and retired. Additionally, if repowering efforts or other operating features are desired for capacity or flexibility (as determined by a separate ongoing load demand and resource study), Sargent & Lundy recommends Units 1, 2, 3, and 4 are demolished, as deemed appropriate, to reclaim property for new generation technology. Sargent & Lundy recommends Units 5 and 6 continue to operate with O&M activities focused on reliability and efficiency improvements to restore the plant's heat rate (such as restoring the feedwater heaters).

The Costa Sur Steam Plant is a strategic location for power generation on the island due to the availability of seawater supply for cooling, the nearby refinery and port services, and the adjacent liquefied natural gas port that supplies gas to EcoEléctrica Natural Gas Power Plant.

PREPA is studying the need for additional grid support and generation throughout the Island. The reclaimed space at Costa Sur could be a good location for smaller, rapid-start GT equipment with integrated synchronous condensing options, such as those in place at Central Hidro Gas Mayagüez Plant. New fast start generation equipment that integrates purge credit, battery storage components for instantaneous response, integrated/clutched synchronous condensing, and similar features could provide quicker support and flexibility for a future grid that is planned to integrate a larger amount of intermittent renewable power. Reciprocating engine plants provide even faster startups than GT equipment and also can be configured to operate on natural gas and in combined-cycle configurations and provide black start capability.

The Costa Sur Unit 5 and 6 plant nameplate capacity is 820 MW. A decline in Plant performance and reliability should be expected during the operating life of a thermal power generation plant, and it is evident in the case of the Costa Sur Steam Plant Units 5 and 6. These units have provided power generation service since the early 1970s, and while a decline in performance has been seen, the conversion to gas has provided the ability to generate power with lower emissions, and until recently, lower O&M costs. We recommend performing a root-cause analysis to determine the best means to restore the Plant's heat rate and improve its overall operating efficiency, which has declined only in the past few years. It must be highlighted that the Costa Sur Steam Plant has been operating successfully on natural gas for the past almost ten years. PREPA has managed to dramatically improve the Plant's emissions with the switch from HFO to natural gas.

Costa Sur's sister units, Aguirre Units 1 and 2, currently has several pressure part components (for natural gas firing) that were not installed and could be used as spares at Costa Sur. Both these pressure part components and natural gas fuel trains are currently being stored outdoors at the Aguirre facility. The equipment appears in good condition, but Sargent & Lundy recommends, with the help of the boiler original equipment manufacturer, investigating the potential use of the equipment in Costa Sur Units 5 and 6. Additionally, PREPA should consider pursuing long-term preservation (e.g., relocating the equipment to indoor storage) for all purchased equipment for natural gas firing.

Care must be taken to ensure that replacements or upgrades to the Plant are suitable for an aggressive, salt-laden marine environment exposed to coastal winds. Typically, competitively priced original equipment manufacturer standards for power generation and balance-of-plant equipment are not well-suited for this type of operating environment. New equipment must be configured for the challenging conditions at Costa Sur. Failure to make allowances for suitable materials, equipment selection, buildings/enclosures, and other aspects of the facility design to protect the Plant from the harsh operating environment will result in excessive future O&M costs and a shorter plant design life for any new installation. Suitable design specifications appropriate for this operating environment include corrosion-resistant material specifications; appropriate welding selections, including special treatment of all metal seams, stitched connections, and fastenings with sealants, gaskets, and coatings; use of protective equipment enclosures; proper system selections; and marine coatings systems. Due to these requirements, coastal power generation sites are inherently more expensive than those installed in less aggressive operating environments and should be planned accordingly.

Ongoing proposals for Plant replacements, upgrades, and new generation should consider the guidelines provided herein.

# 1. INTRODUCTION

The Puerto Rico Electric Power Authority (PREPA) is the electric power company responsible for generating, transmitting, and distributing electricity for the island of Puerto Rico. PREPA engaged Sargent & Lundy to perform an independent technical review of the Costa Sur Steam Plant ("Costa Sur" or the "Plant").

## 1.1. PLANT DESCRIPTION

Costa Sur is located on the southern coast of Puerto Rico in Guayanilla as shown in Figure 1-1. The Plant was designed and erected by United Engineers & Constructors of Philadelphia, Pennsylvania. The Plant has two operational steam power generation units with a combined nameplate generation capacity of 820 megawatts (MW) (Units 5 and 6), which are used for base load power on the island. There are four non-operational steam units (Units 1–4) that are no longer in service. There are also two black start cable gas turbine (GT) generators on site (GT #1.1 and GT #1.2).

**Figure 1-1 — Costa Sur Geographic Location**

**Source:** Costa Sur Presentation

Units 1 and 2 each have a nameplate capacity of 50 MW. The units were installed in 1959 and 1960, respectively, and they operated on heavy fuel oil (HFO). The units have been retired and are idle on the property, with last operation in 2003. These units are not described further in this report.

Operating on HFO, Units 3 and 4 each have a nameplate capacity of 85 MW and were commissioned in 1962 and 1963, respectively. The units have been out of service since mid-2016 and are awaiting decommissioning. Sargent & Lundy included a review of Units 3 and 4 in this report for reference.

Units 5 and 6 each have a nameplate capacity of 410 MW and were commissioned in 1972 and 1973. respectively. Their Combustion Engineering ("CE," now General Electric [GE] Power) boilers were originally designed to burn HFO but were recently modified to burn any combination of natural gas and HFO. They currently run on 100% natural gas and occasionally use HFO to ensure the necessary equipment is available for standby operation, if required.

On January 7, 2020, a 5.9 magnitude earthquake tripped Units 5 and 6. The earthquake greatly impacted the infrastructure of buildings and major equipment. Unit 5 returned to service on August 1, 2020 while Unit 6 was expected to return to service in January 2021. As of October 2020, the Costa Sur station is currently at 35% capacity, and Unit 5 is experiencing a derate related to repairing the hydrogen cooler, which was expected to be resolved by the end of February 2021.

The existing two black start capable GTs on site operate on No. 2 fuel oil and are currently being repaired. GT #1.1 was scheduled to be operable by November 2020 and GT #1.2 is scheduled to be operable in early 2022.

The electrical power from the steam generators is sent to three switchyards that have operating voltages of 38 kilovolts (kV), 115 kV, and 230 kV. They are all interconnected by means of transformers to achieve reliability and flexibility of operation. The two GTs are connected to the 115-kV switchyard through the emergency service station transformer of Units 5 and 6. Units 5 and 6 are connected to the 230-kV switchyard. A high-level configuration of the Plant is shown in Figure 1-2.

## Figure 1-2 — Costa Sur Overall Plant Configuration

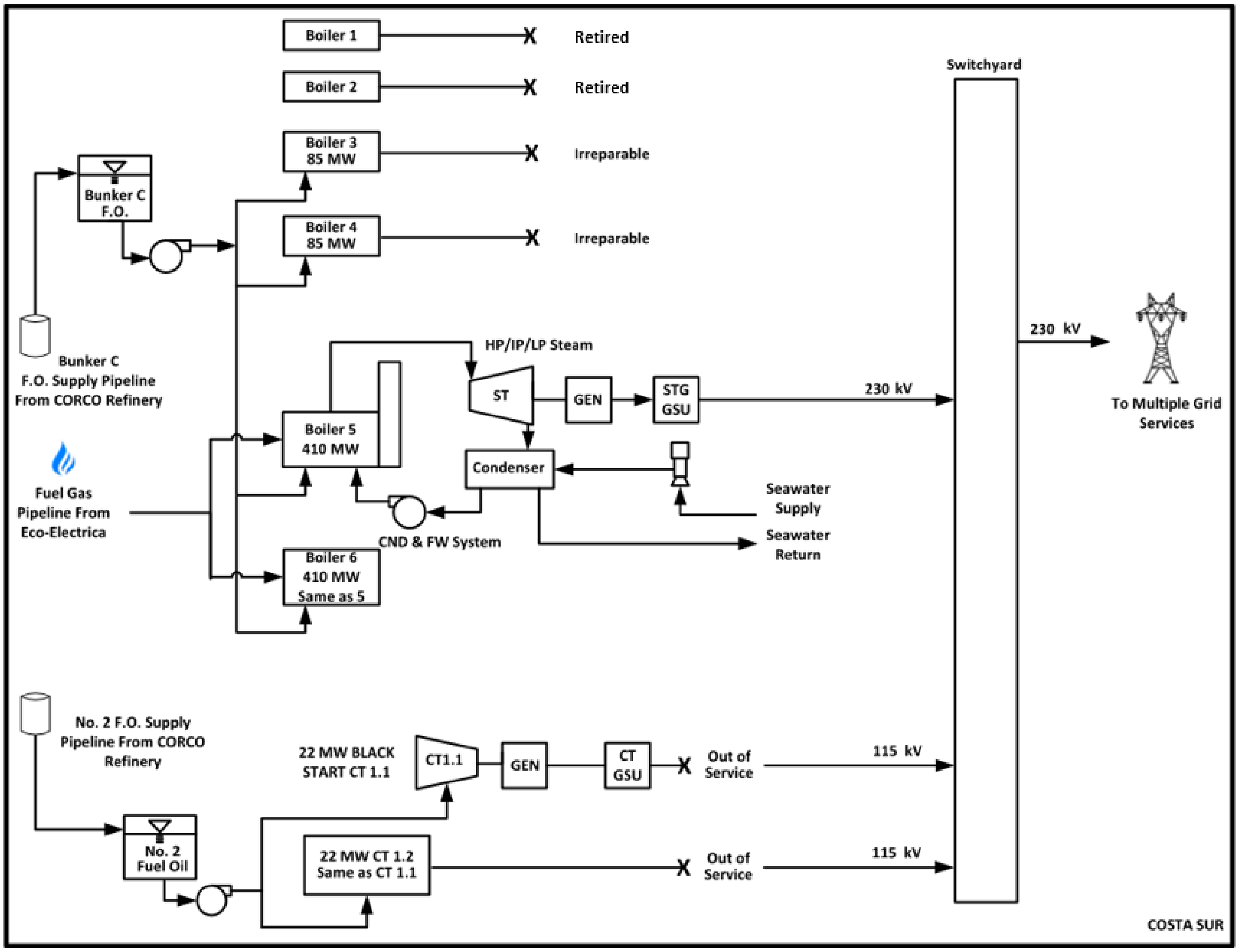


**Figure 1-3 — Costa Sur Steam Plant**

Looking east. Units 1, 2, 3 and 4 are left of center and non-operational.
Units 5 and 6 are right of center, each with two stacks.

## 1.2. SCOPE OF REVIEW

This technical report includes an assessment of the Plant design, operations and maintenance (O&M) activities, Plant organization and personnel, technical performance, commercial arrangements and obligations, and provisions for environmental permitting. Sargent & Lundy's objective is to provide an overview of the condition of the asset, assess whether the facility has been operated and maintained in accordance with generally accepted industry practices, and identify significant challenges to continued successful operation. Recommendations for demolition, equipment upgrades, or operational improvements are also included within our report. Additionally, Sargent & Lundy performed a Phase I Environmental Site Assessment (Phase I ESA) in May 2019 with the site visit in December 2018. Please see report SL-014468.AG.ESA [1] for the Sargent & Lundy's findings of the Phase I ESA.

Sargent & Lundy acquired information to conduct its review from several sources:

- Documentation provided by PREPA's corporate operations and Plant personnel through January 2021. Limited information was provided in August 2021 on the GT #1.2 replacement.
- Discussions with Plant personnel on the phone and during several site visits of the facility from 2018 to 2020.
- Industry data obtained from market research databases and publicly available sources to evaluate Plant characteristics.

Sargent & Lundy understands that this review is being conducted in connection to the request for proposal (RFP) to manage, operate, maintain, asset manage, and decommission, as applicable, one or more of the base-load generation plants and gas turbine peaking plants located throughout the island of Puerto Rico, including Costa Sur.

# 2. TECHNICAL DESCRIPTION

Due to the 2020 earthquake, Costa Sur included one operating steam unit—Unit 5; Unit 6 was scheduled to be online by the end of January 2021. As of October 31, 2020, the total capacity of the Plant was 285 MW. The characteristics of all the generating units at Costa Sur are shown in Table 2-1, including the four steam units and two black start-capable GT generators that are no longer operational.

**Table 2-1 — Production Plant Overview**

| Unit Name | COD | Technology | Fuel | Capacity (MW) | Status (As of October 2020) |
|---|---|---|---|---|---|
| Costa Sur Steam Turbine #1 | 1959 | Steam | HFO | 50 | Retired (2003 last time operated). Irreparable. |
| Costa Sur Steam Turbine #2 | 1960 | Steam | HFO | 50 | Retired (2003 last time operated). Irreparable. |
| Costa Sur Steam Turbine #3 | 1962 | Steam | HFO | 85 | Irreparable. End of Life. |
| Costa Sur Steam Turbine #4 | 1963 | Steam | HFO | 85 | Irreparable. End of Life. |
| Costa Sur Steam Turbine #5 | 1972 | Steam | Nat. Gas/HFO | 410 | Operational. Derated to 285 MW due to hydrogen cooler repair (repair expected to be completed in late February 2021). |
| Costa Sur Steam Turbine #6 | 1973 | Steam | Nat. Gas/HFO | 410 | Non-Operational and Offline, repairs due to earthquake |
| Costa Sur Gas Turbine #1.1 | 1972 | Gas Turbine | Oil No. 2 | 21 | Offline. Being Repaired. |
| Costa Sur Gas Turbine #2.2 | 1972 | Gas Turbine | Oil No. 2 | 21 | Offline. Being Repaired. |

1. **Operational**—Functioning and suitable for power generation.
2. **Non-Operational**—Out of service temporarily and not generating power.
3. **Irreparable**—Equipment requires major expenditure to restore for power generation.
4. **End of Life**—Equipment in its last stage of useful life. Replacement plan or retirement should be considered.
5. **Offline**—Unit being repaired.

## 2.1. MECHANICAL SYSTEMS

This section describes the major mechanical equipment and systems in the Plant and their function in the generation of power.

### 2.1.1. Steam Turbines

Units 3 to 6 each have one steam turbine that receives steam from its unit's boiler to generate power. The steam from the low-pressure section of each turbine exhausts downward into the unit's condenser. The turbines are located outdoors on a common turbine deck with weather shelters for each turbine and generator. The deck is wide and unobstructed, and it is conveniently located adjacent to the control rooms and to the engineering offices in the administration building. A gantry crane—with a main hook rated at 50 tons—and an auxiliary hook—rated at 15 tons—are available for servicing the steam turbines of Units 3 to 6. The crane has access to the bays between the units for equipment laydown. There is another overhead gantry crane made by Zenar; it includes a 15-ton and a 100-ton hoist.

**Units 3 and 4:** The identical tandem compound double-flow turbines each have a rated nameplate capacity of 85 MW and were manufactured by GE. Units 3 and 4 began commercial operation in 1962 and 1963, respectively. Their design throttle pressure is 1,450 psig, and their design main steam and hot reheat temperatures are 1,000°F.

**Units 5 and 6:** GE manufactured the identical tandem compound double-flow turbines. Units 5 and 6 began commercial operation in 1972 and 1973, respectively. Their guaranteed performance of 410 MW was based on high-pressure (HP) inlet steam conditions of 2,679 klb/hr at 2,400 psig and 1,000°F, reheat inlet conditions of 2,371 klb/hr at 451 psig and 1,000°F, and a condenser backpressure of 2.0 inches of mercury, absolute. The turbines, boilers, and balance of plant were designed for steam flows and pressures high enough to develop 479 MW. The HP and intermediate-pressure (IP) sections of the turbine are in a single cylinder. There are two low-pressure cylinders, each receiving their own steam inlet from the cross-over piping leaving the IP section.

### 2.1.2. Generators

The generators for Units 3 to 6 are hydrogen cooled and have static Cutler Hammer exciters. The Units 5 and 6 generators have an additional water-based cooling system for the stators..

The Units 5 and 6 generators are 60-hertz GE 4C4W1 units rated for 24 kilovolts (kV) with continuous output ratings of 544 megavolt amperes at a power factor of 0.85 and with 45 psig hydrogen. The Units 3 and 4 generators are rated at 110 megavolt amperes at 0.85 power factor and 30 psig hydrogen.

### 2.1.3. Boilers

**Units 3 and 4:** The boilers are tangentially fired CE HFO boilers. Based on the CE description, both units have an original maximum continuous rating (MCR) of 487 kilopounds per hour (klb/hr) main steam flow and outlet steam conditions of 1,550 psig and 1,000°F. Units 3 and 4 began commercial operation in 1962 and 1963, respectively.

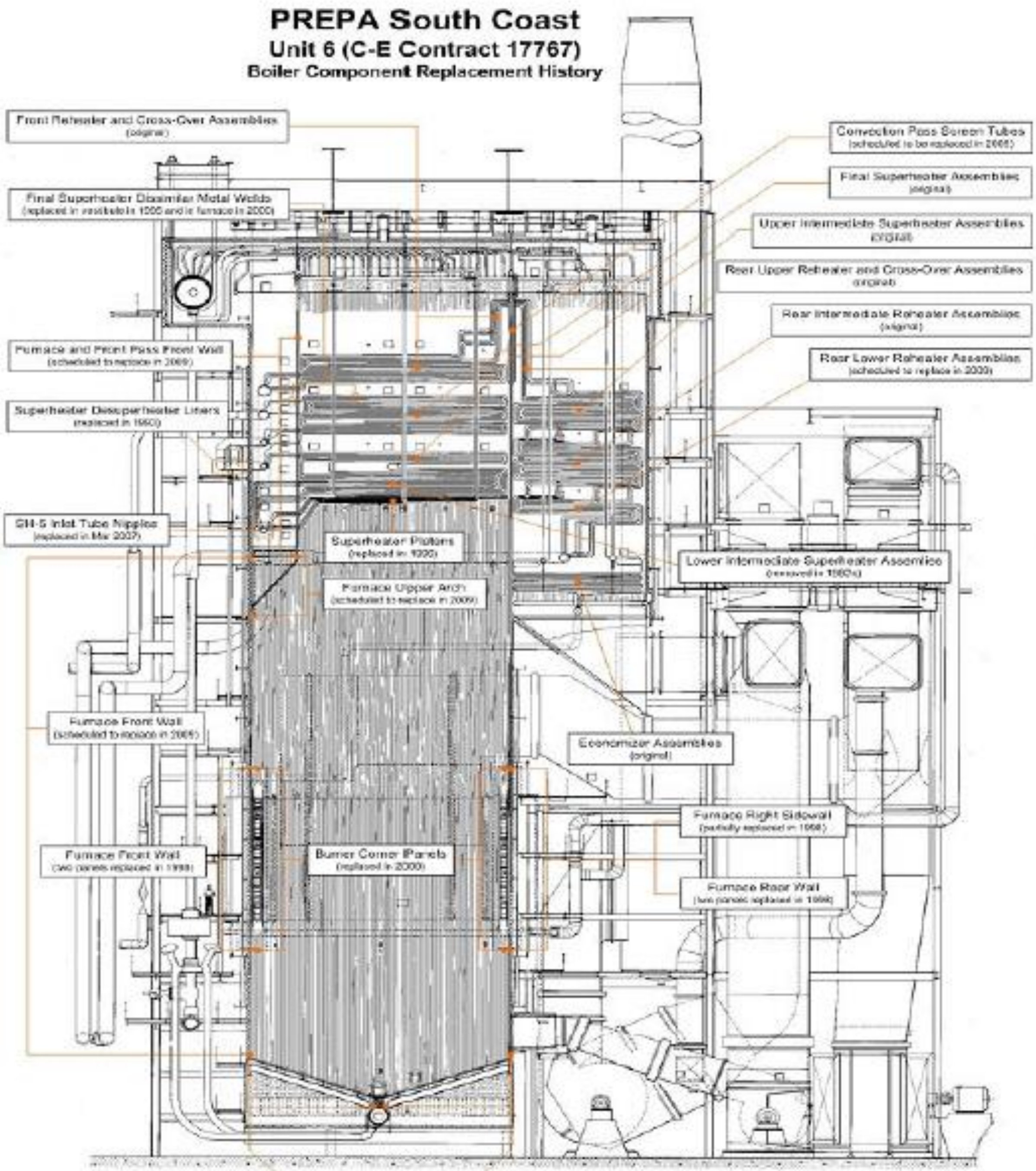
**Units 5 and 6:** The boilers are tangentially-fired CE originally designed to burn HFO. The units were retrofitted in 2010 and 2011 to burn a) natural gas, b) a combination of natural gas and HFO, or c) only

HFO as originally designed. Based on the CE description, both units have an original MCR rating of 2,970 klb/hr main steam flow and outlet steam conditions of 2,620 psig and 1,005°F. Units 5 and 6 began commercial operation in 1972 and 1973, respectively. Plant personnel indicated that the units can obtain the original design output when firing 100% natural gas, but they are rarely dispatched to do so.

There are two boiler blowdown tanks. One receives steam/condensate from the HFO heating skid in case there is an oil leak into the condensate. The main boiler blowdown is routed to the large quench tank from which it is pumped to the closed cooling water tower.

The Forced Draft (FD) and Induced Draft (ID) fans are 2 x 50% capacity, and the gas recirculation fan on each unit is 1 x 100%.

### Figure 2-1 — Unit 6 Boiler Sectional Side View



### 2.1.4. Unit 5 & 6 Steam and Condensate Cycle

The main condenser for each turbine is located below the low-pressure turbine exhaust duct, with the turbines above the auxiliary spaces and equipment rooms. The turbine exhaust steam is condensed in a single pass Baldwin-Lima-Hamilton surface-type condenser cooled by a once-through circulating water system. The tubes in the condensers for Units 5 and 6 are of aluminum-brass material, and they have a tube-cleaning system. Each unit has redundant vacuum pumps to remove air and other non-condensable gases from the condenser during normal operation.

On Units 5 and 6, condensate from the condenser hotwell is forwarded by either of the two 500-horsepower (hp) 100%-capacity vertical condensate pumps to the condensate polisher, a feedwater heater and two 1,250 hp 100%-capacity deaerator pumps, then to three additional low-pressure feedwater heaters and the deaerator. The boiler feedwater pumps (BFPs) draw the de-oxygenated water from the deaerator and boost its pressure for the two HP feedwater heaters and the boiler economizer.

Four extractions from the low-pressure turbine are directed to the low-pressure feedwater heaters upstream of the deaerator, Heaters 1–4. An extraction from the IP turbine goes to the deaerator (Heater 5), and another goes to the high-pressure Heater 6. An extraction from the final stage of the HP turbine, which coincides with the cold reheat line, goes to Heater 7.

There are two DeLaval BFPs on each unit. The 50%-capacity electric BFP has two 4,500 hp motors. The turbine driven BFP is rated at 60%-capacity. Recent repairs were performed on the boiler feedwater pumps, condensate pumps, closed cooling water pumps and boiler circulating water pumps.

### 2.1.5. Circulation Water Systems

Untreated, screened seawater is pumped from Guayanilla Bay for cooling service of the Plant's condensers. The return seawater from the condensers is channeled to a natural pond south of the Plant that flows into the bay. Units 3 and 4 have a shared intake structure and discharge channel as do Units 5 and 6. The discharge channel from Units 5 and 6 is joined by the channel from Units 3 and 4. There are six oil-water separators arranged in parallel to remove oil from various discharges into the channel.

The Circulating Water System for Units 5 and 6 consists of a bayside intake structure, five screenwell chambers with traveling intake screens, screen wash pumps, and two 1,000-hp Bingham-Willamette vertical circulating water pumps for each unit with an installed spare that is shared for redundancy.

The circulating water pumps are mounted to the concrete deck above the water intake basin. A service platform is provided at the motor level for service and inspection of the units. An overhead 30-ton crane with a 15-ton auxiliary hook is installed for maintaining the circulating water pumps, the traveling screens, and the screen wash pumps. The circulating water pumps discharge to the water boxes on either side of the condenser for heat rejection.

**Figure 2-2 — Units 3 and 4 Seawater Intake and Closed Cooling Tower**


Looking west toward the bay. The north end of the Unit 5 cooling tower is visible on the left.

**Figure 2-3 — Units 5 and 6 Seawater Intake and Closed Cooling Tower**


Looking west toward the bay.

### 2.1.6. Closed Cooling Water System

A Closed Cooling Water System uses fiberglass cooling towers to remove heat from independent closed cooling water circuits (one for each unit) in the Plant. These circuits service various equipment coolers located throughout the units. There are two full-capacity closed-cooling water pumps per unit (600 hp each on Units 5 and 6). An outside contractor, GE SUEZ, supplies the chemicals and controls the chemistry of the well water in the closed cooling systems. Units 3 and 4 each have a single-fan cooling tower and Units 5 and 6 each have two cells in a four-cell tower. Blowdown from the cooling towers is directed to the Plant's discharge channel to the bay.

### 2.1.7. Black Start Gas Turbines

The Plant requires approximately 40 MW for black start conditions. In 1972, two full-capacity GTs were installed to meet this need. The GTs are also used to meet peak load demands. They were manufactured by John Brown; each has a nameplate capacity of 21 MW and is fired on No. 2 fuel oil. They are located east of the thermal units and are currently being repaired (damaged from Hurricane Maria in 2017). As a result, black start capacity must be taken from outside the Plant. The GTs are owned, maintained, and operated by PREPA's Hidro Power division. PREPA is also considering the replacement of these GTs with two new approximately 30-MW black start GT generators. Each GT would be able to operate on natural gas or No. 2 fuel oil and will be designed for peaking operation or black start of the Costa Sur facility.

### 2.1.8. Fuel Systems

Natural gas is now the primary fuel for Units 5 and 6. It is supplied via a pipeline from EcoEléctrica natural gas power plant's 42-million-gallon liquefied natural gas tank, which is located approximately 1.6 miles from the Plant. There are two natural gas pressure reducing stations, capable of 100% natural gas capacity (2x100%) to support 100% firing for Units 5 and 6.

Downstream of the main pressure reducing valve (PRV), the gas is further reduced in pressure for use in the two boilers that were retrofitted in 2011. PRV #2 is for Unit 6, and PRV #3 is for Unit 5. The Plant's main PRV reduces the pressure from 650 to 230 psig, and PRVs #2 and #3 reduce the 230 psig gas pressure to 15 psig.

For startup on HFO, four propane tanks are on site in case natural gas is not available. Three of the tanks are located adjacent to the conditioned storage building on the south side of the plant and one is near the condensate storage tanks. A truck delivers propane to the site.

Units 5 and 6 have retained the ability to burn HFO. Units 3 and 4, when they have run, burn only HFO after starting on No. 2 fuel oil.

The facility uses one No. 2 fuel oil tank and has recoated and repurposed another as a well water tank. The active No. 2 fuel oil tank, #S-1, is located east of the GTs and has a 230,000-gallon operating capacity. Also, on the east side of the facility are two 1.8-million-gallon HFO service tanks, tagged #4S and #5S. There are three large HFO storage tanks located at the north end of the facility, each with a nominal capacity of 10.3 million gallons. These large reserve HFO tanks are referred to as #1R, #2R, and #3R. As of October 2020, Tank #1R was out of service. HFO and No. 2 fuel oil are delivered to site through lines from the Commonwealth Oil Refining Company, Inc. refinery. No. 2 fuel oil can also be delivered by truck.

#### 2.1.9. Fire Protection

The fire protection system pressure is reasonable, and the jockey pump remains off. The Plant has a dedicated 400,000-gallon fire water tank and a diesel generator for backing up the electric fire pumps. They also maintain foam systems local to the fuel oil tanks. A fire wall has been installed between the Units 5 and 6 main power transformers.

### 2.2. ELECTRICAL SYSTEMS

#### 2.2.1. Conceptual Design

Units 5 and 6 are each connected via isolated phase bus to their respective generator step-up transformer. The isolated phase bus of each steam turbine generator has two taps of bus, each feeding an oil-filled station service transformer that steps down the voltage and in turn provides power to a 4.16-kV switchgear bus. These two buses at each generating unit are known as the “normal busses,” and they provide power to all the unit’s auxiliary loads. In addition to the normal busses, there is an additional 4.16-kV switchgear bus, called the “emergency bus,” which is fed from the emergency station service transformer.

The normal busses feed larger motor loads directly at 4.16 kV, as well as low-voltage auxiliary transformers that step the voltage down to 480 volts for distribution to low-voltage switchgear busses and motor control centers throughout the plant.

#### 2.2.2. Switchyard and Interconnection

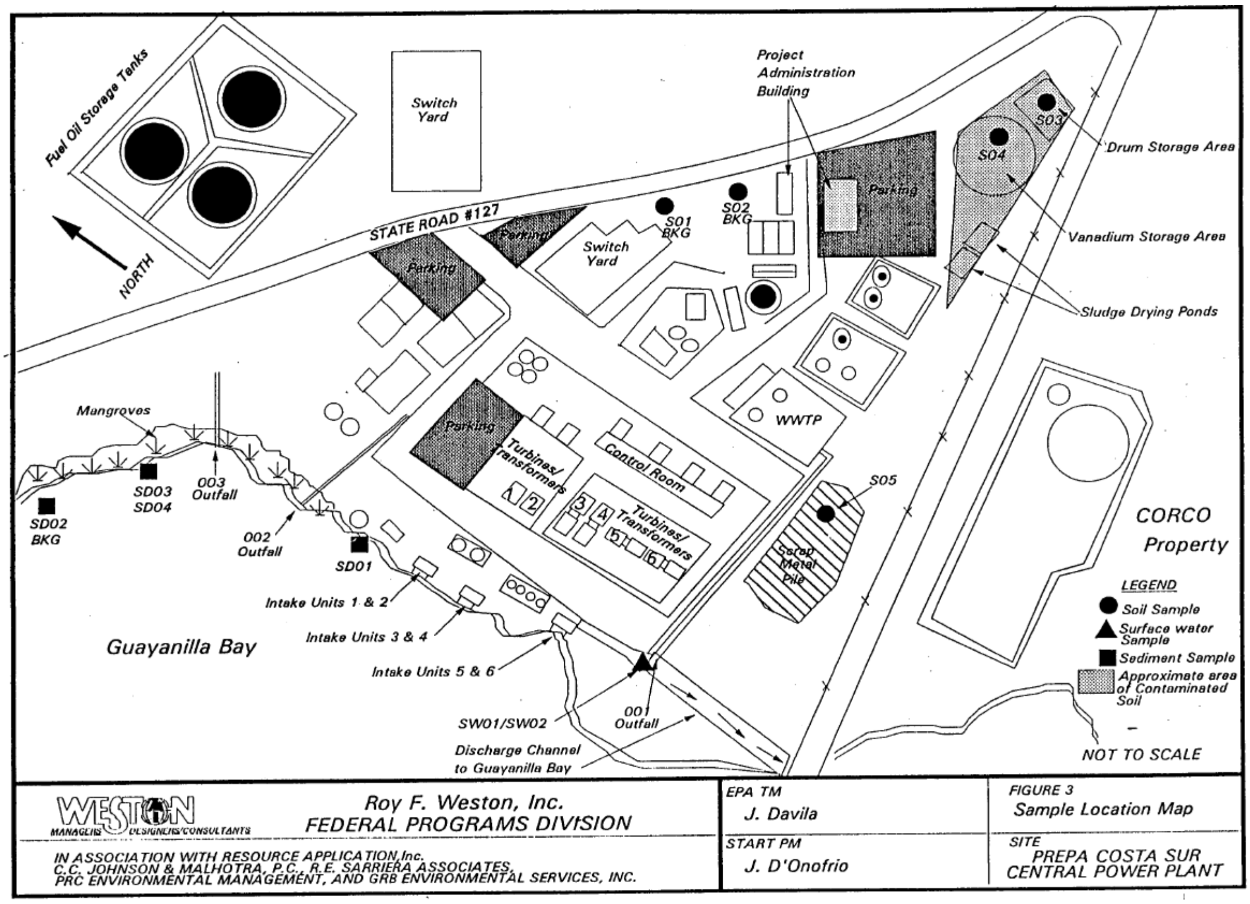
The oil-filled step-up transformers for Units 5 and 6 deliver the power from the generators to the 230 kV switchyard. They are rated 23/230 kV, 328/436/544 megavolt amperes (MVA), OA/FA/FOA and have de-energized tap changers. The Plant also has a spare step-up transformer for use at Costa Sur or Aguirre. The four station service transformers step down the generation voltage to 4.16 kV and have a top rating of 18 MVA.

Currently, the demarcation points (Plant responsibility versus Transmission responsibility) of the Plant’s units are considered to be at the low side termination of the main power transformers (MPTs) and the Emergency Station Service Transformers (ESSTs) due to the division of responsibility on the maintenance of the large power transformers. Additionally, the switchyards’ relays and controls are currently housed in the Costa Sur control room, which is located in a building within the plant boundary, but apart from the power block. Engineering design is underway to identify and further separate the Plant from the PREPA T&D system. A high-level review of the separation required work is included in Sargent & Lundy report TD-0003 Demarcation of PREPA Generation Assets from the Transmission and Distribution System [2].

## 2.3. STRUCTURES

There are several structures on site including an administrative building, Turbine Hall/Auxiliary Buildings, warehouses, and a mechanical and machine shop. An overview of the site layout is shown below.

**Figure 2-4 — General Arrangement**




The Administration Building is a multistory structure. The main offices are located here with an elevator, conference rooms, and support staff offices. The building provides access to the original turbine hall building. The building is dated but in serviceable condition.

The Plant stores spares in a climate-controlled building, non-conditioned enclosures, and outdoors. A spot-check of the anti-corrosion coating on the parts showed it to be intact and effective.

## 2.4. CONTROL SYSTEM

As of October 2020, Foxboro was upgrading the turbine water induction protection system on Units 5 and 6 from a programmable logic controller system. The logic Foxboro developed was being reviewed. Installation of the required wiring has begun. The feedwater heater level controls were being upgraded as well. New actuators will continue being installed as part of the upgrade along with some level indicator components.

In 2010, Foxboro completed a controls system upgrade on Units 5 and 6; additionally, GE performed an upgrade on the turbine control systems to the Mark VI electro-hydraulic. The Units 3 and 4 digital control system is Ovation by Westinghouse. Their turbine controls are a mechanical-hydraulic type system.

As of October 2020, the Plant was purchasing two diesel 600-kilovolt-ampere generators to replace the existing essential services generator.

# 3. EQUIPMENT CONDITION

The condition assessment of the Plant is a descriptive summary of the main equipment, facilities, balance of plant, and site-specific items of interest. The units are discussed individually, as a group where reasonable, or as a combined facility for common infrastructure assessment where applicable.

## 3.1. CONDITION ASSESSMENT METHODOLOGY

Based on interviews, walkdowns, and data gathered on site and sent by PREPA, Sargent & Lundy developed a high-level overall condition assessment for each of the units by using a scoring matrix. The matrix is comprised of six major categories: safety hazards, corrosion control, mechanical assessment, electrical assessment, instrumentation and controls assessment, and civil and structural assessment. A short description of each category follows.

1. **Safety Hazards**—Based on visual observations during our walkdowns from experienced engineering staff.
2. **Corrosion Control**—With most of the facilities located near the coast, corrosion has proven to be a significant aspect of maintenance planning, capital costs, and safety and reliability of facilities.
3. **Mechanical Assessment**—A high-level review of all major mechanical equipment and systems.
4. **Electrical Assessment**—A high-level review of all major electrical equipment and systems.
5. **Instrumentation and Controls Assessment**—A high-level review of all major Instrumentation and Controls equipment and systems.
6. **Civil and Structural Assessment**—A high-level review of all major civil and structural equipment and systems.

Each of the above categories was scored after our site visits and includes a combination of visual assessment, interviewing, and data review as indicated in the scoring tables. Our assessment system for this review is defined in Table 3-1.

**Table 3-1 — High Level Condition Assessment System**

| | |
|---|---|
| (dark green) | **System like new (replaced or refurbished within the past 5 years)** |
| (light green) | System has been maintained with general O&M on a routine basis; no major issues noted |
| (yellow) | Deficiency was noted or components were out of service |
| (orange) | Major issues noted causing a safety, reliability, or unit output issue |
| (red) | Not in operation due to end of life |

As part of a consent decree with the EPA, each unit is mandated to take an environmental outage at intervals of 12 to 18 months. Sargent & Lundy has assumed that all required maintenance activities are conducted during each mandatory environmental outage except where in progress is noted. This key assumption was used in our evaluation of each of the six major condition assessment categories listed above.

## 3.2. SUMMARY OF EARTHQUAKE DAMAGE

On January 7, 2020, a 5.9 magnitude earthquake tripped Units 5 and 6. The earthquake greatly impacted the infrastructure of buildings and major equipment. Unit 5 returned to service on August 1, 2020 while Unit 6 was expected to return to service by the end of January 2021. As of October 2020, the Costa Sur station was at 35% capacity, and Unit 5 was experiencing a derate related to repairing the hydrogen cooler which was expected to be resolved by the end of February 2021.

The major impacts to the station were:

- Equipment was found misaligned
- Buckling on gusset plate connection
- Cracks on concrete pedestal of column and connections at various locations below the turbine deck
- Large storage tank foundation damage found at:
    - Demineralized Water Reserve Tank #1
    - Demineralized Water Tank #2
    - Raw Water Tank #3
- Various vertical/horizontal cracks on masonry walls throughout the plant. Cracks below the turbine need to be further evaluated to determine their structural integrity.
- Concrete secondary containment was broken at piping sleeve section due to movement or vibration of piping.
- Insulation and refractory material compromised and broken down in various pipes, duct walls, conduits, and boiler walls.

- Damage to the main building.

## 3.3. STEAM UNITS 3 AND 4 CONDITION

Units 3 and 4 are not operational due to Mercury and Air Toxics Standards (MATS) regulations as well as safety and economic concerns. Based on discussions with Plant personnel and our observations, significant and costly work would be required to make Units 3 and 4 safe to operate. Currently, a few interchangeable parts are being used from Units 3 and 4 for use on Units 5 and 6. Additionally, when Units 3 and 4 were in operation, both units experienced significant derates due to furnace air in-leakage through the tangent tubed furnace walls (no membrane present) as it is a balance draft unit. It is not possible to generate the design steam conditions with the present state of the boilers.

The boiler tubes and structures are corroded, and the air heaters are extremely corroded. The FD and ID fans would have to operate with much higher motor amps and inlet vane positions to overcome the pluggage and leakage. The steam turbines, generators, and balance-of-plant equipment are expected to be in operating condition, but they have not been exercised or maintained in many months nor have they been properly prepared for long-term storage. The exciters on both turbines are not operational. Finally, Sargent & Lundy observed holes in the roof of Unit 4.

Sargent & Lundy did not conduct a walkdown on the majority of Units 3 and 4; however, a high-level condition assessment of the two units is provided in Table 3-2.

## Table 3-2 — Costa Sur Units 3 & 4 Overall Condition Assessment

| Item | System | Assessment Method | | | Scoring Category | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | Visual | Interview | Data | End of Life | Reliability | Unit Output | Subtotal | Notes |
| 1 | **Safety Hazards** | yes | yes | no | | n/a | n/a | | |
| 2 | **Corrosion Control** | yes | yes | no | | n/a | | | |
| 3 | **Overall Cleanliness & Housekeeping** | yes | yes | no | | n/a | n/a | | |
| 4 | **Mechanical Assessment** | | | | | | | | |
| 4.1 | Steam Generator (boiler) | ~yes (from distance) | yes | no | | | | | Unit is out of service based on economics and MATS requirements. Boiler casing is corroded and a safety issue. The boiler does not have membrane tube walls which results in significant furnace wall air infiltration and significant derates. |
| 4.2 | FD and ID Fans and Auxiliaries | yes | yes | no | | | | | |
| 4.3 | High Energy Piping (HEP) | no | yes | no | | | | | |
| 4.4 | Condensate System | no | yes | no | | | | | |
| 4.5 | Feedwater System | no | yes | no | | | | | BFP 4-2 out of service for bearing with 2-year lead time. |
| 4.6 | Turbine and Auxiliaries | no | yes | no | | | | | |
| 4.7 | Circulating Water and Closed Cooling Water Systems | yes | yes | no | | | | | |
| 4.8 | Compressed Air Systems | no | yes | no | | | | | |
| 4.9 | Emission controls | n/a | yes | no | n/a | n/a | n/a | **n/a** | No emissions controls installed |
| 4.10 | Fuel Systems | no | yes | no | | | | | |
| 4.11 | Seawater Intake | yes | yes | no | | | | | |
| 4.12 | Water Treatment | yes | yes | no | | | | | |
| 4.13 | Underground Piping | no | yes | no | | | | | |
| 4.14 | Fire Protection Systems | no | yes | no | | | n/a | | |
| 5 | **Electrical Assessment** | | | | | | | | |
| 5.1 | Generator | no | yes | no | | | | | |
| 5.2 | Transformers | no | yes | no | | | | | |
| 5.3 | Switchgear | no | yes | no | | | | | |
| 5.4 | Protective Relays | no | yes | no | | | n/a | | |
| 5.5 | Black Start CTs | no | yes | no | | | n/a | | Both CTs are out of service with major components delayed in the repair process. |
| 6 | **Instrument and Controls Assessment** | | | | | | n/a | | |
| 6.1 | Plant Controls | no | no | no | | | n/a | n/a | |
| 6.2 | Turbine Controls | no | no | no | | | n/a | n/a | |
| 7 | **Civil / Structural Assessment** | | | | | | | | |
| 7.1 | Buildings | no | yes | no | | | | | |
| 7.2 | Structural Steel | no | yes | no | | | | | |
| 7.3 | Tanks / Containment | no | yes | no | | | | | |
| 7.4 | Cranes | no | no | no | | | n/a | | |
| 8 | **Overall Condition Assessment** | | | | | | | | **Major issues noted causing a safety, reliability or unit output issue** |

## 3.4. STEAM UNIT 5 CONDITION

Alstom Power (now GE Power) performed a natural gas conversion study for Unit 5, and the unit was converted to burn gas in December 2010. Modifications were made to the superheater and reheater, similar to the modifications recommended for Aguirre Power Plant Complex (Aguirre) Units 1 and 2, to achieve design-steaming capacity when firing 100% natural gas. These modifications include a larger superheater and reduction in reheat surface area. The original Alstom Power thermal analysis was not provided for review; therefore, we were unable to determine the expected performance or recommendations when switching to natural gas firing.

A summary of the recent earthquake damage is found in Section 3.2. The Costa Sur boilers have an MCR rating of 2,970 klb/hr main steam flow at 2,620 psig and 1,005°F. For comparison, the Aguirre boilers are also tangentially fired CE HFO fired boilers built in the early 1970s. They have an MCR rating of 3,170 klb/hr main steam flow at 2,950 psig and 1005°F.

The last inspection of boilers was in 2013. Several indications were noted in the inspection report with the waterwalls, and portions of the superheater side and rear outlet headers appeared to be in poor condition. The finishing superheater is severely misaligned due to its age (overheating); it may not be salvageable and may need replacing soon. Further investigation is needed on these components during the next boiler inspection.

As of October 2020, there were new boiler blowdown pumps on order. Alstom Power informed the Plant it is acceptable to operate without the air preheater steam coils in service when burning gas. With a fuel mixture, the steam coils should still be operated to keep the flue gas temperature above the sulfuric acid dew point temperature at the cold end of the rotary air heater. The Plant, however, continues to operate mainly on 100% gas, and repairing the steam coils is a low priority. They will be left in place on the 1,750-hp FD fan inlets to filter the combustion air.

The 2,250-hp gas recirculation fan is out of service. Similar to the air preheat steam coils, the recirculation fan is not necessary when primarily burning natural gas. The Plant does not plan to maintain the fan or return it to service.

The condensate polisher is operating well. Its controls have been improved with the Foxboro upgrade, including the ability to obtain process feedback information. The Plant plans to replace the sulfur and caustic pipes to the polisher.

Two of the unit's seven feedwater heaters are out of service, limiting the unit's ability to reach full load. The heater repairs will include using explosive plugs to fix leaks. Flow accelerated corrosion has not been an issue on the unit. The HP/IP/LP rotors and parts that were previously in storage are being used to replace the components on Unit 6 turbine in the current major overhaul outage. A rebuilt Unit 5 IP turbine rotor and static parts is currently planned between 2021 and 2022. The steam turbine and the main steam stop and control valves were overhauled in 2013.

Our overall condition assessment summary can be found in Table 3-3. Based on our observations from site visits and from the data provided in 2020, Sargent & Lundy observed the major equipment and components for Unit 5 to be in generally well maintained considering its age; however, a recent hydrogen cooler issue is preventing the unit to obtain full load (currently operating at 285 MW). This was being repaired and planned to be completed at the end of February 2021. The unit condition is in line with similar units built in the late 1960s to early 1970s.

## Table 3-3 — Costa Sur Unit 5 Overall Condition Assessment

| Item | System | Assessment Method | | | Scoring Category | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | Visual | Interview | Data | End of Life | Reliability | Unit Output | Subtotal | |
| 1 | **Safety Hazards** | yes | no | no | | n/a | n/a | | sweating of natural gas piping throughout the facility causing puddles and potential slip hazards. Plant has plans to install insulation to help with sweating of pipe. |
| 2 | **Corrosion Control** | yes | no | no | | n/a | | | On-going maintenance activity and concern; not affecting unit output. |
| 3 | **Overall Cleanliness & Housekeeping** | yes | no | no | | n/a | n/a | | Small amount of issues seen |
| 4 | **Mechanical Assessment** | | | | | | | | |
| 4.1 | Steam Generator (boiler) | yes | yes | yes | | | | | Units 5 and 6 were converted to natural gas firing in 2010. The vaporizer capacity was increased in 2018 to allow 100% firing capacity on both units. The unit does not see any derates due to air infiltration. Portions of the superheater and reheater were recently replaced on both units for natural gas firing, but the finishing superheater may need to be replaced due to severe misalignment. |
| 4.2 | FD and ID Fans and Auxiliaries | yes | yes | yes | | | | | No major issues noted. Fan amps and capacity never been an issue. Steam coils are in poor shape but only required for use when firing HFO. This is not a concern unless HFO firing is expected to increase in the future. |
| 4.3 | High Energy Piping (HEP) | yes | yes | no | | | | | hangers were replaced in 2006, drains and welds are checked during each environmental outage. Unit 6 has experienced historical expansion issues but these have been resolved. |
| 4.4 | Condensate System | yes | yes | yes | | | | | Polishing system is original and is working well since the controls upgrade. |
| 4.5 | Feedwater System | yes | yes | yes | | | | | No issued noted by the plant. |
| 4.6 | Turbine and Auxiliaries | yes | yes | yes | | | | | No issued noted by the plant. |
| 4.7 | Circulating Water and Closed Cooling Water Systems | yes | yes | yes | | | | | Tube plugging not an issue. Circ Wtr pumps and motors being refurbished one at a time. |
| 4.8 | Compressed Air Systems | yes | yes | no | | | | | Modifications to compressor area have improved peformance. |
| 4.9 | Emission controls | no | yes | no | n/a | n/a | n/a | **n/a** | No emissions controls installed |
| 4.10 | Fuel Systems | yes | yes | no | | | | | No issues noted by the plant |
| 4.11 | Seawater Intake | yes | yes | no | | | | | No biological fouling of intake system. Intake screens and wash pumps being replaced to meet 316b |
| 4.12 | Water Treatment | yes | yes | no | | | | | 400% capacity RO system installed in 2015. Original 200% capacity mixed bed available as backup. |
| 4.13 | Underground Piping | no | yes | no | | | | | Pressure integrity is good, per plant input. Cathodic protection is used and is replaced when needed. |
| 4.14 | Fire Protection Systems | no | yes | no | | | n/a | | Jockey pump remains off - system holds pressure; No issues noted by the plant |
| 5 | **Electrical Assessment** | | | | | | | | |
| 5.1 | Generator | yes | yes | no | | | | | No issues noted by the plant |
| 5.2 | Transformers | yes | yes | no | | | | | No issues noted by the plant |
| 5.3 | Switchgear | yes | yes | no | | | | | No issues noted by the plant |
| 5.4 | Protective Relays | yes | yes | no | | | n/a | | No issues noted by the plant |
| 5.5 | Black Start CTs | yes | yes | no | | | n/a | | Both CTs are out of service with major components delayed in the repair process. |
| 6 | **Instrument and Controls Assessment** | | | | | | **n/a** | | |
| 6.1 | Plant Controls | yes | yes | no | | | n/a | | 2010 upgrade by Foxboro |
| 6.2 | Turbine Controls | yes | yes | no | | | n/a | | 2010 upgrade to GE Mark VI |
| 7 | **Civil / Structural Assessment** | | | | | | | | |
| 7.1 | Buildings | yes | yes | no | | | | | |
| 7.2 | Structural Steel | yes | yes | no | | | | | Some corrosion |
| 7.3 | Tanks / Containment | yes | yes | no | | | | | Fuel oil tank number 1 is damaged and out of service but does not impact the reliability of the facility. |
| 7.4 | Cranes | yes | yes | no | | | n/a | | Turbine and Laydown area bridge cranes need refurbishment |
| 8 | **Overall Condition Assessment** | | | | | | | | **Deficiencies were noted or components were out of service** |

## 3.5. STEAM UNIT 6 CONDITION

Alstom Power (now GE Power) also performed a natural gas conversion study for Unit 6, and the unit was converted to burn gas in January 2011. Modifications were made to the superheater and reheater to achieve design steaming capacity when firing 100% natural gas. These modifications include a larger superheater and reduction in reheat surface area. The original Alstom Power thermal analysis was not provided to determine the expected performance or recommendations when switching to natural gas firing.

The last boiler inspection was in 2009. Several indications were noted but are repairable. The reheat outlet header has deep cracking in the interior girth weld, which is a concern and requires immediate investigation since it was indicated 10 years ago. Further investigation is needed on all components during the next boiler inspection.

Similar to Unit 5, operating without the air preheat steam coils when burning gas is acceptable. With a fuel mixture, the steam coils should still be operated to keep the flue gas temperature above the sulfuric acid dew point temperature at the cold end of the rotary air heater. The Plant, however, plans to operate mainly on 100% gas, and repairing the steam coils is a low priority. They will be left in place on the 1,750-hp FD fan inlets to filter the combustion air.

The 2,250-hp gas recirculation fan is out of service. Similar to the air preheat steam coils, the recirculation fan is not necessary when primarily burning natural gas. The Plant does not plan to maintain the fan or return it to service.

The steam turbine and the main steam stop and control valves were overhauled in 2010. The HP/IP/LP rotors were removed from the Unit 6 turbine and sent for repairs. These rotors will be reinstalled in Unit 6 upon their return.

Three of the seven feedwater heaters are out of service on Unit 6 (#3, #6 and #7), which limits the ability of the unit to reach full load. The heater repairs will include using explosive plugs to fix leaks. Flow accelerated corrosion has not been an issue on the unit. The replacement air heater baskets currently on site for Unit 6 will be installed during this outage.

Unit 6 is undergoing repairs due to the recent earthquake. A summary of the recent earthquake damage is found in Section 3.2. Our overall condition assessment summary of Costa Sur Unit 6 can be found in Table 3-4. Sargent & Lundy observed the major equipment and components for Unit 6 to be in generally well maintained considering its age and are in line with similar units built in the late 1960s to early 1970s.

### Table 3-4 — Costa Sur Unit 6 Overall Condition Assessment

| Item | System | Assessment Method | | | Scoring Category | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | Visual | Interview | Data | End of Life | Reliability | Unit Output | Subtotal | |
| 1 | **Safety Hazards** | yes | no | no | | n/a | n/a | | sweating of natural gas piping throughout the facility causing puddles and potential slip hazards. Plant has plans to install insulation to help with sweating of pipe. |
| 2 | **Corrosion Control** | yes | no | no | | n/a | | | On-going maintenance activity and concern; not affecting unit output. |
| 3 | **Overall Cleanliness & Housekeeping** | yes | no | no | | n/a | n/a | | Small amount of issues seen |
| 4 | **Mechanical Assessment** | | | | | | | | |
| 4.1 | Steam Generator (boiler) | yes | yes | yes | | | | | Units 5 and 6 were converted to natural gas firing in 2011. The vaporizer capacity was increased in 2018 to allow 100% firing capacity on both units. The unit does not see any derates due to air infiltration. Portions of the superheater and reheater were recently replaced on both units for natural gas firing but a crack in the interior RH girth weld should be investigated further. |
| 4.2 | FD and ID Fans and Auxiliaries | yes | yes | yes | | | | | No major issues noted. Fan amps and capacity never been an issue. Steam coils are in poor shape but only required for use when firing HFO. This is not a concern unless HFO firing is expected to increase in the future. |
| 4.3 | High Energy Piping (HEP) | yes | yes | no | | | | | hangers were replaced in 2006, drains and welds are checked during each environmental outage. Unit 6 has experienced historical expansion issues but these have been resolved. |
| 4.4 | Condensate System | yes | yes | yes | | | | | Polishing system is original and is working well since the controls upgrade. |
| 4.5 | Feedwater System | yes | yes | yes | | | | | No issued noted by the plant. |
| 4.6 | Turbine and Auxiliaries | yes | yes | yes | | | | | No issued noted by the plant. |
| 4.7 | Circulating Water and Closed Cooling Water Systems | yes | yes | yes | | | | | Tube plugging not an issue. Circ Wtr pumps and motors being refurbished one at a time. |
| 4.8 | Compressed Air Systems | yes | yes | no | | | | | Modifications to compressor area being requested |
| 4.9 | Emission controls | no | yes | no | n/a | n/a | n/a | **n/a** | No emissions controls installed |
| 4.10 | Fuel Systems | yes | yes | no | | | | | No issues noted by the plant |
| 4.11 | Seawater Intake | yes | yes | no | | | | | No biological fouling of intake system. Intake screens and wash pumps being replaced to meet 316b |
| 4.12 | Water Treatment | yes | yes | no | | | | | 400% capacity RO system installed in 2015. Original 200% capacity mixed bed available as backup. |
| 4.13 | Underground Piping | no | yes | no | | | | | Pressure integrity is good, per plant input. Cathodic protection is used and is replaced when needed. |
| 4.14 | Fire Protection Systems | no | yes | no | | | n/a | | Jockey pump remains off - system holds pressure; No issues noted by the plant |
| 5 | **Electrical Assessment** | | | | | | | | |
| 5.1 | Generator | yes | yes | no | | | | | No issues noted by the plant |
| 5.2 | Transformers | yes | yes | no | | | | | No issues noted by the plant |
| 5.3 | Switchgear | yes | yes | no | | | | | No issues noted by the plant |
| 5.4 | Protective Relays | yes | yes | no | | | n/a | | No issues noted by the plant |
| 5.5 | Black Start CTs | yes | yes | no | | | n/a | | Both CTs are out of service with major components delayed in the repair process. |
| 6 | **Instrument and Controls Assessment** | | | | | | **n/a** | | |
| 6.1 | Plant Controls | yes | yes | no | | | n/a | | 2010 upgrade by Foxboro |
| 6.2 | Turbine Controls | yes | yes | no | | | n/a | | 2010 upgrade to GE Mark VI |
| 7 | **Civil / Structural Assessment** | | | | | | | | |
| 7.1 | Buildings | yes | yes | no | | | n/a | | |
| 7.2 | Structural Steel | yes | yes | no | | | | | Some corrosion |
| 7.3 | Tanks / Containment | yes | yes | no | | | | | Fuel oil tank number 1 is damaged and out of service but does not impact the reliability of the facility. |
| 7.4 | Cranes | yes | yes | no | | | n/a | | Turbine and Laydown area bridge cranes need refurbishment |
| 8 | **Overall Condition Assessment** | | | | | | | | **Deficiencies were noted or components were out of service (unit currently in an outage)** |

## 3.6. BLACK START GAS TURBINES CONDITION

The John Brown GTs are owned, maintained, and operated by PREPA's Hidro Power division. The GTs are used for peaking and black starts and are currently in repair (damaged from Hurricane Maria). Black start capacity must be taken from outside the plant. GT #1.1's generator was damaged by Hurricane Maria in 2017. An order was placed for a replacement generator, but its fabrication has been stopped for lack of payment from PREPA. GT #1.1 remains offline, and its return to service was unknown at the time of this report. GT #1.2's turbine rotor and compressor section were removed in 2015 and have remained in the San Juan maintenance shop for repairs. Due to budget constraints and lack of funding for the repairs to the

GT #1.2 turbine, a yard-stored turbine unit decommissioned from the Central Hidro Gas Mayagüez Plant was installed in the GT #1.2 enclosure and is being restored in an attempt to return it to service. PREPA staff estimates that the replacement turbine has over 5,000 remaining hours before it will require its next major inspection overhaul. This restoration work was paused temporarily in mid-2021 but is expected to resume in October 2021, with a target for GT #1.2 testing in January 2022.

PREPA is considering the replacement of these GTs with two new approximately 30 MW black start GT generators. Each GT would be able to operate on natural gas or No. 2 fuel oil and would be designed for peaking operation or black start of the Costa Sur facility.

**Figure 3-1 — Black Start Gas Turbines**

Both GTs are #2 diesel-fueled and both are currently out of service but being repaired.

## 3.7. COMMON SYSTEMS CONDITION

Components are repaired or replaced on Units 5 and 6 and in the facility as needed. For example, Figure 3-2 shows a pair of recently installed blowers for the Unit 5 Gland steam exhausters. Pipe supports are a common system requiring attention.

**Figure 3-2 — Gland Steam Exhauster Blowers**

Unit 5 and 6 control system was upgraded in February 2020 which included:

- 5 servers
- 7 workstations
- 6 switches and 19 monitors
- Cyber security servers

A new 100/15 Ton Zenar Crane was recently installed.

Vegetation is trimmed and sprayed monthly by an outside contractor and is under control.

**Figure 3-3 — Vegetation Management Example**

### 3.7.1. Natural Gas, Units 5 and 6

Units 5 and 6 are successfully operating with 100% natural gas on a regular basis and can both operate at 100% firing capacity. The EcoEléctrica power plant can now supply enough gas to support full load on both Costa Sur Units 5 and 6. The natural gas PRV (PRV) station was recently upgraded to achieve 100% firing capacity and added redundancy (2x100%). There are two trains per PRV station, and three of the four trains will be needed to support a 2 x 410 MW operation.

The natural gas piping delivery system is experiencing surface condensation, i.e., sweating and dripping of water off the pipes. Operating sound levels for the pressure reduction system are above 85 A-weighted decibels due to the significant pressure drop through the system. The operating A-weighted decibels levels are higher-than-normal design practice. The gas pipe condensation is pooling throughout the facility and could be a slip hazard to Plant personnel. Rubber insulation is planned to be installed on the gas piping in the 2021 timeframe to deter the condensation and deaden some of the noise. Noise barriers around the pressure-reducing stations should also be considered.

### 3.7.2. Heavy Fuel Oil

The Plant exercises the fuel oil systems for Units 5 and 6 every two to five months to keep the equipment in working order. In 2015, one of the large HFO reserve Tanks, #1R, collapsed. The other two large HFO tanks, #2R and #3R, were inspected after that failure, and it was determined they did not have the same center support issue that caused yielding on Tank #1R. HFO service Tank #4S is out of service. The leaks in HFO service Tank #5S have been repaired and its inside re-coated. However, with natural gas now being the primary fuel, the two HFO service Tanks #4S and #5S will either remain empty or possibly repurposed.

PREPA is currently applying an epoxy coating to mitigate corrosion on reserve tanks #2R and #3R. PREPA currently has a Tank Inspection Program, per API Code and SPCC compliance, planned in the next six years.

### 3.7.3. Circulating Water System, Units 5 and 6

New traveling screens will be installed for 316(b) compliance as will two new stainless-steel screen wash pumps. The replacement of the traveling screens will begin first quarter of 2021 and is expected to be completed during the first quarter of 2022.The circulating water pumps see heavy fouling from the seawater application. Circulating water pump #4 1,000-hp motor was recently rewound. Circulating water pumps #1, #2, #3, #4 and #5 were recently rebuilt and back onsite. Circulating pump #1, #2 and #3 has new stainless-steel discharge piping. The main condenser has a tube cleaning system that is used every couple of months. The unit operates at reduced load during the cleaning and a shutdown is not required.

### 3.7.4. Plant Electrical System

The condition of the major electrical equipment on Units 5 and 6 is consistent with its age. Most of the major electrical equipment is original, with a few exceptions where equipment has been replaced as needed. All generators, power transformers, switchgear, batteries, and relays undergo periodic maintenance and testing. The Unit 5 and Unit 6 generator rotors were replaced and their stators rewound in 2013 and 2010, respectively. Additionally, the medium-voltage switchgear breakers for Units 5 and 6 were replaced with new ones. The existing cabinets and relays were reused. New low-voltage switchgear breakers are on order to replace the existing ones.

Transformer test results from 2018 indicate some overheating of cellulose and oil, as well as low volumes of combustible gases. While this is not an immediate concern, continued periodic testing is recommended. Recent reports were not available for review.

The Plant has three battery banks, and Plant staff informed Sargent & Lundy in 2019 that they planned to add a fourth in the electrical control room; however, Sargent & Lundy was not provided an update for this report. Currently, the battery bank for Units 3 and 4 feed direct current power to the electrical control room. The new battery will feed the electrical control room and also provide redundancy to the batteries for Units 5 and 6 since it will be sized to back up those systems. Both the batteries for Units 5 and 6 have been replaced recently as well as all four battery chargers that provide power to them. The Plant also upgraded the ABB Cyberex uninterruptible power supply system for Units 5 and 6, doubling the capacity to 30 kV amperes.

The condition of the major electrical equipment on Units 3 and 4 is consistent with its age. Most of the major electrical equipment is original and nearing the end of its useful life, but some equipment has been replaced as needed. Additionally, the generators are out of service and not on turning gear.

### 3.7.5. Instrument Air

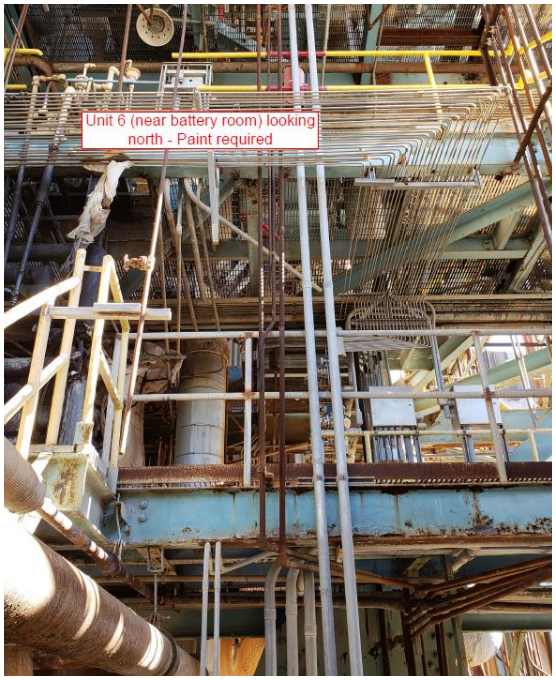
The instrument air systems on Units 5 and 6 are able to produce and maintain dry air. They have four dryers with activated alumina desiccant. The dryer company is out of business, but the Plant has located another company to maintain the dryers. New Unit 5 dyers are on order, and the air system controls will be upgraded. The Unit 5 air compressor area has been refurbished (cleaner; has helped reliability), and the Plant is preparing a proposal for PREPA approval to implement the same changes on Unit 6.

### 3.7.6. Corrosion

Corrosion control is an example of on-going corrective and preventative maintenance. Uninsulated or uncoated lines and tanks are particularly vulnerable to corrosion in the coastal climate. Years ago, most items were scraped and coated regularly in the Plant. The Plant’s budget and staffing for corrosion control has decreased over the years; however, they recognize its importance to safety and operations and therefore continue to address the issue. The most damaged area by corrosion are the condenser, condenser circulator water pump and the discharge pipes. PREPA has invested $1.7 Million to address these areas with an epoxy and carbon fiber coating. In addition, the cathodic protection for the condenser will be modified. The figures and descriptions below illustrate the current level of corrosion on Units 5 and 6.

The structural steel on Units 5 and 6 is only partially painted. The Unit 6 boiler was scheduled to be painted along with its stack but it’s unclear if and when this would occur. New stack insulation was also planned to be installed. The stack ladders on Units 5 and 6 were replaced in the summer of 2018.

**Figure 3-4 — Corrosion Examples, Units 5 and 6**





The closed cooling water system is in good operating condition but has some corrosion and scaling. The system had some earlier chemistry issues since phosphate and some other chemicals were banned from use in the 1990s, and it had some recent issues after the water chemistry contractor went out of business. The chemical feed supply and implementation is now administered by GE-SUEZ, a private contractor.

**Figure 3-5 — Cooling Tower Corrosion, Units 5 and 6**


The Plant will backwash the fill to remove the scaling.

All the main condenser water boxes on Units 5 and 6 have cathodic protection that provides significant corrosion protection inside the condenser. Another concern inside the condensers is microfouling. The positions of the water box sluice gates are varied every two to three days, and the subsequent flow changes decrease microfouling in the water boxes and the condenser tubes. This also reduces turbine backpressure and helps to keep the gates from binding. The Plant inspects the sluice gates every outage. There are four water boxes per main condenser, and they are coated on the inside, which also deters corrosion and microfouling.

### 3.7.7. Fire Protection

The fire protection system pressure is reasonable, and the jockey pump remains off. The Plant has a dedicated 400,000-gallon fire water tank and a diesel generator for backing up the electric fire pumps. They also maintain foam systems local to the fuel oil tanks. A fire wall has been installed between the Units 5 and 6 main power transformers.

## 3.8. RECOMMENDATIONS

Sargent & Lundy's recommendations based on these condition assessments are provided below. PREPA will likely execute all of them as part of their normal operations. Unless noted, the recommendations apply to only Units 5 and 6. These are followed by a discussion of the current use of Unit 3's and Unit's 4 equipment for Units 5 and 6, and a summary of considerations for improved corrosion control.

- Schedule and plan for routine boiler inspections and address any major issues.
- Continue operating on natural gas because this improves emissions and will extend the lives of the units.
- Continue to operate with a blend of HFO and natural gas a few times yearly to exercise the HFO equipment.
- Circulate the HFO in the storage tanks on a regular basis.
- Upgrade the Unit 6 compressed air area similar to the modifications done for Unit 5.
- Continue monitoring the transformers for overheating and the release of combustible gas.

### 3.8.1. Repowering Considerations

Units 3 and 4 had minimal operation in 2016 and have not operated since. The reasons include MATS compliance, safety, and economics. The boilers are in poor condition, but the balance-of-plant systems and the steam turbine generators may be salvageable. A Unit 4 BFP is used to assist Units 5 and 6 during startup. This assistance is discussed below and should be considered with the repowering recommendation in Section 9.

An important consideration in deciding a path forward for Units 3 and 4 is that the Plant uses Unit 4 BFP 4-1 when starting Units 5 and 6. The motor-driven BFPs on Units 5 and 6 can be used for startup, but the Unit 4 BFP has a reduced pressure surge when starting, lessening the negative impact on the feedwater heaters and the feedwater control valves. BFP 4-2 is out of service with a two-year lead time on its electrically isolated bearings. It is not practical to use the Unit 3 BFPs for starting Units 5 and 6. The Unit 3 BFPs, shown in the background of Figure 3-6, are not identical to Unit 4's BFPs and therefore are not practical to swap out because of different balancing drum piping configurations and water sources. However, the Plant is installing piping to allow demineralized water from Units 3 and 4 to become a backup source for Units 5 and 6.

**Figure 3-6 — Unit 4 BFP 4-1**


### 3.8.2. Enhanced Corrosion Control

Care must be taken to ensure that replacements or upgrades to the plant are suitable for an aggressive, salt-laden marine environment exposed to coastal winds. Typically, original equipment manufacturer standards for power generation and balance-of-plant equipment are not well-suited for direct exposure to an ocean-side environment. Care must be taken to ensure that new equipment is fully suitable to the challenging operating environment at Costa Sur. Failure to make allowances for suitable materials, equipment selection, buildings/enclosures, and other aspects of the facility design to protect the Plant from the harsh and corrosive operating environment will result in excessive future O&M costs and a shorter plant design life for any new installation. Suitable specifications appropriate for this location include corrosion-resistant material requirements; marine-specific coatings; appropriate welding selections and special treatment of metal seams and stitched connections; fastenings with sealants, gaskets, and coatings; and increased use of protective equipment enclosures.

# 4. INFRASTRUCTURE AND INTERCONNECTIONS

## 4.1. NATURAL GAS SUPPLY

Natural gas has become the primary fuel for Units 5 and 6 and is supplied via a pipeline from the EcoEléctrica natural gas power plant located approximately 1.6 miles from the Plant. Liquefied natural gas is delivered to the unloading port at the EcoEléctrica power plant. It is stored in a 42-million-gallon insulated tank at near atmospheric pressure and cryogenic conditions. The liquefied natural gas is drawn for regasification as required by the demand of Costa Sur and the EcoEléctrica natural gas power plants.

PREPA (as the buyer) entered a Natural Gas Sale and Purchase Agreement with Naturgy Aprovisionamientos S.A. (as the seller), which became effective April 1, 2012 and was amended on March 10, 2014, May 11, 2015, and June 29, 2017. The contract originally expired on December 31, 2020, but was extended to September 30, 2032 through an amended and restated agreement dated March 23, 2020.

## 4.2. FUEL OIL SUPPLY

No. 2 fuel oil and HFO are delivered through pipelines from the Commonwealth Oil Refining Company, Inc. refinery and stored on site in multiple tanks. HFO is the backup fuel for Units 5 and 6. The No. 2 fuel oil is burned in the GTs used for peaking operation and black starts, but they are currently out of service for major repairs.

On July 31, 2015, PREPA entered a Fuel Oil Purchase Contract (Contract Number 902-02-15) with Freepoint Commodities LLC for the supply of HFO to the Aguirre Steam, Costa Sur, Palo Seco Steam, and San Juan Steam plants. The contract has been extended for additional years through various amendments. PREPA and Freepoint Commodities finalized the fifth amendment to the contract which extended the term until October 31, 2021. Any new owner or operator of the facility is subject to the terms of the contract; however, the new owner or operator may terminate the contract with 180 days of notice. PREPA plans to seek competitive bids to secure its next contract.

On November 21, 2019, PREPA entered a contract (Contract 902-01-19) with Puma Energy Caribe for the supply of No. 2 fuel to all the PREPA plants that operate with this fuel. The original term of the contract was for one year, but the contract includes a provision for an automatic extension upon mutual agreement. PREPA and Puma Energy Caribe extended the contract until November 20, 2021.

In 2021, PREPA will undergo a competitive process to secure its next No. 2 fuel oil supply agreement.

### 4.3. PROPANE SUPPLY

Liquefied propane gas is delivered by truck to the existing PREPA tanks on site. Propane is used to ignite the burners on the boilers when natural gas is not available. PREPA entered a Fuel Purchase Contract for liquefied propane supply (Contract Number 902-08-15) with the Liquilux Gas Corporation. The contract began in March of 2016 and was extended to March of 2019. The price has a $0.3575/gallon fixed component and an escalator factor. Sargent & Lundy was not provided a new or extended contract.

### 4.4. WATER SUPPLY

PREPA's Deep Well 8, 9, 10, and 13 are the primary source of fresh water to the Plant. They are located about 5 miles away from the Plant. A line from the EcoEléctrica desalination plant provides a backup source.

# 5. OPERATIONS AND MAINTENANCE

The Plant is generally producing power 24 hours a day, 7 days a week. The Plant cycles as directed by PREPA dispatch and is rarely at full load. Nighttime production is typically at the minimum stable load on both Units 5 and 6. The staff uses the control room as the center of operations. Daily meetings are used to direct activity and to coordinate efforts among the staff.

## 5.1. STAFFING AND TRAINING

The Plant has three main departments that respond to the Plant manager: Operations, Administrative, and Maintenance. The Plant staffing level was 175 in 2019, which was down considerably from the nearly 300 people that manned the Plant years ago. Sargent & Lundy requested the current Plant staffing level; however, it has not been provided. However, a staff of 175 is in line with similar plants of this size.

The operations department works three shifts, staffing the plant 24 hours a day, 7 days a week. During normal operations, maintenance staff is on site for one shift daily, Monday through Friday. This includes staffing of the precision machine shop on the premises. Extended hours and additional personnel are used during outages. During each shift, the Shift Engineer oversees the Plant operations and management.

The Units 5 and 6 control room has a simulator for the boilers and steam turbines that is used for training, troubleshooting, and experimentation. The demineralized water system also has a simulator for these objectives.

## 5.2. MAINTENANCE PROGRAMS

### 5.2.1. Overview

Units 5 and 6 have regular outages at intervals of 12 to 18 months for maintenance and environmental reasons, per the EPA agreement and PREPA management requirements. In general, the frequent scheduled outages provide time for much of the deferred maintenance items. Many maintenance items are delayed as necessary to the next scheduled outage as parts and supplies become available.

During an environmental outage, routine maintenance activities are performed. The boiler and other components are cleaned, inspected, and replaced if necessary. Larger scopes of work requiring a longer outage are scheduled as needed. Upgrades and significant design modifications are planned during the major overhauls.

The main objective of PREPA's maintenance plan is to use preventative maintenance in conjunction with predictive techniques developed at the Plant level. Maintenance is performed using the original equipment manufacturers specifications, Plant experience, plant routine inspections, equipment monitoring, and O&M manuals as applicable. Rotors and motors are sent to contractors to be rebuilt. There is not a standing formal service agreement with specialist manufacturers, but GE is normally used for boiler and turbine inspections and parts. The plant has extensive workshop capability and is mostly self-reliant for repairs of equipment.

### 5.2.2. Mandatory Environmental Outage

Each PREPA thermal production plant is mandated to perform an environmental outage at intervals of 12 to 18 months. During an environmental outage, the boiler and other components are cleaned to meet the requirements of the Air Compliance Preventative Maintenance Schedule contained in PREPA's Consent Decree with the Environmental Protection Agency (EPA). Each plant may keep a unit in service for up to an 18-month limit, subject to the unit's compliance with the emissions criteria in the Consent Decree.

Several areas are inspected, cleaned, and replaced (if necessary) during each environmental outage:

- At the start of an environmental outage, slag is removed from the boiler and the water walls are cleaned.
- The superheater, reheater, air heater, economizer areas, and the exhaust gas ducts and the stack are washed and inspected.
- Air heater components, seals, baskets, casing, and sector plates are inspected and replaced as necessary. Ductwork is repaired.
- Hoppers are emptied and cleaned, and expansion joints are inspected for corrosion and leakage.
- Fuel handling equipment is inspected, repaired, and recalibrated as necessary.
- The FD and ID fans and the gas recirculation fan are cleaned, noise and vibration levels are monitored, adjustments made, and repairs completed.
- Motors for fans and main boiler pumps are cleaned and inspected. Dampers are inspected and adjusted.
- The windbox, burners, combustion air instrumentation, combustion controls, and soot blowers are inspected; damaged or worn components are either repaired or replaced.
- Monitors for opacity, oxygen, and furnace pressure are cleaned, recalibrated, or replaced as necessary.
- Pumps, feedwater heaters, the deaerator, and associated valves are inspected.
- Lubricating oil systems are inspected.

- Power transformers are inspected and breakers tested and adjusted.
- If a pressurized part of the boiler has been replaced, the boiler part will be pressure tested before the unit returns to service.
- Life extension inspections and non-destructive examination activities are completed on critical systems and components in preparation for future programmed outages.

Plant personnel indicated that all these maintenance activities are conducted during each environmental outage and Sargent & Lundy has confirmed this by reviewing outage summary reports.

### 5.2.3. Preventative Maintenance

The Plant uses technical services from GE for turbine inspections. The Units 5 and 6 steam turbine valves are inspected regularly, and the scope includes cleaning, non-destructive examination, and adjusting HP stop and control valves, reheat stop valves, and intercept valves. Major inspections of the steam turbine are performed every 50,000 equivalent service hours.

Unit outages are now on eight-year spacing instead of six years. Maintenance is planned for these outages on Units 5 and 6 for items like major boiler and turbine inspections and refurbishments and inspecting, refurbishing, or replacing pipe hangers, valves, valve actuators, damper actuators, condenser cleaning, and drain trap replacements. Most of the hangers in the Plant are still original. Requisitions for new equipment and upgrades are routed through the main office in San Juan where parts and supply requests have been delayed or deferred as deemed necessary.

### 5.2.4. Corrective Maintenance

Plant operations staff reports recording maintenance and operational issues in hard copy logs maintained at the site. The issues are prioritized by Plant and PREPA corporate management. The Plant staff attends to these issues when possible during forced and scheduled outages.

### 5.2.5. Predictive Maintenance

Vibration, oil analysis, and thermography data collection and analyses were done in-house by PREPA until recently. A sub-contractor specializing in these predictive maintenance activities was selected to perform this work going forward. No abnormalities were identified by site personnel for the main steam and generation equipment vibration readings. Sargent & Lundy found the vibration readings provided for review from the Units 5 and 6 Bently Nevada steam turbine generator supervisory systems to be within reasonable limits.

## 5.1. MAINTENANCE AND OUTAGE SCHEDULES

The outage schedule is currently unknown. Sargent & Lundy requested the historical and planned outage schedule from PREPA but it was not received. The recent outages at Units 5 and 6 included the following:

Common:

- PREPA currently has a Tank Inspection Program, per API Code and SPCC compliance, planned in the next six years for all power plants. The detailed timing for Costa Sur was not provided.
- A fuel line inspection program is planned for all PREPA power plants in the next six years for code compliance, maintenance, and life extension; however, the detailed timing of the program for Costa Sur was not provided.
- Condition assessment programs for the boilers and high energy piping are also planned in the next six years. The detailed timing of the program for Costa Sur has not provided.

Unit 5:

- An environmental outage was completed in March 2020.
- Major outage in 2020 was completed in July 2020 due to the recent earthquake. The outage work included structural steel repairs, desuperheater link piping replacements, high energy line inspections and repairs, etc.

Unit 6:

- An environmental outage was ongoing and expected to be completed in January 2021.
- As of the end of 2020, was in a major outage due to the recent earthquake. This outage work included structural steel repairs, desuperheater link piping replacements, high energy line inspections and repairs, turbine HP/IP/LP rotor replacement, miscellaneous seal repairs, air heater basket replacement, etc.

## 5.2. SPARE PARTS

PREPA provided spares list for the Plant at the end of 2018, which identified a multitude of small parts as well as air heater baskets, generator rotor, low pressure and IP turbine rotors, pump impellers, and capital valves. Tracking for local spares is done by hand and through the corporate asset management program. Some of the larger spares on site were viewed during our visits.

The Plant stores spares in a climate-controlled building, non-conditioned enclosures, and outdoors as shown in the figure below.

**Figure 5-1 — Storage Building**

Temperature- and humidity-controlled storage building on the left for spare motors and other parts. Propane tanks on the right.

Costa Sur's sister units, Aguirre Units 1 and 2, currently has several pressure part components (for natural gas firing) that were not installed. These components along with natural gas fuel trains are currently being stored outdoors at the Aguirre facility. The equipment appears in good condition, but a detailed assessment is recommended prior to implementing a gas conversion for the units. Sargent & Lundy recommends long-term preservation, such as relocating the equipment to indoor storage, is pursued for all purchased equipment for natural gas firing and for potential use for Costa Sur Units 5 and 6.

## 5.3. ENERGY MANAGEMENT SYSTEM

PREPA, at the corporate level, employs numerous automated control applications to ensure safe and reliable operation of its system. These applications coordinate with or are integrated into larger systems that support PREPA's routine technical and commercial operations. PREPA uses controls and an energy management system (EMS) to regulate the supply-side generation of electricity to match real-time electric power demand from the users.

In 2012, a supplier provided an updated EMS to replace the older system then employed. The 2012 system updated the generation mixture to include intermittent and renewable generation to reflect the new supply-side resources becoming available due to mandated legislation. The EMS also incorporated cyber-security compliance with the North America Electric Reliability Council's infrastructure standards. In addition to upgrading the EMS, the supervisory control and data acquisition functionality was also updated to link the central EMS with the generation plants and substations.

# 6. PERFORMANCE REVIEW

To evaluate the performance of the Plant, Sargent & Lundy reviewed historical operating performance provided by PREPA of Units 5 and 6 and GT #1.1 and GT #1.2 of the Plant and benchmarked it against a group of industry peer units where data was available. Although provided, Sargent & Lundy did not include Units 3 and 4 in this review due to their expected decommissioning. Primary performance indicators reviewed include:

- Generation
- Equivalent Availability Factor (EAF)
- Equivalent Forced Outage Rate (EFOR)
- Net Capacity Factor (NCF)
- Net Heat Rate

NCF is the annual net energy production as a fraction of the energy that would be produced if a plant operated at its rated capacity 100% of the time. EAF is a measure of an electric generating unit's availability where it is a percentage of time that the unit has been available during a specified time period, including the impact of deratings (times when the unit is operating at a lower power output). EFOR is a measure of an electric generating unit's unreliability. It is the percentage of time that a unit is in a forced outage during a specified time period, including the impact of forced unit.

PREPA provided operation data for the past six full years of operation, 2015 through 2020. Sargent & Lundy also reviewed data cataloged by the North American Electric Reliability Corporation (NERC) within their Generating Availability Database System (GADS)[3] and established a peer group of units comparable to Costa Sur Unit 5 and 6 and a separate peer group for GT #1.1 and GT #1.2 to compare reliability data.

Sargent & Lundy applied the selection criteria identified in Table 6-1 to the NERC GADS database[4] to establish the reliability peer group for steam Units 5 and 6. The resulting peer group that reflects these unit characteristics included 67 units, owned by 32 different operators, with the dataset including 417.75 operating years of reporting data. Note that heat rate is not reported to NERC, and therefore peer group

[3] NERC maintains records of reliability information for generating stations within the United States and Canada based on data provided by the station owners and operators. These data are compiled within GADS. Within the GADS, filters can be applied to review reliability data by plant characteristics, such as plant prime mover, nameplate capacity, fuel type, and age. Filters can also be applied for plant generating statistics, such as plant capacity factor. In this way, GADS can report reliability data which are reflective of a peer group of plants with specific characteristics and generating statistics. Sargent & Lundy filtered GADS to obtain reliability statistics which reflect a peer group of units similar to the Costa Sur units.
[4] Accessed via pc-GAR software on November 2, 2020. Version: PC-GAR v4.01.16

data is not presented in this report. Table 6-2 provides a summary of the key performance data for Costa Sur Units 5 and 6 and the peer group.

**Table 6-1 — Costa Sur Steam Units Peer Group**

| Costa Sur Units 5 and 6 | | | Peer Group Characteristics | | |
|---|---|---|---|---|---|
| COD | Unit Gross Capacity (MW) | Operating Fuel | COD | Unit Gross Capacity (MW) | Operating Fuel |
| 1972 | 410 | Natural Gas | 1965-1980 | 300-500 | Natural Gas |

**Table 6-2 — Costa Sur Steam Units Key Performance Data Summary**

| Key Performance Indicator | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Peer Group |
|---|---|---|---|---|---|---|---|
| Generation (MWh)[1] | 5,157,096 | 4,852,240 | 3,351,740 | 3,405,620 | 4,161,520 | 1,024,910 | - |
| Equivalent Availability (%)[1] | 83.90 | 89.54 | 72.76 | 58.78 | 84.26 | 17.71 | 79.28 |
| Net Capacity Factor (%)[1] | 59.47 | 55.80 | 38.65 | 39.27 | 57.93 | 14.23 | 9.99 |
| Equivalent Forced Outage Rate[1] | 7.54 | 12.00 | 7.63 | 10.55 | 15.19 | 82.29 | 18.35 |
| Net Heat Rate (Btu/kWh)[2] | 10,883 | 11,088 | 11,603 | 11,898 | 11,870 | 11,716 | - |

[1] Values for 2015 through 2018 include statistics for Units 3-6, 2019 and 2020 include statistics for Units 5 and 6 only

[2] Btu/kWh = British thermal unit per kilowatt hour

Sargent & Lundy also applied the selection criteria identified in Table 6-3 to the NERC GADS database to establish the reliability peer group for the GT units. The resulting peer group which reflects these unit characteristics included 204 units, owned by 43 different operators, with the dataset including 1,221.25 operating years of annual reporting data. Although the units are similar, the units in the peer group primarily run on Natural Gas rather than No. 2 Fuel Oil as the GT units do. As previously noted, heat rate is not reported to NERC, and therefore peer group data is not presented in this report. Table 6-4 provides a summary of the key performance data for the Costa Sur GTs and their peer group.

### Table 6-3 — Costa Sur GT Units Peer Group

| Costa Sur GT #1.1 and GT #1.2 | | | Peer Group Characteristics | | | | |
|---|---|---|---|---|---|---|---|
| Years in Service | COD | Unit Gross Capacity (MW) | Years in Service | COD | Unit Gross Capacity (MW) | Capacity Factor | Black Start Capability |
| 48 | 1972 | 21 | 40-60 | 1965-1980 | 15-25 | 0%–20% | Yes |

### Table 6-4 — Costa Sur GT Units Key Performance Data Summary

| Key Performance Indicator | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Peer Group |
|---|---|---|---|---|---|---|---|
| Generation (MWh) | 15,600 | 8,260 | 5,404 | 0 | 0 | 0 | - |
| Equivalent Availability (%) | 88.34 | 57.27 | 36.15 | 0.00 | 8.49 | 0.00 | 89.07 |
| Net Capacity Factor (%) | 4.24 | 2.24 | 1.00 | 0.00 | 0.00 | 0.00 | 0.48 |
| Equivalent Forced Outage Rate | 13.61 | 43.21 | 64.30 | 0.00 | 100.00 | 100.00 | 90.09 |
| Net Heat Rate (Btu/kWh)[1] | 14,229 | 14,379 | 14,877 | - | - | - | - |

[1] Btu/kWh = British thermal unit per kilowatt hour

## 6.1. GENERATION

Generation for Units 5 & 6 is provided in Figure 6-1 while the generation of the GT units is shown in Figure 6-2. The generation figures provide totalized information for the annual plant generation of power. Power output has decreased over the last few years for all units, coinciding with the availability of the units. Notably, power output for the steam units has been limited in 2020 due to the January earthquakes removing the units from service. Additionally, GT #1.2 has not operated since 2015 when the turbine rotor and compressor section were removed for repairs. GT #1.1 has not operated since 2017 due to damage from Hurricane Maria.

**Figure 6-1 — Costa Sur Steam Units Generation**

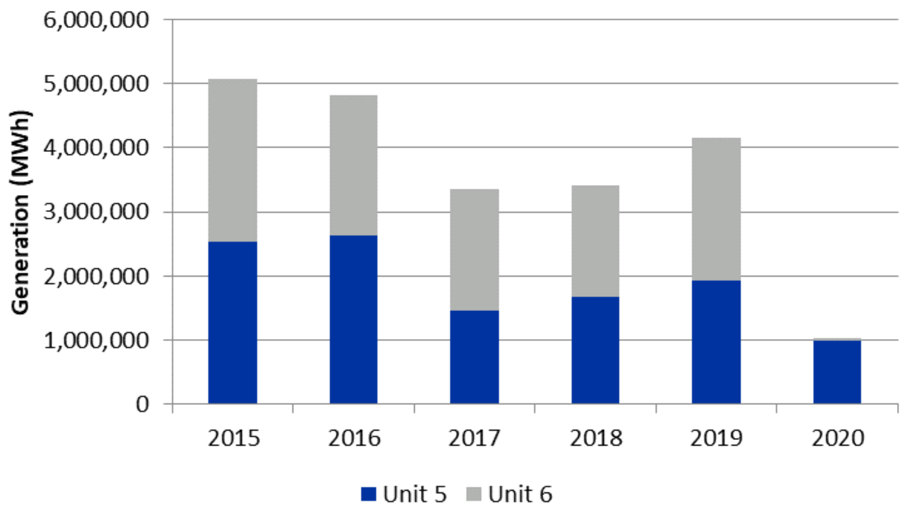
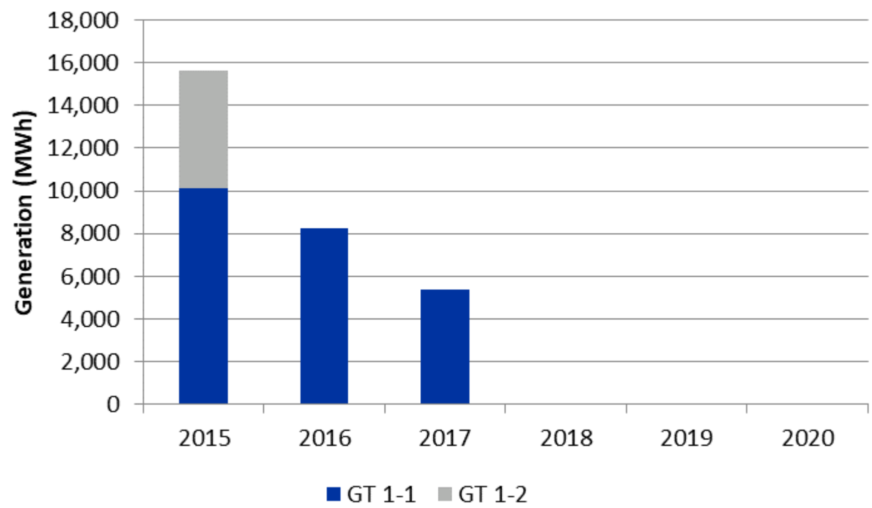



**Figure 6-2 — Costa Sur Gas Turbine Generation**




## 6.2. AVAILABILITY FACTOR

The EAF is the fraction a facility is available to generate electricity at net dependable capacity less derated conditions. EAF is calculated as follows:

EAF = ([Available hours - (Equivalent Unplanned Derated Hours + Equivalent Planned Derated Hours + Equivalent Seasonal Derated Hours)]/Period Hours] x 100

Some of the hours in the formula are considered “equivalent” because they equate a unit’s derate into outage hours. A unit is derated when it can operate but not at its rated capacity. Following the NERC procedures, this derated condition is translated into equivalent outage hours for use in the availability formula. When a unit is in an outage, it is not available to add power to the grid, and this is reflected in the “Available hours” component of the formula. If a unit is offline for an entire year, its availability is zero for that year. This is seen in the Figure 6-4 below, with the black start GTs currently offline for extended periods. Their availability decreases dramatically in 2017 and 2018 as discussed above.

Units 5 and 6 exhibited decreases in availability in 2017 and 2018, but recovered as expected in 2019 after planned work was completed as discussed in their condition assessment Sections 3.4 and 3.5. Availability of the units in 2021 was also expected to recover since being brought back online later in 2020. The availability of Units 5 and 6 are also similar to that of their peers (except for 2020).

**Figure 6-3 — Costa Sur Steam Units Equivalent Availability Factor**

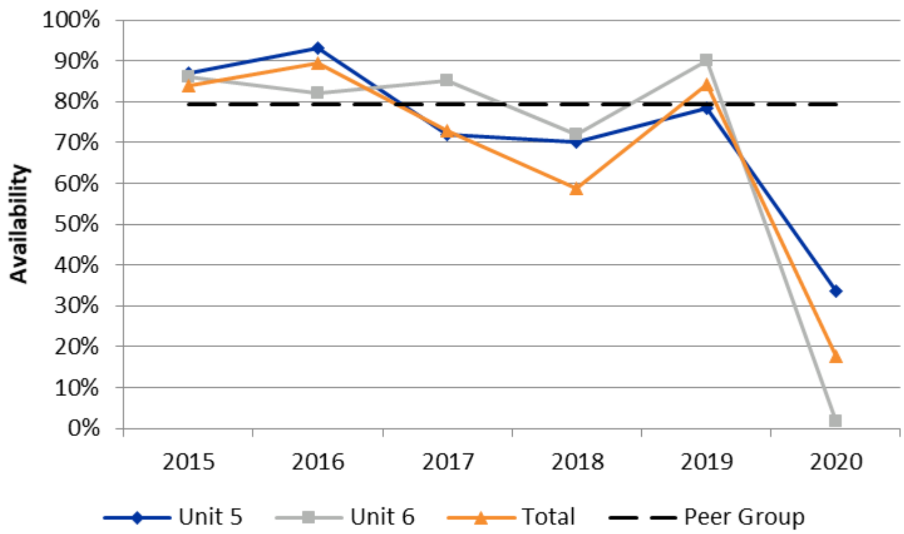
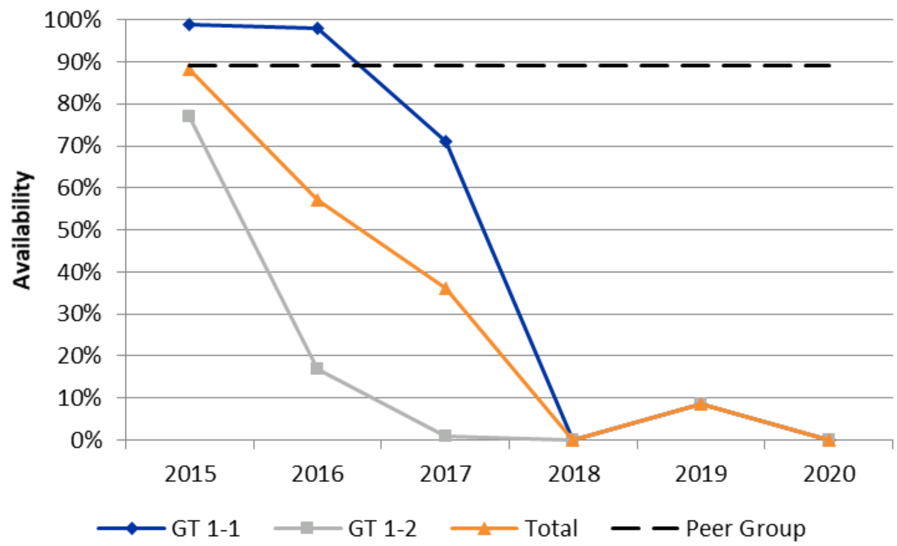


**Figure 6-4 — Costa Sur Gas Turbine Equivalent Availability Factor**




## 6.3. EQUIVALENT FORCED OUTAGE RATE

Equivalent Forced Outage Rate is a measure of the probability that a generating unit will not be available due to forced outages or forced deratings, which does not include planned or maintenance outages. In other words, EFOR is a rating to indicate how the unit is unable to respond, irrespective of system need.

EFOR = (Forced Outage Hours + Equivalent Forced Derated Hours)/(Service Hours + Forced Outage Hours + Equivalent Reserve Shutdown Forced Derated Hours) x 100

The EFOR of the steam units has remained generally below the peer group average; however, the forced outages after the January 7, 2020 earthquake has significantly impacted the Units 5 and 6 EFOR. Unit 5 increased EFOR in 2018 was due to a latent defect from Hurricane Maria in the main power transformer's connection to the grid.

**Figure 6-5 — Costa Sur Steam Units Equivalent Forced Outage Rate**

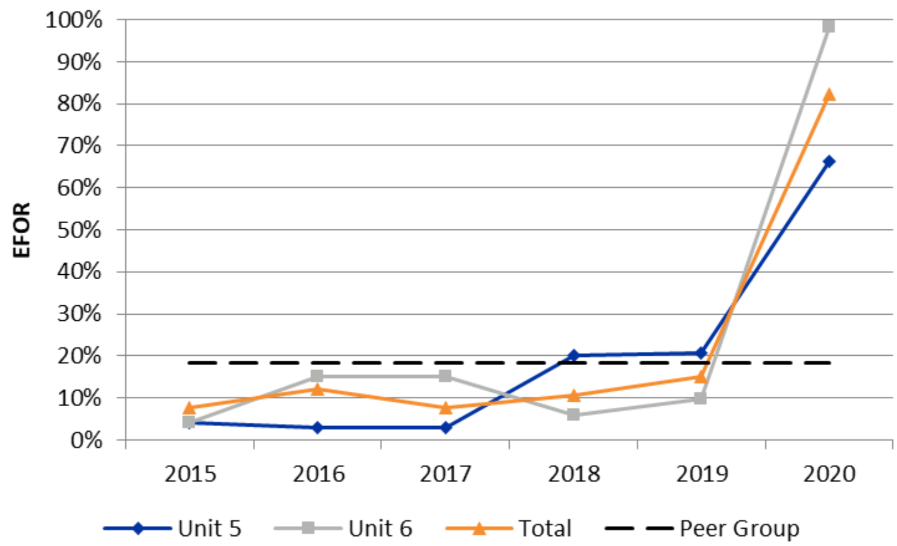
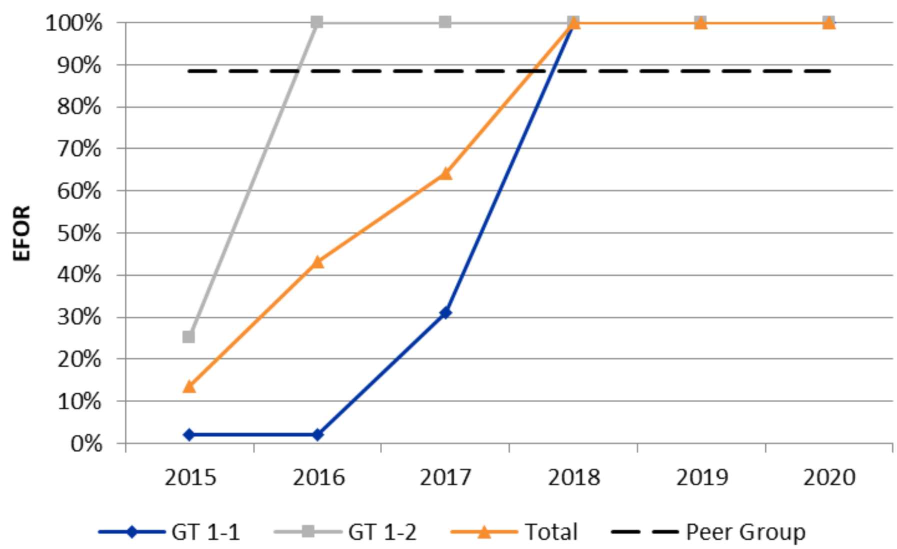



Figure 6-6 depicts the black start GT EFORs. Recall that GT #1.1 began an extended outage in 2017 and GT #1.2 began one in 2015. Refer to Section 3.6 for additional information. Although high, the GTs in the peer group have also experienced high EFOR, nearing 90% on average.

**Figure 6-6 — Costa Sur Gas Turbine Equivalent Forced Outage Rate**




## 6.4. CAPACITY FACTOR

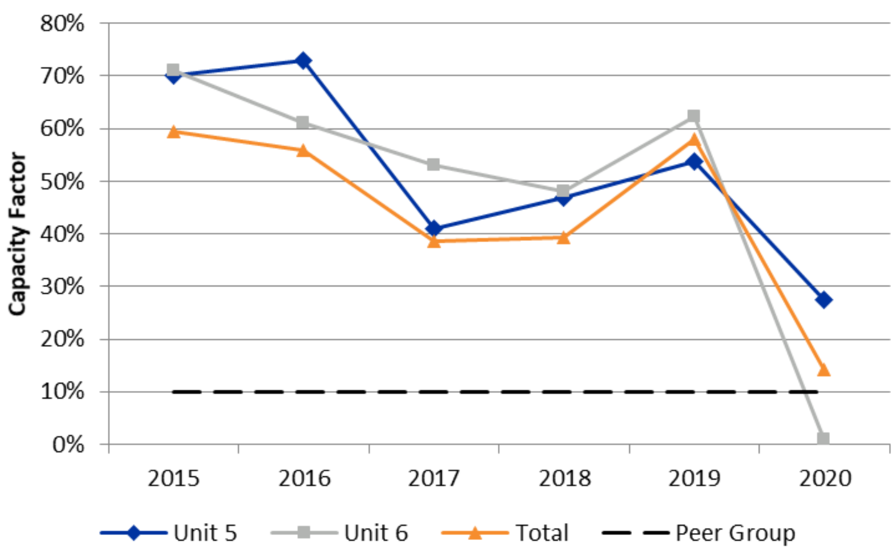
When reviewing availability and forced outage value changes, it is important to identify if the unit was being dispatched differently. In a gross fashion, the NCF provides insight into this. NCF is a percentage representing the average output of the facility during the time it was active (declared operational). The net capacity factor is calculated as follows:

NCF = (Total Net Generation/[Net Capacity at Mean Ambient Temperature x Period Hours]) x 100

The capacity factors exhibited by the Plant are plotted below and follow the same trends as annual generation. An important driver for the capacity factors and the annual generation is the dispatch demand for power. Other governing factors, such as those caused by the 2017 hurricanes and 2020 earthquakes, are disruptions to fuel and water supplies and damage to transmission and distribution systems.

The capacity factor over the last six years for Units 5 and 6 has been significantly higher than the peer group (averaging around 60% compared to 10%). This indicates that other similar units are typically dispatched as peaking units rather than as base load units as Units 5 and 6 are used, as the availability of the peer group is high. Besides system disruptions from the 2017 hurricanes and 2020 earthquakes, the units were dispatched at lower loads, and in 2018, they had reductions in their generating capacity due to issues with feedwater heaters. Details are provided in Sections 3.4 and 3.5. Units 3 and 4 are not included in Figure 6-7 below due to their pending retirement and lack of operating time since 2016. Refer to Section 3.3 for more information on their lack of operating time since 2016, and their limited dispatch prior to then.

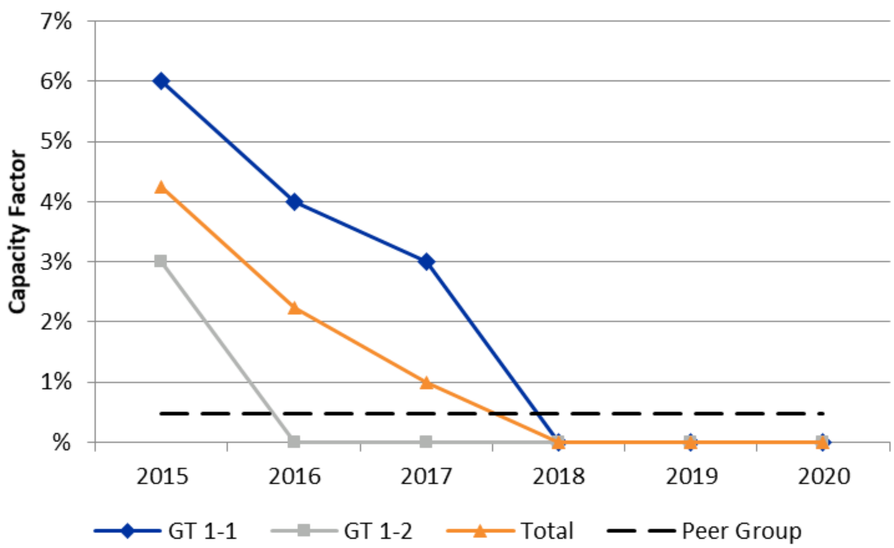
**Figure 6-7 — Costa Sur Steam Units Capacity Factor**




The black start units' capacity factors are shown in the figure below. Due to their small size and primary role as emergency generators, the capacity factors of the black start GTs are an order of magnitude less than the steam units. GT #1.1 had high availability in 2016 (see Section 6.2), but the demand for its power was low from central dispatch; hence its drop in capacity factor in 2016. In 2017, GT #1.1's generator was damaged by Hurricane Maria and has not returned to service due to the repair order being suspended. In 2015, the GT #1.2 rotor and compressor section were removed for servicing, which has not been completed by the Hidro Gas division due to reported budgetary constraints. Instead, a decommissioned turbine from the Central Hidro Gas Mayagüez Plant was installed in the GT #1.2 enclosure and is being restored for service in its place. This restoration work is expected to be completed for unit testing in January 2022. Section 3.6 contains additional detail.

Although the capacity factor has been low for the black start units, when they have operated, they have shown capacity factors higher than other similar units, showing that the units are used for peaking capacity when available, in addition to their black start capabilities.

**Figure 6-8 — Costa Sur Gas Turbine Capacity Factor**



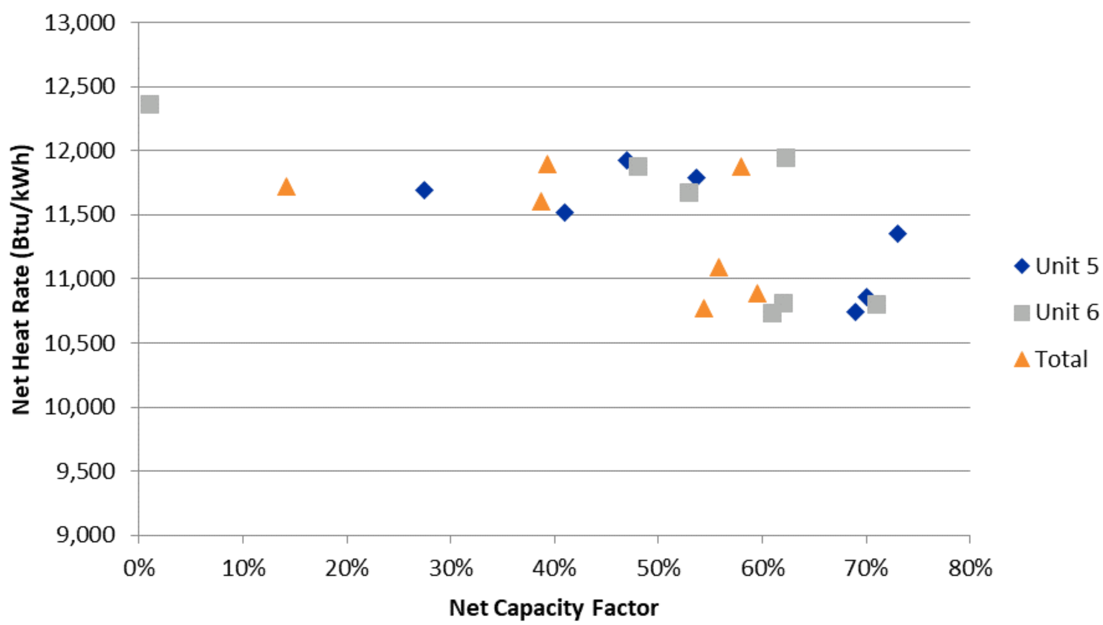

## 6.5. NET HEAT RATE

The heat rate is the amount of energy used by an electrical generator or power plant to generate one kilowatt hour of electricity. Heat rate shows in general the efficiency of the unit and to an extent represents the units to be considered in a dispatch hierarchy. The heat rate is slightly degraded through service.

The heat rates of Units 5 and 6 are increasing, signaling a decrease in their efficiencies. Their gas conversions were completed in late 2010 and early 2011. In 2014, their heat rates were both about 10,800 Btu/kWh, and by 2019 they had increased to 11,900 Btu/kWh. Figure 6-9 below shows the heat rate on both units decreasing as their capacity factors increase. Units are typically more efficient (lower heat rates) when operating at higher loads.

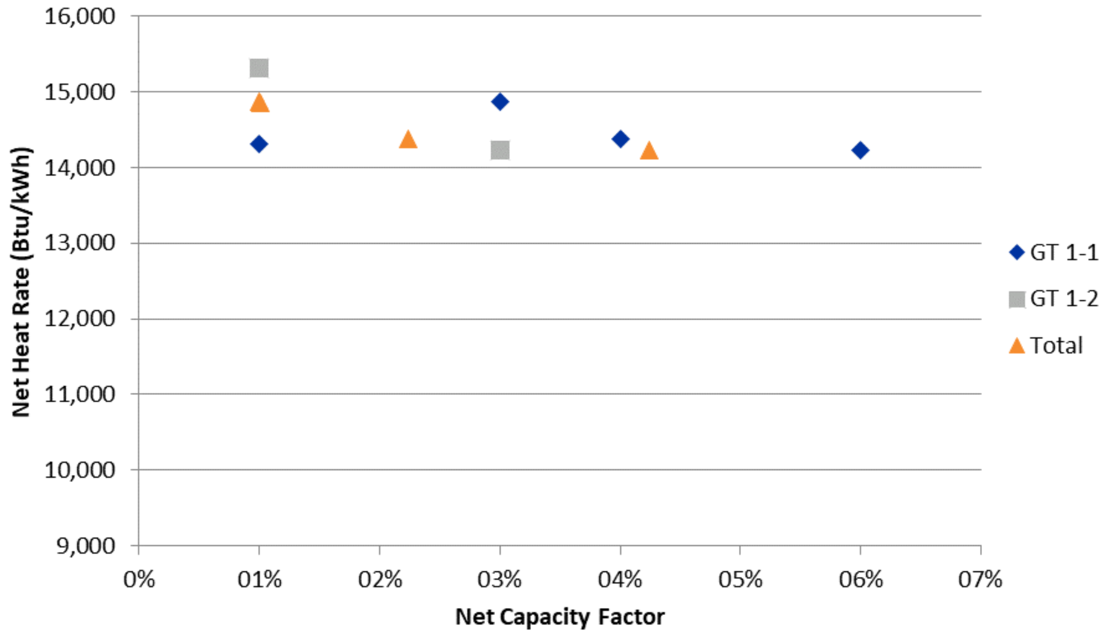
Other natural gas units of their age and size have heat rates in the range of 10,600–12,400 Btu/kWh. While Units 5 and 6 have heat rates in the middle of this comparative range, they have been closer to the forefront in recent years. Sargent & Lundy recommends a detailed study be completed to identify efficiency improvements and estimate their installed cost, resulting fuel savings, and payback period.

**Figure 6-9 — Costa Sur Steam Units Heat Rate v. Capacity Factor**




The net heat rates of the black start GTs have been fairly consistent when they've been operated over the past six years. They have high heat rates, but that is not as important as their availability and reliability for their role as emergency generators. Unfortunately, both units have been out of service for several years. Heat rate for the GT units are provided in Figure 6-10.

**Figure 6-10 — Costa Sur Gas Turbine Heat Rate v. Capacity Factor**



# 7. FINANCIAL REVIEW

Sargent & Lundy compiled the historical O&M and capital expenditures (CAPEX) for Costa Sur from reported PREPA data and fiscal plan forecasts for FY 2015 through FY 2020.

Cost data for Costa Sur is reported under the Generation directorate, which is one of the five PREPA directorates (Generation, Transmission, Distribution, Customer Service, and Administrative & General). Historical O&M costs were obtained from the following data files and reports:

- *725 OPER-CONST by Resp 2008-2020.xlsx*
- *Generation and Sales History.xlsx*
- *IRP2019 - Main Report REV2 06072019 (002).pdf*

Summaries of O&M costs and CAPEX for Costa Sur and comparisons with industry values are presented in the subsections below.

## 7.1. FIXED AND VARIABLE O&M

Fixed O&M costs are independent of the amount of the plant generating output, such as fixed labor, materials, and administrative and general costs. Variable O&M costs are directly proportional to plant generating output, such as chemicals and consumables. The reported fixed and variable O&M costs for Costa Sur are aggregated as are the costs for Costa Sur Unit 5 (410 MW) and Unit 6 (410 MW).[5]

Table 7-1 summarizes the historical O&M costs at Costa Sur for the period of FY 2015 to FY 2020. This does not include corporate costs for the Generation directorate that is common with other plants, such as administrative, technical support, and fuel contracting.

**Table 7-1 — Costa Sur Historical O&M Costs (FY 2015–FY 2020)**

| Costa Sur (820 MW)<br>Historical O&M Costs ($) | FY2015 | FY2016 | FY2017 | FY2018 | FY2019 | FY2020 |
|---|---|---|---|---|---|---|
| **Operating Labor** | | | | | | |
| 355 - Proyectos Conservacion Costa Sur | $ - | $ - | $ - | $ - | $ - | $ - |
| 354 - Jefe Div. Central Gen. Costa Sur | $ 18,230,545.70 | $ 17,429,434.18 | $ 16,312,957.36 | $ 15,341,169.33 | $ 11,806,404.87 | $ 12,181,581.66 |
| **Operating Non-Labor** | | | | | | |
| 355 - Proyectos Conservacion Costa Sur | $ 1,830.00 | $ - | $ - | $ - | $ - | $ - |
| 354 - Jefe Div. Central Gen. Costa Sur | $ 4,420,666.84 | $ 5,005,595.99 | $ 5,462,115.55 | $ 4,663,649.73 | $ 5,281,990.98 | $ 4,013,486.71 |
| **Total O&M Costs ($)** | $ 22,653,043 | $ 22,435,030 | $ 21,775,073 | $ 20,004,819 | $ 17,088,396 | $ 16,195,068 |

FY = Fiscal Year, July 1 to June 30

[5] MW capacity values shown in this report section are nominal values reported by PREPA for cost reporting and do not necessarily reflect the latest tested capacity.

The aggregated O&M costs shown above correspond to the fixed and variable components estimated by PREPA in the Puerto Rico Integrated Resource Plan of 2018-19[6]. Table 7-2 summarizes PREPA's estimate of the fixed O&M (in $/kW-year) and variable O&M (in $/MWh) for the Costa Sur steam units. Sargent & Lundy compared these values with O&M costs for existing units in operation in North America of similar configurations and operating profiles. We determined that the Costa Sur O&M costs are within the typical range of costs for similar units.

### Table 7-2 — Costa Sur Fixed and Variable O&M Cost Breakdown

| | Costa Sur Steam Unit 5 (410 MW) and Unit 6 (410 MW) |
|---|---|
| Fixed O&M (2018 $) | $35.96/kW-year |
| Variable O&M (2018 $) | $2.72/MWh |

## 7.2. CAPITAL EXPENDITURES

Historical CAPEX expenditures reported by PREPA for Costa Sur for FY 2015 through FY 2020 are summarized in Table 7-3. The driving force behind CAPEX in this period appears to be rehabilitation of the turbogenerator. Sargent & Lundy compared these values with CAPEX for existing units in operation in North America of similar ages and configurations.[7] We determined that the annual CAPEX expenditures for Costa Sur are within the typical range of costs for similar units.

### Table 7-3 — Costa Sur Historical CAPEX (FY 2015–FY 2020)

| Costa Sur (820 MW)<br>Historical CAPEX ($) | FY2015 | FY2016 | FY2017 | FY2018 | FY2019 | FY2020 |
|---|---|---|---|---|---|---|
| **Construction/Maintenance Labor** | | | | | | |
| 355 - Proyectos Conservacion Costa Sur | $ - | $ - | $ - | $ - | $ - | $ - |
| 354 - Jefe Div. Central Gen. Costa Sur | $ 2,022,999.00 | $ - | $ 11,019.60 | $ - | $ - | $ - |
| **Construction/Maintenance Non-Labor** | | | | | | |
| 355 - Proyectos Conservacion Costa Sur | $ - | $ - | $ - | $ - | $ - | $ - |
| 354 - Jefe Div. Central Gen. Costa Sur | $ 5,098,911.14 | $ 3,223,857.01 | $ 4,181,775.67 | $ 3,790,880.11 | $ 6,415,045.59 | $ 7,175,301.59 |
| **Total CAPEX ($)** | $ 7,121,910 | $ 3,223,857 | $ 4,192,795 | $ 3,790,880 | $ 6,415,046 | $ 7,175,302 |

[6] "Puerto Rico Integrated Resource Plan 2018-2019 – Draft for the Review of the Puerto Rico Energy Bureau", IRP2019 - Main Report REV2 06072019 (002).pdf, June 2019

[7] Generating Unit Annual Capital and Life Extension Costs Analysis – Final Report on Modeling Aging-Related Capital and O&M Costs, prepared by Sargent & Lundy for the U. S. Energy Information Administration, May 2018.

# 8. ENVIRONMENTAL AND REGULATORY

This section describes certain environmental requirements that currently apply to Costa Sur and includes a limited review of the station's current environmental compliance status. This section does not include a review of new and proposed regulatory initiatives that may have an impact on future operations at Costa Sur.

Costa Sur operates under the key permits and approvals identified in Table 8-1. Based on review of permits and documentation provided by PREPA or publicly available information, all major environmental permits for the Costa Sur facility are current or assumed to be in the process of being renewed.

**Table 8-1 — Costa Sur Power Plant Key Permits and Approvals**

| Permit/Approval Description | ID Number | Permit Expiration Date |
|---|---|---|
| Title V Operating Permit | PFE-TV-4911-31-0397-0021 | February 20, 2007 (renewal application has been filed, see Section 8.1) |
| National Pollution Discharge Elimination System | PR0001147 | August 31, 2023 |
| Resource Conservation and Recovery Act (RCRA) - Industrial and Hazardous Waste | PRD980644504 | N/A |
| Safe Drinking Water Act | PR0431034 | N/A |
| Franchise for the use of Waters of Puerto Rico | R-FA-FAID6-SJ-00256-11042017 | N/A |

Sargent & Lundy reviewed environmental compliance information provided by PREPA and information obtained from United States EPA's Enforcement and Compliance History Online (ECHO) database to determine the current environmental status of the facility. Provided below is a review of the facility's status for the following areas: air emissions, water and wastewater discharge, emergency planning reporting, oil storage spill prevention, and enforcement actions.

## 8.1. AIR EMISSIONS

The Costa Sur Title V Operating Permit includes emission limits and monitoring, recordkeeping, and reporting requirements for the Costa Sur Station. PREPA provided Sargent & Lundy with the facility's Title V operating permit that was issued on February 20, 2002 and expired on February 20, 2007. The facility is required to submit a renewal application to the Puerto Rico Environmental Quality Board (EQB) at least 12 months prior to the expiration date. PREPA submitted a renewal application, and on June 23, 2006, PREQB sent PREPA a letter indicating that its renewal application was administratively complete for the purposes of obtaining the protective cover of the permit application. PREPA noted in Costa Sur's 2016 annual Title V compliance certification that a modification to the Title V permit to incorporate new conditions from Construction Permit PFE-31-0810-0455-II-C was submitted and is under consideration.

The emission units regulated under the Title V operating permit include:

- Two oil-fired boilers with steam turbogenerators with a capacity of 560.2 MMBtu/hr[8] each;
- Two oil-fired boilers with steam turbogenerators with a capacity of 857.7 MMBtu/hr each;
- Two natural gas and oil-fired boilers with steam turbogenerators with a capacity of 3,950.7 MMBtu/hr each; and
- Two combustion turbines, each turbine having a capacity of 301.5 MMBtu/hr.

According to Costa Sur's annual Title V compliance certifications, Units 1 and 2 are not in operation and were retired. The facility is required to retain all required monitoring and supporting information for a period of five years. Recordkeeping and reporting requirements include:

- Semi-annual monitoring reports/sampling;
- Deviations due to emergencies;
- Deviation reporting for hazardous air pollutants;
- Annual emissions reports;
- Annual Title V compliance certification; and
- Monthly reports to provide fuel consumption and fuel sulfur content.

### 8.1.1. Air Permit Compliance

Sargent & Lundy reviewed air compliance documents supplied by PREPA, including annual emissions reports, semiannual monitoring reports, and annual Title V compliance certifications. Sargent & Lundy also reviewed air compliance information included in EPA's ECHO database.

PREPA's annual emissions reports for 2013 to 2019 show that Costa Sur's annual - facility-wide emissions have been at or below allowable levels (see Table 8-2).

[8] Million British thermal units per hour

### Table 8-2 — Costa Sur Power Plant Annual Emissions

| Pollutant | Allowable Emissions (Ton/Year) | Actual Emissions (ton/yr) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| PM | 590 | 398 | 491 | 562 | 501 | 336 | 392 | 475 |
| $PM_{10}$ | 1,038 | 700 | 876 | 949 | 871 | 600 | 700 | 849 |
| $PM_{2.5}$ | 803 | 541 | 677 | 734 | 674 | 464 | 541 | 657 |
| $SO_X$ | 9,884 | 6,727 | 8,337 | 9,333 | 8,416 | 5,712 | 6,664 | 8,083 |
| $NO_X$ | 10,521 | 7,142 | 8,898 | 9,842 | 8,930 | 6,084 | 7,094 | 8,603 |
| VOC | 36 | 25 | 30 | 35.89 | 31 | 21 | 24.3 | 29.4 |
| CO | 388 | 265 | 327 | 374 | 333 | 224 | 261.4 | 317.0 |
| $H_2SO_4$ | 469 | 316 | 396 | 429 | 393 | 271 | 316.3 | 383.6 |
| Pb | **0.08** | **0.06** | **0.07** | **0.08** | 0.07 | 0.05 | 0.05 | 0.07 |
| Fluoride | **0.00** | **0.00** | **0.00** | **0.00** | 0.00 | 0.00 | 0.00 | 0.00 |

PM = particulate matter | PM10 = particulate matter 10 micrometers or less in diameter | PM2.5 = particulate matter 2.5 micrometers or less in diameter | SOX = sulfur oxide | NOX = nitrogen oxide | VOC = volatile organic compounds | CO = carbon monoxide | H2SO4 = sulfuric acid | Pb = lead

Sargent & Lundy reviewed annual Title V compliance certifications for the years 2013 and 2015 through 2019. PREPA did not provide Sargent & Lundy with the annual compliance certification for 2014; therefore, the 2014 compliance certification was not reviewed. There were no reported deviations from the facility's Title V permit for the years 2013, 2015, and 2019. In 2016, 2017, and 2018, PREPA reported excess emissions for opacity. The excess emissions are explained in the reports as being due to other known causes, control equipment problems, startup/shutdown, and process problems. Equipment was adjusted as needed or taken out of service. Note that during portions of 2017 and 2018, PREPA was operating under a No Action Assurance granted by the EPA in the aftermath of Hurricanes Irma and Maria for relief from certain Title V permit requirements, including emission limitations.

Sargent & Lundy also reviewed semi-annual monitoring reports for 2017 through 2019. Sargent & Lundy was not provided semi-annual reports for first half 2020. Semi-annual monitoring reports for 2017 to first half 2018 identify deviations related to opacity levels. Deviations are explained in the reports as being due to other known causes, control equipment problems, startup/shutdown, and process problems. Equipment was adjusted as needed or taken out of service. The No Action Assurance granted by the EPA was effective starting October 2017 and was extended through April 2018, covering portions of the second half 2017 and first half 2018 periods.

Semi-annual monitoring reports for the second half 2017, first half 2018 and second half 2018, and the 2017 Title V compliance certification were not submitted according to the normal reporting schedule. Emergency conditions related to Hurricanes Irma and Maria prevented PREPA from preparing and submitting the required reports on time; therefore, under the No Action Assurance, EPA extended reporting deadlines for all reports covered under the No Action Assurance to May 30, 2018. According to PREPA, the EPA gave PREPA until July 30, 2018 to submit the reports, and the EQB informally extended the deadline consistent with the No Action Assurance. It is Sargent & Lundy's understanding that PREPA submitted the second half 2017 semi-annual report and the annual 2017 Title V compliance certification in March of 2019. According to PREPA, the 1st half 2018 semi-annual report was submitted in February 2019 and the annual 2018 Title V compliance certification was submitted in March 2019.

### 8.1.2. Mercury and Air Toxics Standards

The four oil-fired boilers at Costa Sur are subject to EPA's MATS. Units 3 and 4 are designated as limited-use units (i.e., they are subject to a heat input limit of 8%, averaged over a 24-month block period). "Limited use units" are subject to significantly less stringent requirements under MATS. While these units must comply with the tune-up work practice standard, they are not subject to emissions limits for PM, HCl, or HF, or the startup/shutdown work practice standards. According to PREPA, Costa Sur Units 3 and 4 have met the 8% heat input limit and are in compliance. Units 3 and 4 had minimal operation in 2016 and have not operated since.

Units 5 and 6 include PM Continuous Emissions Monitoring System for demonstrating compliance with the MATS PM limit. Compliance with the hydrochloric acid and hydrogen fluoride limits is demonstrated based on fuel moisture content being less than 1.0%.

Sargent & Lundy reviewed MATS compliance reports for 2016 through third quarter 2019. Sargent & Lundy was not provided MATS compliance reports for the fourth quarter 2019 and 2020; according to PREPA, the MATS compliance reports for the fourth quarter 2019 through second quarter 2020 were being prepared. Based on the reports provided by PREPA, Units 5 and 6 are in compliance with MATS requirements.

## 8.2. WATER AND WASTEWATER DISCHARGE

Sources of wastewater from Costa Sur include condenser cooling water, cooling tower blowdown, fuel heater condensate, miscellaneous use water, wastewater treatment plant effluent, stormwater, fire protection system test water, hydrostatic test water, and reverse osmosis reject water. Wastewater is discharged to the Guayanilla Bay via three separate outfalls.

The facility's discharges are authorized under National Pollution Discharge Elimination System (NPDES) permit number PR0001147. The permit's expiration date is August 31, 2023, and the facility will be required to submit a renewal application by March 4, 2023.

### 8.2.1. NPDES Permit Compliance

Sargent & Lundy performed a review of EPA's ECHO database to determine the facility's NPDES permit compliance status. The ECHO database identifies unresolved Clean Water Act (CWA) violations for the Costa Sur facility dating back to the first quarter 2018.

The listed violations from the first and second quarter of 2018 are identified as "significant non-compliance." PREPA explained that PREPA's records did not show exceedances for the first and second quarter 2018, and that an addendum was submitted to EPA that explains the discrepancies in the NetDMR. Sargent & Lundy reviewed the first quarter and second quarter addendum reports. According to the reports, the discrepancies were due to incorrect units (for free available chlorine) and some information that was not included in the NetDMR but was provided in the addendum. Noncompliance items listed for the third quarter 2018 to third quarter 2020 are identified as "reportable noncompliance." Sargent & Lundy has not been provided information concerning those violations.

EPA's ECHO database identifies one formal enforcement action under the CWA, dated March 20, 2014. This was related to a March 2014 Administrative Order on Consent (AOC) (Docket No. CWA-02-2014-3104) executed between EPA and PREPA. EPA and PREPA entered into the AOC to allow PREPA to install a reverse osmosis treatment technology at Costa Sur. The AOC also allowed PREPA to temporarily discharge backwash and brine wastewater resulting from the reverse osmosis treatment through Outfall 001 into the Caribbean Sea in the absence of a NPDES permit and required PREPA to make various submittals to EPA. On June 28, 2018, EPA issued a letter terminating the AOC, and finding that PREPA had complied with the substantial requirements of the AOC. EPA's letter also noted that EPA had issued a revised NPDES permit to PREPA (effective September 1, 2018) that authorized the discharge of the backwash and brine wastewater resulting from the reverse osmosis treatment through Outfall 001. This case has thus been closed.

Sargent & Lundy also reviewed an inspection report provided by PREPA. On August 16, 2017, EPA conducted a CWA inspection at Costa Sur, and subsequently issued an inspection report. The report noted one exceedance of the copper limitation each at Outfalls 002 and 003 in October of 2016. According to PREPA, there has been no follow-up from the EPA since the inspection. The copper exceedances are noted on the ECHO database with a status of "Resolved Pending," which indicates that the permittee is in compliance with an enforcement order but has not achieved full compliance with permit conditions.

### 8.2.2. 316(b) Cooling Water Intake Structure Requirements

On August 15, 2014, EPA published a final rule implementing Section 316(b) of the federal CWA. The purpose of the rule is to reduce impingement and entrainment of fish and other aquatic organisms at cooling water intake structures used by certain existing power generation and manufacturing facilities.

Costa Sur withdraws cooling water from Guayanilla Bay through two intake structures that pass through the condensers for non-contact cooling water. Although the plant is equipped with three intake structures, the intake structure for the retired boilers is not in use. The intake structures consist of a system of bar racks, traveling screens, and intake pumps. Units 3 and 4 have screens with 3/8-inch mesh, and Units 5 and 6 are equipped with 3/8 inch dual-flow screens. The cooling water is discharged back into Guayanilla Bay, using a once through cooling system.

PREPA has negotiated a 316(b) compliance strategy for Costa Sur. Per the NPDES permit, an alternative schedule has been granted by the EPA for submittal of necessary studies concerning impingement mortality and entrainment. Information on source water, cooling water intake, source water biology, cooling water system, and impingement and entrainment is to be collected and analyzed, and a status report indicating PREPA's preferred impingement mortality compliance method is due March 1, 2023 (four and a half years after the effective date of the NPDES permit, which was September 1, 2018). PREPA's planned compliance strategy is to install new traveling screens for compliance with impingement mortality and entrainment provisions.

## 8.3. EMERGENCY PLANNING REPORTING

The Emergency Planning and Community Right to Know Act (EPCRA) provides national public disclosure of emergency information in order to protect the public from chemical emergencies and dangers. EPCRA Section 312 (40 CFR Part 370) requires facilities that maintain safety data sheets to report the quantity of certain chemicals that are present on site for the previous year; the submittals are known as Tier 2 reports. EPCRA Section 313 (40 CFR Part 372) requires facilities that manufacture, process, or otherwise use listed toxic chemicals in excess of applicable thresholds to prepare and submit a Toxic Release Inventory (TRI) to federal and state agencies.

Sargent & Lundy was provided with a Tier 2 report for the reporting period from January 2017 to December 2017 prepared for Costa Sur and submitted in 2018. Based on review of the Tier 2 report, it appears that the facility is following the necessary reporting requirements.

PREPA provided Sargent & Lundy with TRI reports for calendar years 2016 and 2017. The reports provided by PREPA and EPA's ECHO database confirms that PREPA has prepared and submitted TRI reports.

However, PREPA originally failed to file TRI Form R reports for hydrochloric for the Costa Sur facility in 2010, 2011, and 2012; the reporting violation led to enforcement action, which was settled in 2015 via a Consent Agreement and Final Order with EPA (see Section 8.5.2).

## 8.4. OIL STORAGE SPILL PREVENTION

Sargent & Lundy reviewed a copy of Costa Sur's Spill Prevention, Control, and Countermeasure (SPCC) plan. The SPCC plan, required by 40 CFR Part 112, identifies on-site oil storage containers, and provides a plan for preventing the discharge of oil into navigable waters or adjoining shoreline. The Costa Sur SPCC plan appears to be complete and generally meets the Part 112 requirements.

## 8.5. ENFORCEMENT ACTIONS

### 8.5.1. PREPA Consent Decree[9]

On March 19, 1999, the U.S. District Court for the District of Puerto Rico entered a Consent Decree between the United States and PREPA (Civil Action No. 93-2527) ("1999 Consent Decree"). The Consent Decree includes detailed requirements to promote compliance with the Clean Air Act, Clean Water Act, RCRA, CERCLA[10], and EPCRA. Requirements for the Costa Sur facility included implementing a CAA compliance program, CWA compliance program, and preparing a SPCC plan, among other requirements. A Consent Decree modification, lodged on June 21, 2004, included additional objectives for monitoring and reducing air emissions such as: methodology for opacity readings, reducing fuel sulfur content, and nitrogen oxide emissions reductions.

It is Sargent & Lundy's understanding through discussion with PREPA that PREPA is generally complying with the requirements of the Consent Decree; however, PREPA paid stipulated penalties under the CAA and CWA compliance programs in 2017 and 2018.

### 8.5.2. TRI Violation

On December 2, 2013, EPA conducted an inspection at Costa Sur to determine compliance with TRI Form R reporting requirements. TRI reports are due July 1 of each year for each listed TRI chemical that exceeds the manufactured, processed, or otherwise used threshold. Subsequent to the inspection, it was determined that PREPA should have filed TRI Form R reports for hydrochloric acid for PREPA's Aguirre, Palo Seco, and Costa Sur facilities during reporting years 2010, 2011, and 2012. The case was settled for $37,500.

[9] The Consent Decree primarily applies to Palo Seco, Aguirre, Costa Sur, and San Juan facilities.
[10] Comprehensive Environmental Response, Compensation, and Liability Act

### 8.5.3. Safe Drinking Water Act Violations

The ECHO database identifies Safe Drinking Water Act violations that occurred between 2008 and 2020; the violations are shown to be archived or resolved. Reported Safe Drinking Water Act violations were related to coliform levels and monitoring and reporting. Based on discussion with PREPA, the violations were resolved, and subsequent verification of compliance was demonstrated. The ECHO database also identifies alleged violations of the total coliform rule in the fourth quarter 2015 and first quarter 2016. According to PREPA, the most recent record of a Safe Drinking Water Act violation was in 2013, and the issue has since been resolved.

The 2008 violation resulted in an administrative order to comply with the total coliform rule, which included requirements for sampling, complying with the Maximum Contaminant Level of total coliforms, a cleaning program, and reporting. According to PREPA, the administrative order requirements have been met, and the matter has been resolved.

The 2009 notice of violation was related to missing monitoring parameters in reports submitted in 2008 (synthetic organic chemicals, trihalomethanes, and haloacetic acids). In response, PREPA provided the identified testing results for synthetic organic chemicals and communicated to the Puerto Rico Health Department that PREPA was not required to monitor trihalomethanes and haloacetic acids because Costa Sur uses ultraviolet light lamps as its method of disinfection. PREPA requested that the violation be dropped. According to PREPA, the matter has been resolved.

The 2013 notice of violation was for non-compliance with the Maximum Contaminant Level for lead and copper. In response, PREPA provided sampling results demonstrating that lead and copper were measured below the Maximum Contaminant Level. According to PREPA, this issue has been resolved.

ECHO identifies two “unresolved” violation notices from 2018 and 2020. The 2018 violation is related to nitrate monitoring reporting, and the 2020 violation is related to coliform monitoring.

## 8.6. SUMMARY

Sargent & Lundy performed a limited environmental review of publicly available information and information provided by PREPA to determine the compliance status for Costa Sur. Sargent & Lundy did not find any compliance-related issues that would prevent renewal of the existing permits or impact near-term operation of the facility. However, the items listed below were identified as having unknown or potential compliance implications for Costa Sur.

- **Water and Wastewater**
  - EPA's CWA inspection report dated August 16, 2017 identified one reported exceedance of copper in outfalls 002 and 003 for the monitoring period of October 2016. According to PREPA, there has been no follow up from EPA since the inspection.
  - Violations during the third quarter 2018 to third quarter 2020 are identified in ECHO as "reportable noncompliance." Sargent & Lundy has not been provided information concerning those violations.
  - ECHO identifies two "unresolved" violation notices from 2018 and 2020. The 2018 violation is related to nitrate monitoring reporting, and the 2020 violation is related to coliform monitoring.

# 9. RECOMMENDATIONS AND CONCLUSIONS

Sargent & Lundy recommended that Units 3 and 4 at Costa Sur be removed from service and retired. The decommissioning plan for Units 3 and 4 are currently being evaluated by PREPA's Generation, Planning, and Finance Directorates. This decommissioning plan is expected to be presented to the Governing Board in 2021. Additionally, if repowering efforts or other operating features are desired for capacity or flexibility (as determined by a separate ongoing load demand and resource study), Sargent & Lundy recommends Units 1, 2, 3, and 4 are demolished as deemed appropriate, to reclaim property for new generation technology. Sargent & Lundy recommends Units 5 and 6 continue to operate with O&M activities focused on reliability and efficiency improvements to restore the plant's heat rate. Additionally, a remaining useful life study could be conducted to provide some clarity around the length of time the steam units may be operable.

The Costa Sur Steam Plant is a strategic location for power generation on the island due to the availability of seawater supply for cooling, the nearby refinery and port services, and adjacent liquefied natural gas port that supplies gas to EcoEléctrica Natural Gas Power Plant.

PREPA is studying the need for additional grid support and generation throughout the island. The reclaimed space at Costa Sur could be a good location for smaller, rapid-start GT equipment with integrated synchronous condensing options, such as those in place at Central Hidro Gas Mayagüez Plant. New fast start generation equipment that integrates purge credit, battery storage components for instantaneous response, integrated/clutched synchronous condensing, and similar features could provide quicker support and flexibility for a future grid that is planned to integrate a larger amount of intermittent renewable power. These new units can also provide black start capability for the Costa Sur Steam Plant, which currently relies on outside power for startup since the Plant's two gas turbines are not in operation and currently being repaired. Reciprocating engine plants provide even faster startups than GT equipment and also can be configured to operate on natural gas and in combined-cycle configurations and provide black start capability.

The Costa Sur Units 5 and 6 plant nameplate capacity is 820 MW. A decline in Plant performance and reliability should be expected during the operating life of a thermal power generation plant, and it is evident in the case of the Costa Sur Steam Plant Units 5 and 6. These units have provided power generation service since the early 1970s, and while a decline in performance has been seen, the conversion to gas has provided the ability to generate power with lower emissions, and until recently, lower O&M costs. We recommend performing a root-cause analysis to determine the best means to restore the Plant's heat rate and improve its overall operating efficiency, which has declined only in the past few years. It must be highlighted that the Costa Sur Steam Plant has been operating successfully on natural gas for the past almost ten years. PREPA has managed to dramatically improve the plant's emissions with the switch from HFO to natural gas.

Care must be taken to ensure that replacements or upgrades to the Plant are suitable for an aggressive, salt-laden marine environment exposed to coastal winds. Typically, competitively priced original equipment manufacturer standards for power generation and balance-of-plant equipment are not well-suited for this type of operating environment. New equipment must be configured for the challenging conditions at Costa Sur. Failure to make allowances for suitable materials, equipment selection, buildings/enclosures, and other aspects of the facility design to protect the Plant from the harsh operating environment will result in excessive future O&M costs and a shorter plant design life for any new installation. Suitable design specifications appropriate for this operating environment include corrosion-resistant material specifications; appropriate welding selections, including special treatment of all metal seams, stitched connections, and fastenings with sealants, gaskets, and coatings; use of protective equipment enclosures; proper system selections; and marine coatings systems. Due to these requirements, coastal power generation sites are inherently more expensive than those installed in less aggressive operating environments and should be planned accordingly.

Ongoing proposals for Plant replacements, upgrades, and new generation should consider the guidelines provided herein. New operating regimes and other comparisons must be made so equipment is selected to suit the future direction of the power generation and distribution system planned for Puerto Rico.

Additional recommendations are provided in the report along with the following, more pressing ones:

- Identifying and addressing any systems impacted by the recent earthquake which weren't addressed prior to each unit being brought back online.
- Continue to operate with a blend of HFO and natural gas a few times yearly to exercise the HFO equipment.
- Increase corrosion control efforts.
- Commission a heat rate improvement study to identify options to improve efficiency and estimate the cost and fuel/energy savings for each.

# 10. REFERENCES

1. Sargent & Lundy report, Costa Sur Phase I Environmental Site Assessment, SL-014468.CS.ESA, dated May 20, 2019
2. Sargent & Lundy report, Demarcation of PREPA Generation Assets from the Transmission and Distribution System, TD-0003, dated October 4, 2019