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

IN RE: REVIEW OF THE PUERTO RICO ELECTRIC POWER AUTHORITY´S 10-YEAR INFRASTRUCTURE PLAN – DECEMBER 2020	**CASE NO.**: NEPR-MI-2021-0002 **SUBJECT**: Motion to Submit PREPA's Hydroelectric Fleet Application and Request for Confidential Designation

MOTION TO SUBMIT PREPA'S HYDROELECTRIC FLEET APPLICATION PACKAGE AND REQUEST FOR CONFIDENTIAL DESIGNATION

COMES NOW the Puerto Rico Electric Power Authority (PREPA), through its counsel of record, and respectfully submits and requests as follows:

1. On March 26, 2021, the Puerto Rico Energy Bureau of the Public Service Regulatory Board (the "Energy Bureau" or "Bureau") entered *Resolution and Order* (the "March 26 Order") requiring PREPA to continue reporting to the Energy Bureau and FEMA, within the next five (5) years, the progress of all ongoing efforts related to the final approval of the submitted projects not yet approved by the Energy Bureau.

2. In compliance with the March 26 Order, PREPA herein submits for the review and approval of the Energy Bureau document titled 4339-HM-HMGP-001966 PREPA Hydroelectric Fleet Application of the Energy Bureau including the proposed mitigation activity to retrofit and upgrade hydroelectric plants in Puerto Rico ("Hydro Application Package"). The Hydro Application Package was originally contemplated for the Community Development Block Grant (CDBG) Program, however, it is currently before the consideration of the Central Office for Recovery, Reconstruction and Resiliency (COR3) to determine preliminarily its eligibility under the FEMA mitigation grant (404 program) for Hurricane Fiona, which has not yet opened. PREPA will submit a final version to COR3 once the grant is approved.

3. The Hydro Application Package is consistent with the goals, strategies, and objectives of the Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program plan, and are also aligned with the operative IRP and Modified Action Plan approved by the Energy Bureau on August 24, 2021.[1] It also includes details on the existing conditions of PREPA's hydroelectric facilities, the problems to be solved, objectives, project methodologies, phases and costs.

4. The Hydro Application Package contains critical energy infrastructure information (CEII) that cannot be disclosed to the public. The CEII included in the Application package are global positioning system (GPS) coordinates of the power plant.

5. The following is a detailed list of the information that PREPA asserts is confidential and must be kept under seal.

Exhibit	**Description**	**Confidential Information**	**Request for Confidentiality**
Exhibit A	4339-HM-HMGP-001966 PREPA Hydroelectric Fleet Application	GPS Location Page 5- Project Locations	CEII

6. Article 6.15 of the *Puerto Rico Energy Transformation and RELIEF Act*, Act no. 57 of 2014, as amended ("Act 57")[2], provides that "any person who is required to submit information to

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[1] *See, Final Resolution and Order on the Puerto Rico Electric Power Authority's Integrated Resource Plan* entered in case no. CEPR-AP-2018-0001, *In Re: Review of the Puerto Rico Electric Power Authority Integrated Resource Plan*.

[2] *Puerto Rico Energy Transformation and RELIEF Act,* Act no. 57 of May 27, 2014, 22 L.P.R.A. §§ 1051-1056.

the Energy [Bureau] believes that the information to be submitted has any confidentiality privilege, such person may request the [Bureau] to treat such information as such[.]" *Id.* at Sec. 6.15. "If the Energy [Bureau], after the appropriate evaluation, believes such information should be protected, it shall grant such protection in a manner that least affects the public interest, transparency, and the rights of the parties involved in the administrative procedure in which the allegedly confidential document is submitted." *Id.* at Sec. 6.15**(a).** If the Energy Bureau determines that the information is confidential, "the information shall be duly safeguarded and delivered exclusively to the personnel of the Energy [Bureau] who needs to know such information under nondisclosure agreements." *Id.* at Sec. 6.15**(b).** "The Energy [Bureau] shall swiftly act on any privilege and confidentiality claim made by a person subject to its jurisdiction by means of a resolution to such purposes before any allegedly confidential information is disclosed." *Id.* at Sec. 6.15**(c).**

7. Pursuant to its vested powers, the Energy Bureau approved the *Regulation on Adjudicative, Notices of Compliance, Rate Review and Investigations Proceedings* ("Regulation 8543").[3] Regarding the safeguards that the Energy Bureau gives to confidential information, Regulation 8543 provides that:

> [i]f in compliance with the provisions of [Regulation 8543] or any of the Energy Bureau's orders, a person has the duty to disclose to the Energy Bureau information considered to be privileged pursuant to the Rules of Evidence, said person shall identify the allegedly privileged information, request the Energy Bureau the protection of said information, and provide supportive arguments, in writing, for a claim of information of privileged nature. The Energy Bureau shall evaluate the petition and, if it understands the material merits protection, proceed according to what is set forth in Article 6.15 of Act No. 57-2014, as amended.

Regulation 8543 at Sec. 1.15.

[3] Energy Bureau, *Regulation on Adjudicative, Notices of Compliance, Rate Review and Investigations Proceedings*, No. 8543 (December 16, 2015).

8. Federal and Puerto Rico law protect the confidentiality of CEII, the public disclosure of which may pose a security threat in that the information could be useful to a person or group in planning an attack on critical infrastructure. *See, e.g.*, 18 C.F.R. § 388.113, as amended by Federal Energy Regulatory Commission (FERC) Order No. 683, *Critical Energy Infrastructure Information* (issued September 21, 2006); *USA Patriot Act of 2001*, § 1016, creating the *Critical Infrastructures Protection Act of 2001*, including 42 U.S.C. § 5195c(e) (defining Critical infrastructure). FERC regulations subject such information to limitations on use and disclosure to "ensure that information deemed CEII stays out of the possession of terrorists." 18 C.F.R. § 388.113(d)(4). *Off. of People's Counsel v. Pub. Serv. Commn*., 21 A.3d 985, 991, Util. L. Rep. P 27157, 2011 WL 2473405 (D.C. App. 2011).

9. Under the Critical Infrastructures Protection Act of 2001, the term "critical infrastructure" means "systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters." 42 U.S.C. § 5195c(e).

10. In 2006, FERC Order no. 683 amended the regulations for gaining access to CEII and simplified procedures for obtaining access to CEII without increasing vulnerability of the energy infrastructure and ensuring that access to CEII does not facilitate acts of terrorism.

11. A utility is not required to obtain FERC or other federal government approval in order to designate information as CEII. For example, information required by FERC's Annual Transmission Planning and Evaluation Report, Form No. 715, ("FERC No. 715"), is *de facto* considered CEII and is automatically afforded the heightened protections. FERC No. 715 requires that any transmitting utility that operates integrated (non-radial) transmission facilities at or above

100 kV must annually submit information including but not limited to: Power Flow Base Cases, Transmitting Utility Maps and Diagrams, Transmission Planning Reliability Criteria, Transmission Planning Assessment Practices, and Evaluation of Transmission System Performance. Any utility that submits the required transmission information pursuant to FERC No. 715 does so with the knowledge that, as stated in the Form's Instructions, FERC "considers the information collected by this report to be CEII and will treat it as such." *See also* 18 C.F.R. § 141.300(d) relating to the Form and CEII.

12. Mainland regulators typically do not require a utility that designates material as CEII to follow any process before the federal government in order to make or support such a designation, and, further, that the regulator, in its informed discretion, can establish limits on how information that it considers CEII can be accessed.

13. Furthermore, and regarding the argument made by PREPA, FERC has ruled on several occasions that global positioning system (GPS) coordinates of any project features "qualify as CEII because it provides more than just location." *See e.g.* Final Rule, Docket Nos. RM02-4-000, PL02-1-000; Order No. 630, Note 31, entered on February 21, 2003 (ruling that FERC considered the global positioning system coordinates of any project features (precise surveyed or GPS coordinates at or above two decimal points of accuracy of equipment and structures) gas information to qualify as CEII because it provides more than just location).[4]

14. The Energy Bureau, in prior dockets has accepted the Authority's designations of material as CEII, recognizing that both federal law and Puerto Rico law support such designations when applicable.[5] Accordingly, and pursuant to the above, it is respectfully requested that the Honorable

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[4] Federal Register: March 3, 2003 (Volume 68, Number 41); Rules and Regulations, pp. 9857-9873.

[5] *See e.g. Resolution and Order* entered on August 27, 2019, in case no. CEPR-AP-2018-0001, *In Re: Review of the Puerto Rico Electric Power Authority Integrated Resource Plan*.

Energy Bureau find that the information categorized by PREPA as CEII is confidential and that the Secretary of the Energy Bureau be directed to keep the confidential CEII under seal.

WHEREFORE, PREPA respectfully requests the Energy Bureau to take notice and approve the Hydroelectric Application Package, find that the information categorized by PREPA as CEII is confidential and order the Secretary of the Energy Bureau to keep the confidential CEII under seal.

RESPECTFULLY SUBMITTED.

In San Juan, Puerto Rico, this 10th day of July 2022.

CERTIFICATE OF SERVICE

It is hereby certified that I have filed the foregoing with the Clerk of the Energy Bureau using the electronic filing system using https://radicacion.energia.pr.gov/login and also, that I have served a copy on LUMA Energy, LLC and LUMA Energy ServCo, LLC through their counsel of record at laura.rozas@us.dlapiper.com and margarita.mercado@us.dlapiper.com.

In San Juan Puerto Rico on this 10th day of July 2023.

/s Joannely Marrero Cruz
Joannely Marrero Cruz

Exhibit 1

PREPA Hydroelectric Fleet Application

4339-HM-HMGP-001966

PREPA Hydroelectric Fleet Application

Table of Contents

Sub-Applicant Information/POC

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HM Plan Information

Questions and Responses

Is the organization that is applying for HMGP funding covered by a current FEMA-approved multi-hazard mitigation plan, in compliance with 44 CFR 201.6?

The sub-applicant is not covered by a 201.6 (local hazard mitigation plan requirements) compliant hazard mitigation plan; however, the sub-applicant is a Commonwealth agency and is covered by a 201.4 compliant standard state hazard mitigation plan and therefore eligible to receive HMGP funding.

The Plan Name: 2021 Puerto Rico State Natural Hazards Mitigation Plan

Type of Plan: Standard State Hazard Mitigation Plan

Date of Approval: 7/30/21

Describe How the Proposed Activity is Consistent with the Goals, Strategies and Objectives of the FEMA-approved mitigation plan:

The proposed mitigation activity to retrofit and upgrade hydroelectric plants in Puerto Rico is consistent with the goals, strategies, and objectives of the mitigation plan according to the following sections:

Table 4-1 "State Agencies and Other Stakeholder's Mitigation Responsibilities" on page 209 lists the Puerto Rico Electric Power Authority's Mitigation Responsibilities as:

- Identify and implement mitigation measures whose purpose is to protect and avoid the possibility of losses in electrical installations to continue to ensure continuity or rapid recovery of the system after emergencies or disasters
- Inspect, maintain, and take any necessary mitigation measures on water reservoirs or dams under its jurisdiction

Project Locations

Caonillas 1	[redacted]	[redacted]
Caonillas 2	[redacted]	[redacted]
Carite 1	[redacted]	[redacted]
Carite 2	[redacted]	[redacted]
Carite 3	[redacted]	[redacted]
Dos Bocas	[redacted]	[redacted]
Garzas 1	[redacted]	[redacted]
Garzas 2	[redacted]	[redacted]
Isabela 1	[redacted]	[redacted]
Isabela 2	[redacted]	[redacted]
Isabela 3	[redacted]	[redacted]
Rio Blanco	[redacted]	[redacted]
Toro Negro 1	[redacted]	[redacted]
Toro Negro 2	[redacted]	[redacted]
Yauco 1	[redacted]	[redacted]
Yauco 2	[redacted]	[redacted]

Existing Conditions

Background Information

The Commonwealth of Puerto Rico, population approximately 3.2 million people, consists of the easternmost islands of the Greater Antilles in the Caribbean Sea, approximately 1,200 miles southeast of Florida. The Puerto Rico Electric Power Authority (PREPA, also known as Autoridad de Energía Eléctrica, or AEE) supplies Puerto Rico's electricity. PREPA is a government agency that owns the electricity transmission and distribution systems for the main island, Vieques, and Culebra, as well as about 86% (nearly 5,000 megawatts) of the installed electricity generating capacity. It serves more customers—about 1.5 million—than any other public electric utility in the United States.

Puerto Rico's current electrical system is heavily reliant on the use of fossil fuels to generate power. According to the energy profile developed by the United States (U.S.) Energy Information Administration (EIA) in 2021, Puerto Rico has no proved reserves or production of fossil fuels. The Commonwealth has renewable resources in the form of solar, wind, hydroelectric, and biomass, but relies primarily on imported fossil fuels to meet its energy needs. Puerto Rico consumes about 27 times more energy than it produces.

Petroleum accounts for about two-thirds of the Commonwealth's total energy use and fuels more than 60% of the island's generating capacity. While natural gas accounts for only one-fifth of the Commonwealth's total energy use, the amount of natural gas needed is not produced and there are no proved reserves. After Hurricane Maria made landfall in late September 2017, Puerto Rico's liquefied natural gas (LNG) imports declined as less natural gas was needed during the widespread electricity outage.

Although Puerto Rico has no coal reserves and produces no coal, they consumed 1.5 million tons of coal in 2020, accounting for about one-tenth of total energy use. Most of the coal was used to fuel the power plants. Renewable resources account for the rest of Puerto Rico's energy use and include solar energy, wind energy, hydroelectric, and biomass.

For fiscal year 2021 (July 2020-June 2021) about 3% of PREPA's electricity came from renewable energy (RE), with solar photovoltaics (PV) accounting for slightly more than half and wind power accounting for one-third of total renewable generation. The remainder came from hydroelectric and landfill gas-fueled facilities.

Energy Goals

Puerto Rico's goal is to reduce dependency on fossil fuels and shift toward RE sources. On April 11, 2019, the Governor of Puerto Rico signed into law the Puerto Rico Energy Public Policy Act. The Energy Public Policy Act updated and unified policy initiatives pursuant to the Puerto Rico Electric Power Enabling Act, the Puerto Rico Electrical System Transformation Act, the Puerto Rico Energy Transformation and Relief Act, the Puerto Rico Public Policy Act on Energy Diversification Through Alternative and Sustainable Renewable Energy, and the Net Metering Act, among others. Key provisions/goals related to reducing Puerto Rico's reliance on fossil fuels and its shift towards the use of renewable energy sources and technology include:

1. Eliminating the use of coal-based energy by no later than January 1, 2028.
2. Reaching 40% compliance with the Renewable Portfolio Standard (RPS) by the year 2025; 60% compliance by the year 2040; and 100% compliance by the year 2050. Note: The RPS classifies RE as solar, wind, geothermal, renewable biomass, qualified hydroelectric energy, marine and hydrokinetic, ocean thermal, and any other "clean or renewable energy" as defined by the Commonwealth Energy Public Policy Office via future regulation.
3. Promoting energy storage technologies across consumer classes to facilitate integration of renewable and capitalize distrusted energy resources
4. Reaching 30% energy efficiency (EE) by 2040
5. Under the Puerto Rico Energy Public Policy Act, PREPA must obtain 40% of its electricity from renewable resources by 2025, 60% by 2040, and 100% by 2050.

The Biden-Harrison Administration's Commitment to Supporting Puerto Rico's Renewable Energy Goals

Per a 2022 statement and release from the U.S. White House, the Biden-Harris Administration is committed to facilitating the investment needed to construct a modern, dependable, and cost-effective power system in Puerto Rico that is resilient in the face of future storms and supports the accomplishment of Puerto Rico's renewable energy goals. The policy set milestones to transition Puerto Rico away from imported fossil fuel in favor of generating RE with the island's own excellent supply of sun, wind, water, and other renewable resources.

The study, Puerto Rico Grid Resilience and Transition to 100% RE (PR100), will leverage the most advanced U.S. research capabilities across multiple Department of Energy (DOE) national laboratories. The PR100 study, directed by DOE's Office of Electricity in partnership with the Federal Emergency Management Agency (FEMA), will establish clean energy pathways for plausible Puerto Rico trajectories through 2050.

The PR100 study is part of DOE's broader portfolio of support to achieve short-term recovery goals and long-term energy resilience. The study is modeled after the Los Angeles "100% Renewable Energy Study" (LA100), which evaluated a wide range of future scenarios to help Los Angeles understand options for and implications of meeting its renewable energy goals. Study results showed that meeting Los Angeles' goal of dependable, 100% RE by 2045, or even 2035, is achievable.

Additionally, FEMA and the U.S. Department of Housing and Urban Development (HUD) are working collaboratively with the government of Puerto Rico to administer over $12 billion of federal recovery funds earmarked for rebuilding and improving the energy sector. In keeping with President Biden's executive orders on tackling the climate crisis and Puerto Rico's Energy Public Policy Act of 2019, these funds are being used to minimize greenhouse gas emissions and support initiatives in Puerto Rico that focus on mitigation, adaptation, and resilience. Currently, PREPA's electric power grid significantly underperforms the industry in terms of reliability. The most tracked and reported reliability metrics used in the industry are System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI). According to "LUMA's J.D. Power Customer Satisfaction Performance Metrics Baselines," PREPA's 2019 SAIFI is 8.8 occurrences and SAIDI is 1097 minutes. These metrics were calculated by LUMA using PREPA data and industry's best practices. Furthermore, LUMA analyzed results from Year to Date (YTD) to the end of August 2019 and YTD to the end of August 2020 to compare reliability performance. Comparing the results of SAIDI and SAIFI indicate that SAIDI degraded by 29% and SAIFI by 20%. These concerning performance metrics call for timely, substantial, and targeted investments in the electric grid and improved maintenance practices, as system performance continues to worsen over time, increasing vulnerability to disasters.

Energy Adaption

As noted by the IPCC, the cumulative scientific evidence is unequivocal: Climate change is a threat to human well-being and planetary health. With respect to energy adaptation, the IPCC's Sixth Assessment Report (Summary for Policymakers, 2022), states "within energy system transitions, the most feasible adaptation options support infrastructure resilience, reliable power systems and efficient water use for existing and new energy generation systems (extremely high confidence). Energy generation diversification, including renewable energy resources and generation that can be decentralized depending on context (e.g., wind, solar, small scale hydroelectric) and demand side management (e.g., storage, and energy efficiency improvements) can reduce vulnerabilities to climate change, especially in rural populations (high confidence). Adaptations for hydroelectric and thermo-electric power generation are effective in most regions up to 1.5°C to 2°C, with decreasing effectiveness at higher levels of warming (medium confidence). Climate responsive energy markets, updated design standards on energy assets according to current and projected climate change, smart-grid technologies, robust transmission systems and improved capacity to respond to supply deficits have high feasibility in the medium- to long-term, with mitigation co-benefits (extremely high confidence)."

FEMA's Position on Climate Change and Climate Change Adaption

In a recent FEMA press release announcing new initiatives to advance climate change resilience, Deanne Criswell, the FEMA administrator, stated "Climate change is the crisis of this generation. Combating it requires mitigating future risks and reducing impacts. In partnership with federal science agencies, we are analyzing how climate change will increase the frequency and severity across all hazards, and what next steps are necessary to protect communities nationwide."

FEMA recently developed its 2022-2026 Strategic Plan through input from internal and external stakeholders. Following the recent Biden Administration Executive Orders on climate change, equity and environmental justice, FEMA will collaborate with partners to increase climate literacy among emergency managers, build climate resilient communities and empower risk-informed decision making, all with a whole-of-community approach. "As our nation confronts the impacts of climate change, the challenge is clear. It is imperative that we invest in building a more resilient nation. Our programs and policies must protect communities and the economy from the worst impacts of climate-related disasters before they occur," Administrator Criswell added (October 28, 2021).

Climate Change Impact on Hydroelectric Generation

At present, Puerto Rico has 20 hydroelectric generating units, most of which are more than 70 years old, sited on reservoirs that often supply drinking and irrigation water as well as electricity. Hydroelectric generation varies significantly and is affected by rainfall, competing water uses, and lack of funds for maintenance. A major factor contributing to electricity generation by hydroelectric facilities is climate change.

According to the U.S. Energy Information Administration, concentrations of CO_2 in the atmosphere are naturally regulated by many processes that are part of the global carbon cycle. The flux, or movement, of carbon between the atmosphere and the earth's land and oceans is dominated by natural processes like plant photosynthesis. Although these natural processes can absorb some of the anthropogenic CO_2 emissions produced each year (measured in carbon equivalent terms), starting in about 1950, CO_2 emissions began exceeding the capacity of these processes to absorb carbon. This imbalance between greenhouse gas emissions and the ability for natural processes to absorb those emissions has resulted in a continued increase in atmospheric concentrations of greenhouse gases. Concentrations of CO2 in the atmosphere have increased by about 43% since 1850.

Increasing greenhouse gas concentrations are warming the planet. In computer-based models, rising concentrations of greenhouse gases produce an increase in the average surface temperature of the earth over time. Rising temperatures may produce changes in precipitation patterns, storm severity, and sea level. Collectively, this is commonly referred to as climate change.

Assessments by the Intergovernmental Panel on Climate Change (IPCC) suggest that the earth's climate warmed 0.85 degrees Centigrade (1.53 degrees Fahrenheit) between 1880 and 2012. Some development and adaptation efforts have reduced vulnerability. The rise in weather and climate extremes has led to some irreversible impacts as natural and human systems are pushed beyond their ability to adapt.

The U.S. Environmental Protection Agency (EPA) further notes that "climate change is expected to affect tropical cyclones by increasing sea surface temperatures, a key factor that influences cyclone formation and behavior. The U.S. Global Change Research Program and the Intergovernmental Panel on Climate Change project that tropical cyclones will become more intense over the 21st century, with higher wind speeds and heavier rains." The amount of rain falling during the most intense 1% of storms has increased more than 30%. Furthermore, rising temperatures cause snow to begin melting earlier in the year, altering the timing of streamflow in rivers that have sources in mountainous area, like Puerto Rico.

Hydroelectric and climate change show a double relationship. On the one hand, as an important renewable energy resource, hydroelectric contributes significantly to the avoidance of greenhouse gas (GHG) emissions and to the mitigation of global warming. On the other hand, climate change is likely to alter river discharge, impacting water availability and hydroelectric generation. Hydroelectric power plants are sensitive to the volume and timing of stream flows. During times of increased rainfall, dam operators must allow water to bypass the electric turbines to prevent downstream flooding.

Additionally, hydroelectric contributes significantly to the reduction of GHG emissions and to energy supply security. Compared with conventional coal power plants, hydroelectric prevents the emission of about 3 GT CO_2 per year, which represents about 9% of global annual CO_2 emissions. Hydroelectric projects may also have an enabling role as an adaptive measure regarding the impacts of climate change on water resources. Regulated basins with large reservoir capacities are more resilient to water resource changes, less vulnerable to climate change, and act as a storage buffer against climate change. Although hydroelectric power generators do not directly emit air pollutants, the operation of hydroelectric plants can impact the environment. A dam and reservoir changes natural water temperatures, water chemistry, river flow characteristics, and silt loads. All these changes can affect the ecology and the physical characteristics of the river. These changes can have negative impacts on native plants and on animals living in surrounding areas.

Studies of recent hurricanes also strongly suggest that spatial precipitation distribution of a hurricane is in part constrained by a rising or falling Sea Surface Temperature (SST). Models of this correlation between SST and precipitation project an increase in rainfall rates of up to 15% for an increase of 2° Celsius within 100 km. of a tropical storm. Hurricane Harvey in 2017 (1 of 3 Category 4 hurricanes to make landfall in 2017) is a good example of this, with rainfall recorded at 60 inches in some places and damages of over 125 billion dollars. The probable consequences of climate change-driven rises in SST will result in an:

- Increase in hurricane intensity
- Increase in hurricane frequency
- Increase in hurricane precipitation
- Increase in hurricane destructiveness
- A longer lasting hurricane season
- Hurricanes which are less constrained to areas with historically warmer waters.

The Oak Ridge National Laboratory, at the direction of the United States (U.S.) Department of Energy (DOE), in a 2017 study called "The Effects of Climate Change on Hydroelectric" conducted a study to evaluate the potential effects of climate change on water availability for hydroelectric generation in the United States. The intent of the study was to evaluate large-scale climate change effects of all federal hydroelectric plants, enabling policymakers to evaluate potential climate change impacts across the entire federal hydroelectric fleet. It was concluded that the most important climate change effects on hydroelectric generation are likely to be early snowmelt and change in runoff seasonality. Since hydroelectric generation impacted by temperature change, and runoff and precipitation conditions, reservoir storage provides a vital buffer to help manage runoff variability. The temperature-triggered, earlier snowmelt effect represents a significant finding from the future climate projections. The overlapping complexity of physical and policy-related constraints such as issues of aging infrastructure that may result in decreased performance and competing water uses, may reduce the ability of hydroelectric plants to mitigate climate-induce variability in runoff and may increase the complexity of future hydroelectric operations.

As the threat of climate change has accelerated and sustainability has become an important topic, many small island nations, including Puerto Rico, are adapting by incorporating renewable sources of energy into their energy systems. This has been an especially important conversation because of the severity of the power outages across the entire island after the storm and the inability to get electricity back up and running for everyone until many months after the event. LUMA has analyzed PREPA's electric power grid and compared SAIFI and SAIDI metrics of 2019 with 2020 and determined significant degradation in grid's performance. The results of 2020 SAIDI indicated degradation by 29% and SAIFI by 20%. The metrics yield vulnerability of PREPA's electric power grid, as overall system performance deteriorates over time. However, as the shift to RE has started, there have been many questions and concerns presented. One of the bigger questions being asked is whether an increase in RE deployment in Puerto Rico is viable in the short term, and if RE on their own will be resilient enough to withstand future natural disasters and prevent another large-scale blackout.

From 2012-2014, Black and Veatch was engaged in a detailed system evaluation of the PREPA hydroelectric system. In 2021, The Energy Bureau ordered PREPA to complete a feasibility study on refurbishing each of its 16 hydroelectric facilities, including the expected cost and change in electricity production, as well as the potential to control production to produce at the times of greatest value and achieve a 0.28 capacity factor. The knowledge gained from the study in 2014, allowed Back and Veatch, in 2021 to build on this familiarity with the systems including analysis from computer hydrologic-hydraulic water models to further assess the hydroelectric retrofitting opportunity. One of the critical limitations on hydroelectric potential is the availability of water to operate the turbines. Despite the effects climate change has on hydroelectric, PREPA is exploring options to update 16 hydroelectric facilities as stated in the new Integrated Resource Plan as a part of its requirement to increase the use of renewable energy.

<u>State of Hydroelectric Generation in Puerto Rico</u>

Despite the effects climate change has on hydroelectric, PREPA is exploring options to update 16 hydroelectric facilities as stated in the new Integrated Resource Plan (IRP) as part of its requirement to increase the use of RE.

10 hydroelectric facilities are included in the Black and Veatch report and are part of five hydroelectric systems:

1. Dos Bocas-Caonillas (Dos Bocas, Caonillas 1 and Caonillas 2)
2. Toro Negro (Toro Negro 1 and Toro Negro 2)
3. Garzas (Garzas 1 and Garzas 2)
4. Yauco (Yauco 1 and Yauco 2)
5. Rio Blanco

Five additional hydroelectric facilities not included in the Black and Veatch report but to be included in the assessment are:

6. Carite (Carite 1(4 units), Carite 2, and 3)
7. Isabela (Isabela 1, 2, and 3)

The existing maximum capacity for the ten facilities evaluated by Black and Veatch is approximately 94.7 MW. Currently, four of the ten hydroelectric plants are active. The total capacities from the active facilities are approximately 38.8 MW. The remaining systems are currently inactive.

The hydroelectric plants have common requirements needed so that the generation can be increased, and operation is efficient to meet the policy requirements discussed above. Additionally, hydroelectric investment is a major component of building a foundation for a well-planned, progressive, and orderly transition to renewable power generation as part of PREPA's environmental and social obligations.

Common facility upgrades required at all sites include, but are not limited to, mechanical and electrical systems, generator, turbines and controls, penstock, water conveyance, transmission and communication, governors, flood control and drainage. PREPA has an Energy Control Center (ECC) in Monacillo, San Juan, which currently provides voltage and power control remotely for 2 hydroelectric facilities, Yauco 1 and 2, after these plants are locally started and put online manually. For personnel in the ECC to be able to remotely control a unit, network communication between the facilities is needed. Currently, PREPA has communication infrastructure installed around the island utilizing microwave radio with line-of-sight antennas and fiber optic cables run with the transmission lines.

SCADA Systems

For hydro facilities with a working ECC to plant communication network and adequate metering interface, the electrical generation data is automatically gathered by the local Remote Terminal Unit (RTU) and available instantaneously to ECC personnel. For hydro facilities without a working ECC network, personnel at the ECC must call the local operator each hour and manually log the generation data into their system.

Governors

The governor controls the speed and power output of the turbine. In the event of a frequency deviation on the transmission line (system frequency), the governor can be configured to automatically respond in a direction to help restore the frequency. Most of the hydroelectrical facilities have existing mechanical governors, which are outdated and inefficient. The Electrical Power Research Institute (EPRI) published a series of Hydro Life Extension Modernization Guides in 2006. Although the guides are over 15 years old, they provide valuable information for evaluating older facilities. Over time, the governor may experience a change in responsiveness and frequency control stability due to wear in mechanical components.

The U. S. Department of the Interior Bureau of Reclamation (USBR), U. S. Department of Army Corps of Engineers (USACE), U. S. Department of Energy Western Area Power Administration (WAPA) and U. S. DOE Bonneville Power Administration (BPA) published the Federal Replacements Units, Service Lives, Factors report in 2017. According to the USBR report, the service life for a mechanical governor is 50 years and the service life for a digital governor control system is 15 years.

Turbines

Hydroelectric turbines use the force of moving water that pushes a series of blades mounted on a rotor shaft. The force of the fluid on the blades spin/rotate the rotor shaft of a generator. The generator, in turn, converts the mechanical (kinetic) energy of the rotor to electrical energy. Most hydroelectric power plants use water stored in a reservoir or diverted from a river or stream.

Penstock

Penstocks are pipes or long channels that carry water down from the hydroelectric reservoir to the turbines inside the actual power station. They are made of steel and water under high pressure flows through the penstock.

Failure due to excessive internal pressure in penstocks typically occur after load rejection due to sudden valve/gate closure. The failure sequence of events is as follows:

1. Generator under load is suddenly disconnected from the power grid due to a circuit breaker trip or similar reason.
2. With the load disconnected, the generator begins to increase speed since the hydraulic forces driving the turbine are no longer resisted by electrical load (this is sometimes called run away.)
3. The speed governor, which regulates turbine/generator speed by controlling valve/gate position of the turbine quickly closes the valve/gate in response to the increase in machine speed.
4. The sudden valve/gate closure causes a temporary, but large pressure wave within the penstock, which is often referred to as water-hammer or transient pressure.
5. The large pressure increases cause high tensile stresses in the penstock shell and fails the penstock.
6. Water is released through the failed penstock until the intake gate is closed or until water in the reservoir has drained to below the intake sill.

Water Conveyance

Any structure that conveys water from one location to another. Facilities associated with the transmission, storage, impoundment, and diversion of water on and across National Forest System lands. Water conveyance structures include, but are not limited to reservoirs and dams, diversion structures, headgates, pipelines, ditches, canals, and tunnels.

The operation of electricity systems depends on rapid and flexible generation sources to meet peak demands, maintain the system voltage levels, and quickly re-establish supply after a blackout. Energy generated by hydroelectric installations can be injected into the electricity system faster than that of any other energy source. The flexibility of hydroelectric systems, mainly their ability to ramp up and down relatively quickly, make them exceptionally appropriate for addressing any sudden or projected changes in other generation technologies and in providing ancillary services, thus maintaining the balance between the electricity supply and demand.

Hydroelectric Systems and Plants

The Dos Bocas- Caonillas Hydroelectric System includes three plant developments: Dos Bocas, Caonillas 1, Caonillas 2. The Dos Bocas-Caonillas Hydroelectric System works as a network, joined by tunnels, penstocks and reservoirs and are part of a cascading system of lakes, rivers, and tunnels. The Lago Dos Bocas Dam, located in the municipality of Utuado in north central Puerto Rico, was constructed in 1942 for hydroelectric power generation.

The Lago Dos Bocas reservoir became an essential part of the Puerto Rico Aqueduct and Sewer Authority (PRASA) North Coast Super aqueduct (SA) Project in 1996 and is supplied by controlled releases for hydroelectric power generation to replenish the public supply raw water intake pool located about 10 kilometers downstream from the Lago Dos Bocas Dam.

As of 2005, the SA supplies about 4.03 cubic meters per second (348,192 cubic meters per day) of potable water to communities extending along the north coast from Arecibo to the San Juan metropolitan area.

The water used for energy generation in Caonillas 2, is also used to generate energy in Caonillas 1 and later in the Dos Bocas plant. Events that occur in the Dos Bocas Reservoir have direct implications upstream of the reservoir. From this point of view, if hydroelectric generation in Dos Bocas needs to be increased, the releases from Caonillas could be augmented or vice versa.

Dos Bocas

The Dos Bocas system has a potential capacity to generate 18 MW at 2.3 kilovolts (kV); however, it is limited to 15 MW due to water head constraints. The Dos Bocas hydroelectric facility was constructed in 1942 and consists of a three-unit powerhouse with an original rated capacity of 18.6 MW, but currently, the facility is rated at 15MW. The total annual electricity produced over the 30-year study period is about 24,000 MWh, and the average existing cost of operating this facility is about $887,400 annually.

Physical Condition:

The Dos Bocas facility consists of three Francis-type turbines (3 units x 5 MW each). The Dos Bocas reservoir is filled with sediments drawn into the turbines, causing operational problems. Additionally, one of the units has experienced a decrease in efficiency, which could be a consequence of premature wear due to sediment passing through the turbine. The existing governors are Woodward mechanical-hydraulic types located on the generator floor.

To produce the maximum power, the unit needs to be upgraded, mechanical and electrical equipment need to be refurbished and small diversions needs to be restored and automated. The total annual electricity produced over the 30-year study period is about 24,000 MWh. The average existing cost of operating this facility is about $887,400 annually. To ensure maximum efficiency and production, the Dos Bocas facility will need:

- Upgraded generators
- retrofit of the three turbines to increase capacity factor, including upgrading turbine-generator controls, and transformers to result in an increase in overall plant output.

The Black and Veatch report stated the governors have good/fast response time and the units can be used for frequency control. There is a functional fiber optic network to the plant and functioning SCADA system allowing remote monitoring at the ECC. The ECC does not have any remote control of the generating units. There is microwave communication between Dos Bocas and Caonillas 1 to facilitate remote operation of the Caonillas 1 units.

The generating units are operated from the main control benchboard and control panel in the powerhouse control room. The operator manually steps the unit through the startup sequence. Unit 2 and Unit 3 are equipped with GE's Ex2100 solid state excitation systems. Unit 1 has the original rotating excitation system. The facility has a functional fiber optic network to the plant and functioning SCADA system allowing remote monitoring at the ECC. The ECC does not have any remote control of the generating units. There is also microwave communication between Dos Bocas and Caonillas 1 to facilitate remote operation of the Caonillas 1 units.

To provide ECC remote startup, shutdown control of the units, automation of the manual sequences including synchronization is needed. By automating the speed matching, this would also provide the required interface for remote load control. There is no remote voltage control but adding A SCADA interface to the Units 2 and 3 modern excitation systems that have monitoring and control from the control room operator workstation is needed.

Caonillas 1

The Caonillas 1 dam and powerhouse were built in 1948. The powerhouse contains two vertical Francis turbines coupled with generators to produce 10 MW each. For a total of 20 MW. Caonillas I is currently offline and inactive due to damage from flooding during Hurricane Maria. The Caonillas dam, damaged during Hurricane Maria, limited the flow of water and energy production of the facility. Flow has also been impacted by the settlement of sediment in the tunnel from the Jordan diversion to Lago Caonillas. Even though there is no production, there is a cost incurred to maintain the facility. The average annual cost to maintain the facility before the improvement implementation is about $293,000.

Physical Condition:

The facility's generator step-up transformers are damaged, affecting the efficiency and operation of the facility. Both units have modern digital governors using a high-pressure hydraulic system with accumulators rated for 2,000 psi. The electronic governor control panel with the GE Fanuc VersaMax programmable logic controller (PLC) was flooded and suffered permanent damage. The new PLC will include automatic frequency response as part of the governor control package.

The Caonillas 1 plant is fully automated and can be remotely controlled from the Dos Bocas hydroelectric facility. In addition to load control, the units can be started and stopped remotely from Dos Bocas. Currently, the communication system is a microwave system, but a more reliable means of communication with Dos Bocas is frequently interrupted. Damage from Hurricane Maria also affected the operation of the pumps, rendering them incapable of managing the flooding at the location.

To ensure the facility can withstand future hazard events and remain active to generate maximum output, the electric and mechanical systems need to be upgraded for efficiency, response, and resiliency. Upgrade of the generators and retrofit of the two turbines will increase capacity and increase plant output.

To ensure accurate data is available to inform decisions, the communication systems need to be upgraded including SCADA. Also Included in the retrofit are the turbine-generator controls, transformers, and sump pump system.

Caonillas 2

The Caonillas 2 powerhouse, the closest to the urban areas of Utuado, PR, was constructed of concrete in 1950 and consists of one vertical 4MW Francis turbine. The Caonillas 2 plant was flooded during Hurricane Georges in 1998 and the unit is not operational. In general, all the mechanical systems for the turbines, and balance of plant mechanical systems need replacement to bring the system back to operational condition.

Physical Condition:

In 1998, the facility flooded during Hurricane George and again in 2017, due to Hurricane Maria. Much of the electrical generation and mechanical equipment, along with the control systems suffered damage. Additionally, the switch yard, including the transformers and the breakers were damaged and are not operable. Even though the facility is not in service, there is a cost incurred to maintain the facility. The average annual cost to maintain the facility is $13,400.

Presently, the facility cannot withstand future hazard events and remain active. The electric and mechanical systems are not in working order to provide for efficiency, response, and resiliency. The damaged components and equipment include, but not limited to, the governor and automated valve system, cooling system, switchgear and protective relays, breakers, controls, service/step-up transformers, and switchyard. Additionally, due to age and repeated damage to the powerhouse equipment, the generator cannot operate at a higher capacity factor and consequently, result in less dependence on upstream reservoir capabilities. Upgraded water conveyance structures and penstocks will improve power generation. The addition of a flood wall at the turbine discharge channel is also needed.

The original equipment is a Woodward Type HR mechanical governor. There are no operational fiber optic or microwave communication links to this facility. There is an HSQ Technology 2500 Series RTU that is outdated with an inadequate circuit board. The 2500 Series RTU processor has been phased out of service (no longer sold new) by HSQ in 2005, therefore the SCADA system is over 16 years old and inadequate and is not automated. The current system does not allow for remote control communication system from the dispatch center or automated generation modes to enhance reactive power and frequency response

Toro Negro Hydroelectric System

The Toro Negro Hydroelectric System, constructed of concrete, is one of the oldest systems in operation, and has been classified as an historic site, and is still fully operable. The system includes two powerhouses, Toro Negro 1, and Toro Negro 2, two major reservoirs, El Guineo and Matrullas, twelve diversion structures, a splitter box, and a series of tunnels, penstocks, and canals. Toro Negro 2 receives its flow from El Guineo via a penstock. Flow from Toro Negro 2 and the diversion structures is combined in a common splitter box before being conveyed through a tunnel crossing Puerto Rico’s central divide and then discharging through a canal to the Aceitunas forebay, which then routes the flow to Toro Negro 1.

One of the challenges for this system is water conveyance. Although it is fully operable, continuous repair of the penstock is required. In 2021, due to penstock failure, the entire plant flooded causing damage to the generator, controls, BOB, and the penstocks. Because of its historic designation, upgrades and automation are difficult and should be implemented with diligence so there is no risk of removing components that will affect the historic attributes.

This system provides electricity to approximately 12,500 people in and around Villalba, including a local hospital, schools, and the police station. The pipelines also provide raw water supply for approximately 300 residents.

Toro Negro 1

Physical Conditions:

The Toro Negro 1 powerhouse, constructed in 1929, contains three operable 1.5 MW Pelton type turbine generators (Units 1-1, 1 2, & 1-3) and one (1) 4 MW Pelton type turbine generator (Unit 1-4); which was added later in 1937. Units 1-1 and 1-2 are often online. Unit 1-4 is currently considered as a reserve unit, as there is not sufficient water flow to Toro Negro 1 due to the lack of availability of water from the operation of Toro Negro 2.

The Toro Negro 1 hydroelectric electric facility is currently an active hydroelectric plant, but despite being fully operable, some components have been damaged and require upgrades providing for updated and enhanced equipment to withstand hurricane force winds, and water inundation.

Given the current conditions of the plant and its water sources, the average annual electricity produced is 8.782 MWh. The Units 1-1, 1-2 and 1-3 turbines have manual needle operators and deflector control. The three smaller units are equipped with flywheels to increase momentum ride through and improve governing stability. The Units 1-1, 1-2 and 1-3 controllers are a mechanical hydraulic type manufactured by Woodward Governor Company. Speed sensing is via a belt riding over the turbine shaft. The needles are controlled manually using a handwheel at the unit to adjust unit speed, frequency, and load. Units 1-1, 1-2 and 1-3 do not have automatic frequency response capability.

The Aceitunas forebay is upstream of the Toro Negro 1 facility and has two intake gates. The Aceitunas forebay formerly was level controlled from the powerhouse, but communications were lost after Hurricane Maria. Presently, the local operators watch for overflow coming down a channel and watch the penstock pressure to verify that the water level is adequate for operation. The intake gates are manually controlled locally at the forebay. Restoring communication and remote control of the intake gates from the Toro Negro 1 facility can reduce water spillage, resulting in decreased generation. The intake to the Matrullas canal (outlet from the Matrullas reservoir) has a gate. Prior to Hurricane Maria, the gate was automatically controlled from Toro Negro 1. However, the communication system was damaged during Hurricane Maria and now the gate is manually opened and closed by an operator locally using a phone to communicate with the personnel at the powerhouse for opening and closing of the gate.

The powerhouse does not include automatic frequency response, digital mechanical system, or an upgraded electrical system. The powerhouse's efficiency, response and resiliency are negatively impacted. Additionally, the generators, turbine-generator controls, transformers the four turbines have exceeded their useful life span, minimizing capacity factor, resulting in a decreased overall plant output. The damaged and outdated penstocks and water conveyance structures reduce the force and amount of water from the reservoir, thus, reducing hydroelectric output.

The current SCADA system is not automated, so communication enhancement includes an upgrade to an automated system that includes remote control from the dispatch center and automated generation modes to enhance reactive power and frequency response. The average annual cost to maintain the facility is $1,043,200.

The Units 1-1, 1-2 and 1-3 turbines have manual needle operators and deflector control. The three smaller units are equipped with flywheels to increase momentum ride through and improve governing stability. The Units 1-1, 1-2 and 1-3 controllers are a mechanical hydraulic type manufactured by Woodward Governor Company. Speed sensing is via a belt riding over the turbine shaft. The needles are controlled manually using a handwheel at the unit to adjust unit speed, frequency, and load. Units 1-1, 1-2 and 1-3 do not have automatic frequency response capability. Unit 1-4 has a Woodward Type LR mechanical governor. The unit speed can be controlled locally from the main control benchboard. The mechanical governor will respond automatically to frequency deviations.

The powerhouse has a functioning microwave communication to the plant allowing ECC monitoring. Remote monitoring of the facility from the ECC is provided by a modern Harris RTU. There is no remote control of the generating units from the ECC. The generating units are manually controlled locally. In addition to manual control of the load described above, the voltage is also controlled by manually closing field breakers and adjusting rheostats.

ECC remote startup, shutdown control of the units, the manual startup and shutdown sequences including synchronization are not automated. Modern control systems use programmable logic controllers (PLCs) or other processors to provide the unit startup / shutdown sequencing, synchronization, and load control. The control systems include input/output modules to interface the instrumentation and equipment. The manual needle, deflector operators and the digital governors to support automatic sequencing and remote load control are outdated. The existing voltage regulators and field breakers are not adequate to support automatic sequencing and remote voltage control.

Toro Negro 2

Physical Condition:

The Toro Negro 2 powerhouse was constructed in 1937 and contains one single nozzle over-hung 2.0 MW Pelton turbine generator. The unit has experienced a large number of penstock repairs due to its severely degraded condition. Although identified repairs were completed, unit is currently not operational due to the need of a water by-pass gate vale at the entrance to the powerhouse. Said valve is on order and it is expected to be installed during the next two months. The historical average annual net generation is 1,910 MWh. However, there is no current electric power production. The unit has the original mechanical Woodward governor.

Despite age, they are in working order. However, the Toro Negro 2 plant is currently offline awaiting testing to be returned to service due to penstock damages. Even though there is no production, costs are incurred to maintain the facility. The average annual cost to maintain the facility is $143,300.

Daily operations and power generation are impacted due to the age and condition of the generator and controls. To increase capacity factor and increase overall plant output, upgraded turbines are also needed. Output will be increased by upgrading the water conveyance structures and upgrading the penstocks. The electrical and mechanical equipment has components that have exceeded its design life, including the oil-filled circuit breaker.

ECC remote startup, shutdown control of the units, the manual startup and shutdown sequences including synchronization are not automated. The mechanical governor does not support automatic sequencing and remote load control. The current SCADA system is not automated. Communication enhancements include an upgrade to the automated system that includes remote control from the dispatch center and automated generation modes to enhance reactive power and frequency response.

Garzas Hydroelectric System

The Garzas Dam, a hydroelectric generation facility, was constructed as part of a large rural electrification plan undertaken by the Puerto Rico Reconstruction Administration Construction that began in 1935 and it included the reservoir, hydroelectric plant, and three minor river diversions.

The Garzas Hydroelectric System includes two powerhouses (Garzas 1 and Garzas 2), the Garzas reservoir, and six diversion structures.

Garzas 1

Physical Condition:

The Garzas 1 power plant, constructed in 1941, contains two single-nozzle, over-hung 3.6 MW Pelton type turbines, each driving a single generator. The microwave system is currently not in working order and there is no RTU at this facility for remote control. The second transmission line, previously in service to the Garzas 1 plant connecting power and communications over to the Garzas 2 is not in service. The second transmission line allowed the Garzas 2 unit to be controlled from the Garzas 1 powerhouse, improving coordination between the two facilities.

The Garzas 1 units are manually controlled locally at the plant from the main control benchboard and relay/metering panel. ECC remote startup, shutdown control of the units, the manual startup and shutdown sequences including synchronization is not possible with the current systems in place but is necessary for improved efficiency and response.

At present, the capacity factor and overall plant output is reduced due to outdated and inadequate equipment. Outdated and inefficient equipment include the transformers, including penstocks and water conveyance structures, generators, and turbines, along with the turbine controls. Automatic sequencing and remote load control is not possible because of the current mechanical governors. Automatic sequencing requires digital governors. The microwave system used is not adequate to support communication between sites. The current SCADA system is not automated, preventing remote control from the dispatch center and automated generation modes to enhance reactive power and frequency response.

Garzas 2

Physical Condition:

The Garzas 2 powerhouse was constructed in 1941 and contains one single-nozzle, double over-hung 5.0 MW Pelton type turbine pair, driving a single generator between the turbines. The 38 KV, transmission line, connecting the plant to the grid, was damaged during flooding from Hurricane Maria.

Currently there is no communication to this facility from ECC as the microwave system is outdated. Remote control monitoring of the facility is provided with an outdated HSQ Technology 2500 Series RTU. The ECC does not have any remote control of the unit due to transmission line failure preventing timely communication. The transmission line that connected power and communication between the Garzas 1 and the Garzas 2 plants is not in working order. This communication line allowed the Garzas 2 unit to be controlled from the Garzas 1 powerhouse.

Because the facility has not been upgraded and is not automated, ECC remote startup, shutdown control of the units, the manual startup and shutdown sequences including synchronization cannot be implemented. Digital governors are needed to support automatic sequencing and remote load control, but the plant currently has a mechanical governor. The outdated voltage regulator rheostat does not support automatic sequencing and remote voltage control. Because the microwave system is outdated, remote communication link cannot be restored. The existing SCADA RTU does not support remote ECC operation, affecting reactive power and frequency response.

To prevent continued damage from water inundation, installation of a flood wall at the facility between the plant, switchyard and river channel will reduce the risk of flooding.

<u>Yauco Hydroelectric System</u>

The Yauco Hydroelectric System includes one inactive and one active powerhouse (Yauco 1 and Yauco 2) and five reservoirs (Yahuecas, Guayo, Prieto, Luchetti, and Loco) connected by a series of tunnels. Yauco 1 is a one-unit powerhouse, and Yauco 2 is a vintage two-unit powerhouse, built in 1953.

<u>Yauco 1</u>

Physical Conditions:

The Yauco 1 powerhouse was constructed in 1956 and contains a single 25 MW, vertical six jet Pelton type turbine generator unit. Due to vibration issues, the unit has not been operable since 2014.

The Yauco I hydroelectric facility is comprised of a one-unit powerhouse with an original rated capacity of 25 MW but is now operating at a reduced capacity of approximately 11 MW. The reduced capacity is due to the turbine experiencing severe vibrations when operating above this output.

The mechanical governor impacts efficiency and output and does not support automatic sequencing. The governor is a mechanical-hydraulic cabinet actuator type supplied by Woodward Governor Company. The governor operates the jet deflectors in unison with the needles slowly following the movement of the deflectors. When Pelton turbines are required to operate over a wide load range, it is common for the governor to provide automatic change between one-needle up to six-needle operation. This maintains higher efficiency over the load range compared to a constant six-needle operation. The existing governor does not provide this operation.

Currently, the microwave at this plant is not in service. There is an outdated HSQ Technology 2500 Series RTU which has lost some functionality for remote monitoring and control. Previously, the ECC had the capability to remotely start and stop the unit, but this capability is no longer working. Additionally, the ECC was able to remotely start the emergency generator, however, this functionality is no longer working. Some of the RTU circuit boards have failed. The facility retrofit will include an upgrade and digital conversion of the plant’s mechanical system, upgrade of the electrical systems for improved efficiency, response, and resiliency.

The current output, efficiency, response, and resiliency are impacted due to the age and condition of the plant's equipment including the transformers, penstocks. water conveyance structures, generators, and turbines. The current SCADA system is not automated, so communication and remote control from the dispatch center and automated generation modes to enhance reactive power and frequency response is not available.

Yauco 2

Physical Conditions:

Yauco II is a 1953 vintage powerhouse and is comprised of two 4.5 MW, vertical Francis type turbine generator unit powerhouse with an original rated capacity of 10 MW, which is operating at a capacity of approximately 8 MW, both units being used se needed in both generation and synchronous mode.

Each unit has a gate shaft Type HR mechanical governor manufactured by Woodward Governor Company. The wicket gates can be controlled locally from the main control panel. Once online, the unit load can be controlled remotely from ECC. The plant has a modern Harris RTU panel but has outdated HSQ Technology 2500 Series RTU panel.

The units are often run in synchronous condense mode allowing ECC load and voltage control. The units are manually put online and shut down locally at the walk-in control panel located in the powerhouse control room.

The mechanical governor impacts efficiency and output and does not support automatic sequencing. The plant also has a functioning microwave communication allowing ECC remote monitoring and load / voltage control, a modern Harris RTU panel and an outdated HSQ Technology 2500 Series RTU panel. The units are run in synchronous condense mode allowing ECC load and voltage control and are manually put online and shut down locally at the walk-in control panel located in the powerhouse control room.

Frequency response and reactive power are not optimal. The hydroelectric plant does not operate at full capacity due to the condition and age of the transformers, penstocks, water conveyance structures, generators, and turbines. The current SCADA system is not automated, so communication with ECC is impacted.

The Río Blanco Hydroelectric System

This system consists of one plant development, the Río Blanco hydroelectric facility. The Rio Blanco hydroelectric facility is a series of diversion dams, flow conveyance and the powerhouse. The Cubuy dam diverts water from the Cubuy River into the flow conveyance system. The Sabana dam diverts water from the Sabana River into the flow conveyance system. The Icacos dam creates a small storage reservoir on the Icacos River and diverts flow into the conveyance system. The Prieto dam diverts water from the Prieto River into the flow conveyance system and the penstock intake.

Rio Blanco

Physical Conditions:

The Rio Blanco powerhouse was constructed in 1930 and contains two 2.5 MW horizontal Pelton type turbine generator units, which has maximum capacity to produce 6.25 MW of electricity. The Rio Blanco powerhouse has been out of service for the past ten years. Repairs to the flow conveyance system are required and some of the electrical equipment is beyond its useful life, including the oil-filled circuit breakers in the powerhouse.

The governor is a mechanical type deriving its operating power from a leather belt on the turbine/generator shaft. The governor has only one electrical connection, a raise-lower motor to run a valve which opens and closes the needle valve. The units are equipped with flywheels to increase momentum ride through and improve governing stability. There is a speed control raise-lower switch on the main control panel for local operation.

The plant has a functioning fiber optic network allowing remote monitoring at the ECC. There is an older Harris RTU providing the ECC data for remote monitoring. The ECC does not have remote control at this facility. The units are controlled manually from the main control panel in the powerhouse control room. There is a manually adjusted rheostat and mechanical voltage regulator for local voltage control. The generator circuit breakers are manually closed from the front of the main control panel using a large lever connected to the oil circuit breaker compartment behind the panel.

Because the current systems are not automated, it is not possible to provide ECC remote startup, shutdown control of the units, the manual startup, shutdown sequences or synchronization. The mechanical governor impacts efficiency and output and does not support automatic sequencing. The outdated voltage regulator does not support automatic sequencing and remote voltage control. The manually operated, oil type generator circuit breakers are outdated.

Frequency response and reactive power are not optimal. The hydroelectric plant does not operate at full capacity due to the condition and age of the transformers, penstocks, water conveyance structures, generators and turbines and turbine controls. The current SCADA system is not automated, so communication with ECC is impacted.

To prevent continued damage from water inundation, installation of a flood wall at the facility between the plant and the river channel will reduce the risk of flooding.

The Isabela Hydroelectric System

The Isabela Hydroelectric System consists of three hydroelectric plants that are currently not operational and do not produce power. Plant 1 was constructed in 1972, Plant 2 was constructed in 1940 and Plant 3 was constructed in 1947.

Carite Hydroelectric System

The Carite Hydroelectric System originally consists of 3 hydroelectric plants with a capacity to produce 9.5 MW combined. The success achieved in the operation of the hydroelectric system of Carite motivated the construction of Carite Power Plant #2, in 1922 and Carite 3 in 1936.

In 1908 a law was passed creating the Costa Sur Irrigation District. As part of this, the Carite, Patillas and Guayabal dams were built to provide water for irrigation of the Southern coast. Lake Carite was the first in a series of artificial lakes developed as part of the irrigation system of the southern coast. This was the government's first hydroelectric power station The Carite Hydroelectric System is in the Municipality of Guayama and was built by the Irrigation Service of the South Coast to take advantage of the waterfall from Lake Carite to the channels of the irrigation system of the area. The topography of this area varies in elevation from approximately 110 to 545 meters above mean sea level.

In 1913 the Carite 1 Hydroelectric Plant was built to provide electricity for the development of the region. The Carite 1 plant was the first hydroelectric plant owned by the Government. Later, due to an increase in electricity demand and the success of the Carite 1 plant, the construction of Carite 2 and 3 hydro plants started.

It was not until the boom of the thermoelectric plants boosted by the low prices of petroleum in the 1970s that the hydro power plants fell in disuse because of the economic changes on the island. The Carite System ceased operations in 1972. In 1992, unit 1-4 at Carite 1 was replaced to re-activate the Carite Hydroelectric System, but the re-activation was not completed due to the excessive costs of repairing the penstocks. In 1999 the Carite Hydroelectric System was decommissioned.

Since the Carite hydro power plants have been decommissioned, irrigation usage has continued and is managed and maintained by the Dams and Reservoirs Division, the Carite dam, and the Western Guamaní Canal. PREPA's Hydro and Gas Division continues to oversee the infrastructure that was once the power generating components of the system. The Carite system consists of the following elements:

- Three hydroelectric plants: *Carite 1, Carite 2, and Carite 3*
- A major reservoir: *Carite*
- Four forebays: Carite, *Carite 1, Carite 2, and Carite 3*
- Two stream intake structures or diversion dams: *Carite 1 and Carite 2*
- Other structures
    - Tunnels
    - Penstocks
    - Canals
    - Diversion Structures

Decommissioned for many years, in April 2011, the Puerto Rico Electric Power Authority (PREPA) contracted CSA Architects and Engineers, LLP (CSA) to perform an evaluation of the agency's hydroelectric power systems to determine the potential for rehabilitation and production increase of the systems. The study included the observations, information, and evaluation of the Carite hydroelectric system. System components were visited and evaluated; meteorological and physical information of the system was collected for the upcoming water availability analysis and identification of potential infrastructure and equipment issues were studied to determine the feasibility to allow the system to produce electric power.

Carite 1

The hydroelectric power plant was built in various stages, beginning in 1915 with two (2) Units 1-1 and 1-2, each with a capacity of 0.56 MW. In 1924, unit 1-3 (0.56 MW) was installed and unit 1-4 was added in 1931 (1.68 MW). An attempt at replaced happened in 1992. Carite 1 has capacity to produce 6 MW of electricity. The building is made of reinforced concrete, concrete masonry walls and gabled zinc roof composed of structural steel trusses.

Of the three hydroelectric plants, the Carite 1 building is in better condition when compared to Carite 2 and Carite 3, which may be due to the attempt in 1992 to reactivate the plant. The tunnels, canals and forebays are partially deteriorated. Obstructions and damage from landslides have been reported by PREPA personnel.

Because the current systems are not automated, it is not possible to provide ECC remote startup, shutdown control of the units, the manual startup, shutdown sequences or synchronization. The mechanical governor impacts efficiency and output and does not support automatic sequencing. The outdated voltage regulator does not support automatic sequencing and remote voltage control.

Frequency response and reactive power are not optimal. The hydroelectric plant does not operate at full capacity due to the condition and age of the transformers, penstocks, water conveyance structures, generators and turbines and turbine controls. The current SCADA system is not automated, so communication with ECC is impacted.

Carite 2

Carite 2 plant was built in 1928 with a capacity of .64 MW. The Carite 2 building has deteriorated over the years. The current capacity of Carite 2 is 1.2 MW but has the potential to produce 2 MW of electricity. The building is constructed of reinforced concrete and concrete masonry walls. The building has a rusty gabled zinc roof, with structural steel trusses.

The goal is to increase capacity factor, with a resulting increase in overall plant output. Currently the equipment is not sufficient to provide maximum output including generators, turbines, auxiliary systems including the governor and automated valve system, cooling system, switchgear and protective relays, breakers, controls, service and step-up transformers and the switchyard. and other required equipment for plant operations (please elaborate and provide specifics

Frequency response and reactive power are not optimal. The hydroelectric plant does not operate at full capacity due to the condition and age of the transformers, penstocks, water conveyance structures, generators and turbines and turbine controls. The current SCADA system is not automated, so communication with ECC is impacted.

Carite 3

Carite 3, with 1 unit built in 1936, has a capacity factor of .64 MW. The current capacity of Carite 3 is 0.8 MW but has the potential to produce 1.5 MW of electricity. The building is constructed of reinforced concrete and concrete masonry walls. The building has a flat zinc roof with structural trusses in extremely poor condition. The goal is to increase capacity factor, with a resulting increase in overall plant output.

Currently the equipment is not sufficient to provide maximum output. The outdated equipment includes generators, turbines, auxiliary systems including the governor and automated valve system. Additionally, the cooling system, switchgear and protective relays, breakers, controls, service and step-up transformers and the switchyard. and other required equipment for plant operations are outdated and inefficient.

Frequency response and reactive power are not optimal. Another crucial factor contributing to reduced output is the age of the transformers, penstocks, water conveyance structures, generators, turbines, and turbine controls. The current SCADA system is not automated, so communication with ECC is impacted.

Project Alternatives

Preferred Alternative:

The proposed project is aimed at reducing Puerto Rico's reliance on fossil fuels and its continued contribution to global warming and climate change, increasing the resilience of Puerto Rico's overall power grid to climate-induced risks, particularly during and after a hurricane or major storm event, and increasing the reliability of the power supply during major storm events. To achieve this, the proposed project will implement a full retrofit of 16 hydroelectric plants, including a wind retrofit of each facility's windows, doors and roofs, and upgrades of the existing equipment to increase the capacity factor of each plant. The proposed hydroelectric facility upgrades will (1) add needed protection to the facilities during a hurricane to make the sites more resilient and allow the plants to recover more quickly and efficiently following a hurricane, (2) help establish a process for restoring the island's power grid to working order, and importantly, (3) increase the overall production of each hydroelectric plant, which will reduce overall reliance on fossil fuel generation. The proposed project has the potential to add upwards of approximately 120 MW of hydroelectric generation to Puerto Rico's grid capacity mix.

Details about each hydroelectric plant's retrofit and upgrade are as follows:

- Dos Bocas: Upgrade 27 windows and one exterior door with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 166 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include upgrading generators for reliable backup power, upgrading three turbines to a more efficient design, upgrading transformers to provide necessary functions, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Caonillas 1: Upgrade four windows and one exterior door with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 168 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include upgrading generators for reliable backup power, upgrading two turbines to a more efficient design, upgrading transformers to provide necessary functions, upgrading the sump pump system, upgrading equipment controls and remote/automated communications with equipment to ensure quick functions of equipment, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Caonillas 2: Upgrade nine windows and one exterior door with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 170 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: Adjustments to one generator and one turbine to produce a higher capacity factor for the plant, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Toro Negro 1: Upgrade 83 windows and three exterior doors with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 176 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading generators for reliable backup power, upgrading four turbines with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Toro Negro 2: Upgrade 10 windows and one exterior door with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 172 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading the generator for reliable backup power, upgrading one turbine with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Garzas 1: Upgrade 28 windows and one exterior door with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 175 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading generators for reliable backup power, upgrading two turbines with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Garzas 2: Upgrade 42 windows and three exterior doors with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 175 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading the generator for reliable backup power, upgrading one twin-rotor turbine with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Yauco 1: Upgrade 11 windows, two louvers and two exterior doors with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 175 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading the generator for reliable backup power, upgrading one turbine with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Yauco 2: Upgrade 19 windows, one louver and two exterior doors with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 177 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading generators for reliable backup power, upgrading two turbines with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Rio Blanco: Upgrade 42 windows and three exterior doors with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 179 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading generators for reliable backup power, upgrading two turbines with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, the addition of a retaining wall to prevent flooding of the facility, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Isabela 1: Upgrade 18 windows and one exterior door with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 165 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading generators for reliable backup power, upgrading two turbines with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during One of the project.

- Isabela 2: Upgrade 56 windows and one exterior door with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 166 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability.

Equipment upgrades will include: upgrading generators for reliable backup power, upgrading turbines with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Isabela 3: Upgrade 19 windows and one exterior door with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 163 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading the generator for reliable backup power, upgrading one turbine with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Carite 1: Upgrade 45 windows and four exterior doors with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 185 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading generators for reliable backup power, upgrading four turbines with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Carite 2: Upgrade 41 windows and one exterior door with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 185 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading the generator for reliable backup power, upgrading one turbine with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

- Carite 3: Upgrade 12 windows and two exterior doors with hurricane wind-resistant equipment that can provide adequate protection against Risk Category IV windspeeds of 186 mph. The facility will also receive upgraded equipment to allow for maximum output, efficiency, and reliability. Equipment upgrades will include: upgrading the generator for reliable backup power, upgrading one turbine with a more efficient design, upgrading transformers to provide necessary functions, upgrading the water conveyance system, including penstocks, to maximize water flow, upgrading equipment controls and remote/automated communications with equipment to ensure quick response and functions, as well as upgrades to any other required electrical or mechanical equipment identified during Phase One of the project.

Due to the number of sites to be mitigated included in the project (16 total locations) and the diverse activities required to refine the detailed scope of work and technical specifications, it is proposed to phase this project. Phase One of the project will include all required studies, surveys and assessments, initial permitting and coordination, engineering design, finalization of the scope of work and the work schedule and EHP compliance activities, as needed. Upon Phase One approval from COR3 and FEMA, Phase Two of the project will include any additional procurement activities, final design activities, consultation with appropriate agencies, demolition as needed, mobilization and installation, inspection activities and closeout.

All required wind retrofits of the facilities will be done in compliance with Puerto Rico Building Code 2018, ASCE 7-16, and FEMA P-2062 and will meet the testing requirements of ASTM E1996 and ASTM E1886, able to withstand at least a Type D missile. Upgrades to the equipment of the facilities will be done in observance with FEMA P-1019, Puerto Rico Building Code 2018 and any other required local, commonwealth or federal codes and regulations.

The proposed project is estimated to cost $320,790,000.00 (based on existing reports of the hydroelectric plants and RS Means) and take 156 weeks to complete.

Second Alternative

Non-Selected

The second alternative is the construction of a solar wind farm. The solar wind farm would be approximately 800 acres in size and would produce 102 MW of electricity. A solar facility of this scale will generate emission free electricity to power thousands of homes in Puerto Rico and reduce the carbon footprint emitted by burning fossil fuels. A series of studies and assessments will be performed to determine the technical feasibility, project location, and specifications of electrical components required. The construction of solar panels and its infrastructure will comply with the windspeeds specified in ASCE 7-16 and other local, commonwealth, and federal rules and regulations.

The estimated cost of this project is $360,000,000.

Non-selection rationale:

This alternative was not selected as this alternative would require a large amount of land, is more susceptible to damage during storms, and is more costly than the preferred alternative. This alternative would require acquisition of 800 acres of land. Land acquisition of this scale will be costly and time consuming given existing land pressures in Puerto Rico (land is relatively scarce and there are several competing uses such as housing and agricultural production). In addition, Solar installations in locations with regular extreme weather conditions may need to be specially retrofitted or designed to withstand wind and windborne debris.

Third Alternative

No Action

If no action is taken at the hydroelectric plants, then many communities throughout Puerto Rico will be affected. The hydroelectric power plants will continue to operate at reduced to zero capacity causing thousands of residents and many critical facilities to suffer from daily planned and unplanned power outages. This could negatively impact critical systems such as telecommunications, potable water and transportation around the metropolitan area and the other strategic locations.

Hazards Description

This project addresses several hazards, including power outages, high winds, and climate change. During hurricane events, Puerto Rico suffers power outages that can leave residents across the island without power for weeks or even months. Puerto Rico has a fleet of hydroelectric power plants that could provide a reliable source of power to the island, but they are currently unable to operate at optimal capacity and withstand the impacts of natural hazards.

Problem to be Solved

The problems to be solved by the proposed project include improving the resilience of Puerto Rico's grid infrastructure, reducing reliance on fossil fuels and current contributions to climate change, as well as supporting Puerto Rico's efforts to increase electricity reliability during and following hurricane events.

Objectives

The objectives of this project are to improve the reliability and resiliency of Puerto Rico's hydroelectric power plants by:

- Increasing the capacity factor at the hydroelectric plants
- Increasing the contribution of hydroelectric generation to the grid
- Supporting Puerto Rico's clean energy transition

This will in turn reduce Puerto Rico's reliance on fossil fuels, its contributions to global warming and climate change, and help reduce the likelihood and intensity of future hurricane events.

Work Breakdown Structure

The project is proposed to be completed in two distinct phases, which combined are expected to take 156 weeks to complete. All activities will be undertaken in compliance with any federal, commonwealth and local regulations and requirements.

Phase One is expected to take 40 weeks and will include:

1. Procurement activities
2. Engineering studies and development of new data and analysis of all project locations
3. Fabrication of engineering design plans
4. Development of opinion of probable costs
5. Refined cost effectiveness determination
6. Initiating permits, coordination, and consultation
7. EHP impact statement and documentation
8. Updated project designs
9. Final scope of work and work schedule development

All identified deliverables will be submitted to COR3/FEMA for review and approval at the conclusion of Phase One. Once deliverables are approved by COR3/FEMA, Phase Two will commence and is anticipated to take 116 weeks, pending required elements that are out of the sub-applicant's control, such as final permitting. Phase Two will include all construction activities comprised of:

1. Approvals, procurement activities, permitting activities and fees
2. Finalization of project design
3. Finalization of opinion of probable costs
4. Ongoing coordination with any federal and commonwealth agencies (as required)
5. Construction activities in accordance with the final plans including, but not limited to, site work, mobilization, demolition, fabrication, installation of wind retrofit elements, upgraded hydroelectric equipment, demobilization, and electrical tie-in to the power grid
6. Commissioning, testing, and inspections
7. Administrative closeout and financial reconciliation

Project Methodology

The proposed project will be phased due to the number of locations and the diverse activities included in the scope of work, which will allow for additional and necessary scope of work refinement, final design development and construction in accordance with all necessary federal, commonwealth and local agencies laws, regulations, codes, and standards. Phase One will include all technical studies, site assessments, initial engineering designs, scope refinement, EHP review, initial permitting activities, and evaluation of the final extent of impacts for the project. Licensed professionals will perform site assessment, data collection, and engineering design.

Phase One is expected to take 40 weeks to complete all activities, including:

1. Procurement activities
2. Engineering studies and development of new data and analysis of all project locations, including but not limited to:
    a. Hydraulic and hydrologic study
    b. Wind vulnerability and building structure/envelope assessment
    c. Environmental Impact Statement (EIS) development, NEPA process, environmental recommendations (REA) and determination of environmental compliance (as required)
    d. Flora and fauna/natural habitat categorization
    e. Archeological survey
    f. Tree inventory and mitigation plan
    g. Hydrographic Survey and Report
    h. Bathymetric survey
    i. Geotechnical study and topographic survey
    j. Resilience assessment of all hydroelectric facilities
3. Fabrication of engineering design plans:
    a. Initial engineering design plans
4. Development of opinion of probable costs:
    a. Preliminary opinion of probable cost of construction activities
5. Refined cost effectiveness determination:

a. Update Benefit Cost Analysis (BCA) and all necessary supporting documentation

6. Initial permits, coordination, and consultation:

   a. EHP consultations with federal agencies that may be consulted, including but not limited to:

      i. Federal Energy Regulatory Commission (FERC)
      ii. U.S. Environmental Protection Agency (EPA)
      iii. Federal Emergency Management Agency (FEMA)
      iv. National Oceanic & Atmospheric Administration (NOAA)
      v. U.S. Army Corps of Engineers (USACE) Jacksonville
      vi. U.S. Geological Survey (USGS)
      vii. United States Fish & Wildlife Service (USFWS)
      viii. National Marine Fisheries Service
      ix. U.S. Coast Guard
      x. U.S Forest Service
      xi. Department of Energy
      xii. Department of the Interior
      xiii. U.S. Department of Commerce
      xiv. Council on Environmental Quality

   b. EHP consultations with commonwealth agencies that may be consulted, including but not limited to:

      i. Puerto Rico Permits Management Office (OGPe)
      ii. Puerto Rico Electric Power Authority (PREPA)
      iii. Puerto Rico Aqueduct and Sewer Authority (PRASA)
      iv. Department of Natural and Environmental Resources (DNER) and Environmental Quality Board

v. Puerto Rico Energy Regulatory Bureau

vi. Puerto Rico Planning Board

vii. State Historic Preservation Office

viii. Institute of Puerto Rican Culture

ix. Puerto Rico Department of Health

x. Puerto Rico Department of Agriculture

xi. Fire Bureau of the Puerto Rico Public Safety Department

xii. Department of Economic Development and Commerce

xiii. Pertinent NGO's and community organizations

7. EHP impact statement and documentation of coordination with EHP agencies

8. Updated project designs:

    a. Revisit and update design plans, prepare designs for Phase Two approval

9. Final scope of work and work schedule development:

    a. Update narrative for the construction phase of the project

    b. Update work schedule to include all major milestones, deliverables, and project management activities

At the conclusion of Phase One, all identified deliverables will be submitted to COR3 and FEMA for review and approval. No construction activities will take place until prior written authorization from FEMA and COR3 is received.

Phase Two, expected to take approximately 116 weeks, will include all project construction implementation activities, including:

1. Approvals, procurement activities, permitting activities and fees:

    a. Phase Two permits and endorsements from any required local, commonwealth or federal agencies

2. Finalization of project design:

    a. Final design drawings for all locations (100%)

3. Finalization of opinion of probable costs:
    a. Final opinion of probable cost of construction for cost analysis after bid
4. Ongoing coordination with any federal and commonwealth agencies (as required):
    a. EHP monitoring throughout construction activities and milestones
5. Construction activities in accordance with the final plans including, but not limited to:
    a. Sitework, mobilization and staging at all project locations
    b. Demolition and removal of equipment from all project locations (as required)
    c. Fabrication and installation of wind retrofit equipment at all hydroelectric plants
    d. Fabrication and installation of all upgraded equipment at hydroelectric plants
    e. Electrical tie-in to grid activities at all locations
    f. Demobilization
6. Commissioning, testing, and inspections
7. Administrative closeout and financial reconciliation

Procurement activities for each phase will comply with federal, commonwealth and local regulations and requirements.

Long Term Changes in the Area

No long-term changes in the area are projected that would impact the efficacy of the proposed project.

Long Term Maintenance

A detailed analysis of long-term maintenance requirements will be determined during engineering design and delivered at the conclusion of Phase One. Annual maintenance activities are anticipated to include:

- Daily evaluation of component performance and maintenance
- Unit maintenance such as routine visual inspection, monitoring/changing fuel and filters, and components and connections maintenance (monthly)
- Routine cleaning/lubricating of the components of the system, including quarterly allowance for replacement parts (quarterly)

Please refer to the document (*4339-1966_BCA_20221013_BCA Attestation Letter) for the detailed estimated maintenance costs for each station.*

Other Projects in the Same Area

Although there are many projects currently funded or projected to be funded with funding from FEMA and many other agencies supporting Puerto Rico's recovery from hurricanes and earthquakes over the last five years, none are projected to duplicate the scope work of this project.

Work Schedule

Sequence	Task or Activity	Duration (Weeks)
1	Phase One: Kickoff activities, procurement activities	10
2	Phase One: Engineering studies and development of new data and analysis of all project locations	8
3	Phase One: Fabrication of engineering design plans	10
4	Phase One: Development of opinion of probable costs	1
5	Phase One: Refined cost effectiveness determination	2
6	Phase One: Initiating permits, coordination, and consultation	3
7	Phase One: EHP impact statement and documentation	2
8	Phase One: Updated project designs	2
9	Phase One: Finalization of scope of work and work schedule	1
10	Phase One: Deliverables to COR3/FEMA for review and approval	1
		Phase One Duration: 40 Weeks

11	Phase Two: Approvals, procurement, permitting activities and fees	10
12	Phase Two: Finalization of project designs	2
13	Phase Two: Finalization of opinion of probable cost	2
14	Phase Two: Coordination with federal and commonwealth agencies	4
15	Phase Two: Construction activities – site work, mobilization, demolition, fabrication, installation, demobilization, electrical tie-in	94
16	Phase Two: Commissioning, testing, inspections	2
17	Phase Two: Administrative closeout and financial reconciliation	2
		Phase Two Duration: 116 Weeks

Budget Narrative

See *4339-1966_Budget Narrative_20220825_Project Budget Narrative* in the application package.

5% Management Cost

See *4339-1966_Project Management Cost_20220825_5% Project Management Cost* in the application package.

SFM Schedule

Quarter	Task or Activity	Estimated FEMA Funds	Estimated Other Funds	Estimated Local Cost	Total Cost
Quarter 1	Phase One: Kickoff activities, procurement, engineering studies and development	$8,250,000.00	$0.00	$0.00	$8,250,000.00

	of new data and analysis				
	Quarter Total:	**$8,250,000.00**	**$0.00**	**$0.00**	**$8,250,000.00**
Quarter 2	Phase One: Fabrication of engineering design plans	$8,250,000.00	$0.00	$0.00	$8,250,000.00
	Quarter Total:	**$8,250,000.00**	**$0.00**	**$0.00**	**$8,250,000.00**
Quarter 3	Phase One: Development of opinion of probable costs, refined cost effectiveness determination, initiating permits, coordination, and consultation, EHP impact statement and documentation	$8,250,000.00	$0.00	$0.00	$8,250,000.00
	Quarter Total:	**$8,250,000.00**	**$0.00**	**$0.00**	**$8,250,000.00**
Quarter 4	Phase One: Updated project designs, finalization of scope of work and work schedule, deliverables to COR3/FEMA for review and approval	$8,250,000.00	$0.00	$0.00	$8,250,000.00

	Quarter Total:	**$8,250,000.00**	**$0.00**	**$0.00**	**$8,250,000.00**
		Total Phase I:			**$33,000,000.00**
Quarter 5	Phase Two: Approvals, Permitting activities and fees, finalization of project designs, finalization of opinion of probable cost, coordination with federal and commonwealth agencies	$35,973,750.00	$0.00	$0.00	$35,973,750,00
	Quarter Total:	**$35,973,750.00**	**$0.00**	**$0.00**	**$35,973,750.00**
Quarter 6	Phase Two: Construction activities – site work and mobilization	$35,973,750.00	$0.00	$0.00	$35,973,750.00
	Quarter Total:	**$35,973,750.00**	**$0.00**	**$0.00**	**$35,973,750.00**
Quarter 7	Phase Two: Construction activities - demolition	$35,973,750.00	$0.00	$0.00	$35,973,750.00
	Quarter Total:	**$35,973,750.00**	**$0.00**	**$0.00**	**$35,973,750.00**
Quarter 8	Phase Two: Construction activities – fabrication	$35,973,750.00	$0.00	$0.00	$35,973,750.00
	Quarter Total:	**$35,973,750.00**	**$0.00**	**$0.00**	**$35,973,750.00**

Quarter 9	Phase Two: Construction activities – installation	$35,973,750.00	$0.00	$0.00	$35,973,750.00
	Quarter Total:	$35,973,750.00	$0.00	$0.00	$35,973,750.00
Quarter 10	Phase Two: Construction activities – demobilization	$35,973,750.00	$0.00	$0.00	$35,973,750.00
	Quarter Total:	$35,973,750.00	$0.00	$0.00	$35,973,750.00
Quarter 11	Phase Two: Construction activities – electrical tie-in	$35,973,750.00	$0.00	$0.00	$35,973,750.00
	Quarter Total:	$35,973,750.00	$0.00	$0.00	$35,973,750.00
Quarter 12	Phase Two: Commissioning, testing, inspections, administrative closeout, and financial reconciliation	$35,973,750.00	$0.00	$0.00	$35,973,750.00
	Quarter Total:	$35,973,750.00	$0.00	$0.00	$35,973,750.00
		Total Phase II:			$287,790,000.00
		All Estimated FEMA Funds:	All Estimated Other Federal Funds:	All Estimated Local Funds:	All Total Estimated Cost:
		$320,790,000.00	$0.00	$0.00	$320,790,000.00

Reference material

Included in the application package.

Required Uploads/Supporting Documentation

HM Plan
Included in the application package.

Mapping
Included in the application package.

EHP Checklist
Included in the application package.

BCA Packet
Included in the application package.

SF-424
Included in the application package.

SF-424-A
Included in the application package.

SF-424-B
Included in the application package.

SF-424-C
Included in the application package.

SF-424-D
Included in the application package.

Certification Regarding Lobbying
Included in the application package.

Drug Free Workplace
Included in the application package.

Letter For Management Costs
Included in the application package.

Other Funding Agencies
Included in the application package.

General Conditions
Included in the application package.

Maintenance Agreement
Included in the application package.