Energy Technical Advisory Council (ETAC) Vieques & Culebra Generation & Microgrid Technical and Financial Funding Justification

Submitted by:
Energy Technical Advisory Council
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Executive Summary

PREPA is pursuing a microgrid for the Vieques & Culebra islands as the current 38kV cable serving from Puerto Rico main island (Line 5400) was severed during the hurricane. The terminal and substation on the main island were flooded and damaged. The submarine cable is near the end of its useful life. PREPA has patched the submarine cable back together to provide an alternative to the FEMA generators but this is not a long term solution. Any permanent submarine cable will require new sites, permitting, terminals on all islands, different voltage and new routing. Anticipate about 10 years to plan permit fund complete a new cable a new cable will take 4+ years to implement.

1.1 Synopsis

1.2 Current State

Vieques & Culebra are served via a 38kV submarine transmission cable from Puerto Rico main island. During Hurricane Maria, the 38 kV submarine transmission cable and the associated substation connecting Puerto Rico to the islands was damaged and rendered inoperable. Since the storm, PREPA and FEMA have provided temporary power to the islands using backup high-speed diesel generators. . PREPA has patched the submarine cable back together to provide an alternative to the FEMA generators but this is not a long term solution. Any permanent submarine cable will require new sites, permitting, terminals on all islands, different voltage and new routing. Anticipate about 10 years to plan permit fund complete a new cable a new cable will take 4+ years to implement.

1.3 Deficiencies in Current State

Dependency to the Main Island
In an event of a long-term interruption of grid power supply from the main island, such as what was experienced following the 2017 Hurricane season, Vieques & Culebra could not sustain reliable power at the current state.

Inflexible Power Source
The current 38 kV submarine cable coming from the main grid, although in operation, is unreliable given its fragility. This will eventually be resolved with the installation of a permanent 115 kV submarine cable loop which will be available at a later stage in approximately 10 – 12 years. However, safe and stable is needed in a shorter time horizon to ensure continuity and reliability whether the power comes from within the Vieques & Culbera islands or from the main Puerto Rico grid.

Unreliable Operation
During normal non-emergency operation, the current system has inadequate operational flexibility using diesel-only, or grid+diesel back-up options. For example, outages of the diesel plant related to interconnection work/repairs, diesel plant main transformer or switchgear outage could cause power

supply interruption or operation with no back-up capability. The same applies to any transformer, interconnection or switchgear work (whether planned or unplanned).

Inadequate Sustainability and Scalability
The current system if not redesigned does not help achieve the renewables (sustainability) goals stated in the Governor's Recovery Plan. A system is needed to to accommodate and fully leverage additional distributed energy resources (DER) added in the future.

1.4 Codes and Standards

General Codes and Standards
The proposed project on Culebra and Vieques will comply with the standards and codes listed below, as applicable. Depending on the final design, some of these standards and codes may not apply, while other standards and codes may apply that are not listed.

- Title 18 CFR, Conservation of Power and Water Resources
- Title 40 CFR, Protection of the Environment
- Title 49 CFR, Transportation
- National Electrical Code (NEC)
- National Electric Testing Association (NETA)
- American National Standards Institute (ANSI)
- Institute of Electrical and Electronics Engineers (IEEE)
- Occupational Safety and Health Association (OSHA)
- National Fire Protection Association (NFPA)
- The Environmental Protection Agency (EPA)
- American Society for Testing and Materials, ASTM
- International Electrotechnical commission (IEC)
- Joint Regulation for the Evaluation and Expedition of Permits Related to Development and Use of Lands (Oficina Gerencia de Permisos; OGPe)
- Puerto Rico Building Code 2018:
    - International Building Code (IBC) 2018
- Puerto Rico Mechanical Code 2018
    - International Mechanical Code {IMC) 2018
- Puerto Rico Plumbing Code 2018
    - Plumbing Code 2018 International Plumbing Code (I PC) 2018
- Puerto Rico Fire Code 2018
    - International Fire Code (IFC) 2018
- Puerto Rico Fuel and Gas Code 2018
    - International Fuel and Gas Code (IFGC) 2018
- Puerto Rico Energy Conservation Code 2018
    - International Energy Conservation (IECC) 2018
- Puerto Rico Existing Building Code 2018
    - International Existing Building {IEBC)
- Puerto Rico Private Sewage Disposal Code 2018

- International Private Sewage Disposal (IPSDC) 2018
- American Society of Civil Engineers Standards
- PREP A Standards and Regulations
- American Concrete Institute ACI ~318 (latest revision)
- Environmental Quality Board SPCC Permit
- American Petroleum Institute API - 2610 Design, Construction
- Operation, Maintenance & Inspection of Terminal and Tank Facilities.
- NFPA-30- Flammable and Combustible Liquid Code
- American Society for Testing and Materials, ASTM
- "Manual Para el Disefio y Construcci6n de Mallas Conectadas a Tierra Para Subestaciones Y Equipos"
- "AEE- Patrones de Construcci6n de Distribuci6n Aerea, 1986"
- "AEE- Patrones de Construcci6n de Uneas de Transmisi6n, Mayo 1992"
- Joint Regulation for the Evaluation and Expedition of Permits Related to Development and Use of
- Lands (Oficina Gerencia de Permisos; OGPe)

Specific Codes and Standards

Battery & Battery Management Systems

A. UL 1973, Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light
B. Electric Rail (LER) Applications
C. UL 9540A, Test Method for Evaluating Thermal Runaway Fire Propagation in Battery
D. Energy Storage Systems

Power Conversion Systems

A. UL 1741, Standard for Inverters, Converters, Controllers and Interconnection System
B. Equipment for Use with Distributed Energy Resources
C. IEEE 1547-2018, Standard for Interconnection and Interoperability of Distributed Energy
D. Resources with Associated Electric Power Systems Interfaces
E. IEEE 1547.1, Standard Conformance Test Procedures for Equipment Interconnecting
F. Distributed Resources with Electric Power Systems

Transformers and Reactors

A. UL 1561, Standard for Dry-Type General Purpose and Power Transformers
B. UL 1562, Standard for Transformers, Distribution, Dry-Type- Over 600 Volts
C. IEEE C57, Standards Collection: Distribution, Power, and Regulating Transformers.
D. D. IEEE C57.12.34, Standard Requirements for Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High-Voltage 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage andBelow
E. IEEE C57.91, Guide for Loading Oil-Immersed Distribution and Power Transformers.
F. IEEE C57.12.90, IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers; and Guide for Short-Circuit Testing of Distribution and Power Transformers.
G. IEEE C57.16, Requirements, Terminology and Test Code for Dry-Type Air-Core Series-Connected Reactors
H. IEEE C57.19.00, General Requirements and Test Procedure for Outdoor Power Apparatus Bushings
I. IEEE C57 .19.01, Performance Characteristics and Dimensions for Outdoor Apparatus Bushings

J. NEMA TR-1, Transformers, Regulators, and Reactors

Surge Protectors and Arrestors

A. NEMA LA 1, Surge Arresters
B. IEEE C62, Standards Collection: Guides for Surge Protection
C. IEEE C62.11, IEEE Standard for Metal-Oxide Surge Arrestors for AC Power Circuits (>1kV)
D. IEEE C62.22, Guide for the Application of Metal Oxide Surge Arrestors for Alternating Current Systems

Circuit Breakers

A. UL 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
B. UL 489B, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures for Use with Photovoltaic (PV) Systems
C. NEMA/IEEE/ASA/ANSI C37, Standards Series for substations and circuit breakers.
D. IEEE 37.04, Rating Structure of AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
E. IEEE C37.06, Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
F. IEEE C37.09, Test Procedure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
G. IEEE C37.011, Guide for the Application of Transient Recovery Voltage for AC High Voltage Circuit Breakers

Disconnect Switches

A. UL 98, Enclosed and Dead-Front Switches
B. UL 98B, Outline of Investigation for Enclosed and Dead-front Switches for use in Photovoltaic Systems
C. UL 248, Standards Collection: Low-Voltage Fuses
D. UL 2579, Outline of Investigation for Low-Voltage Fuses- Fuses for Photovoltaic Systems
E. IEEE C37.30, IEEE Standard Definitions and Requirements for High Voltage Air Switches, Insulators, and Bus Supports
F. IEEE C37.32, Standard for Switchgear- High Voltage Air Switches, Bus Supports and Switch Accessories- Schedule of Preferred Ratings, Manufacturing Specifications and Application Guide.
G. IEEE C37.33, Standard for Switchgear- High Voltage Air Switches- Rated Control Voltages and their Ranges.
H. IEEE C37.34, Standard Test Code for High Voltage Air Switches
I. IEEE C37.35, Guide for the Application, Installation, Operation and Maintenance of High Voltage Air Disconnecting and Load Interrupter Switches.
J. IEEE C37.37, IEEE Standard Loading Guide for AC High Voltage Switches (in excess of 1000 Volts)
K. IEEE C37.46, Specifications for Power Fuses and Fuse Disconnection Switches
L. IEEE C37.471 Specifications for Distribution Fuse Disconnecting Switches, Fuse Support and Current Limiting Fuses
M. M. NEMA FU 1, Low Voltage Cartridge Fuses
N. N. NEMA SG 6, Fuses

O. O. ANSI C37.42-1996 American National Standard Specification for High-Voltage Expulsion Type Distribution Class Fuses, Cutouts, Fuse Disconnecting Switches and Fuse Links

Protection

A. IEEE C37.21 I Standard for Control Switchboards
B. IEEE C37.21 Electrical Power System Device Function Numbers and Contact Designations
C. IEEE C37.91 I IEEE Guide for Protective Relay Applications to Power Transformers
D. IEEE C37.98, Standard for Seismic Testing of Relays
E. IEEE C37.99, Guide for Protection of Shunt Power Capacitors
F. IEEE C37.90, IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus
G. G. IEEE C37.90.1, IEEE Standard Surge Withstand Capability (SWC) Tests for ProtectiveRelays and Relay Systems
H. IEEE 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
I. IEEE 141, Recommended Practice for Electric Power Distribution for Industrial Plants
J. IEC 255-5, Electric Relays. Part 5: Insulation Tests for Electric Relays
K. IEC 255-22, Electric Relays. Part 22: Electrical Disturbance Tests for Measuring Relays and Protection Equipment
L. IEEE C67.92-1987 ---IEEE Guide for the Application of Neutral Grounding in Electrical Utility Systems
M. IEEE Standard 665-1995 --- IEEE guide for generating station grounding
N. IEEE Standard C37.97-1979 --- IEEE Guide for Protective Relay Applications to Power System Buses
O. IEEE Standard 1100 ~ 2005 ---IEEE Recommended Practice for Powering and Grounding Electronic Equipment
P. IEEE Standard 1100-1992 ---IEEE recommended practice for powering and grounding sensitive electronic equipment

Control Equipment

A. A ANSI/IPC 2615, Printed Board Dimensions and Tolerances
B. ANSI/IPC A600J, Acceptability of Printed Boards
C. IPC A-610G, Acceptability of Electronic Assemblies
D. IEEE 525, Guide for Design and Installation of Cable Systems in Substations.
E. IEEE 1613, Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations
F. IEEE Standard 1050-1996--- IEEE Guide for Instrumentation and Control Grounding in Generating Stations

LV, MV, HV, EHV Connectors/Cable

A. NEMA CC1, Electric Power Connectors for Substations
B. Aluminum Electrical Conductor Handbook-Aluminum Association

Harmonics

A. IEEE 519, IEEE Guide for Harmonic Control and Reactive Compensation of Static Power Converters

Grounding

A. IEEE 80, Guide for Safety in AC Substation Grounding
B. IEEE 1246, Guide for Temporary Protective Grounding Systems Used in Substations
C. IEEE Standard 81 Part 1, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System & Part 2: Guide for Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems

Seismic and Wind

A. A IEEE 693, IEEE Recommended Practice for Seismic Design of Substations
B. IEEE 1527, Recommended Practice for the Design of Flexible Buswork Located in Seismically Active Areas
C. American Society of Civil Engineers Standards ASCE/SEI 7-16; Minimum Design Loads and Associated Criteria for Buildings and Other Structures

Auxiliary AC and DC Supply Power

A. IEEE 141, Recommended Practice for Electric Power Distribution for Industrial Plants
B. IEEE 142, Recommended Practice for Grounding of Industrial and Commercial Power Systems
C. IEEE 446, Emergency and Standby Power Systems for Industrial and Commercial Power Systems
D. IEEE 1491, Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications.
E. IEEE 1584/1584a, Guide for Performing Arc Flash Hazard Calculations
F. IEEE Standard 1184-2006 ---IEEE Guide for Batteries for Uninterruptible Power Supply Systems

Fire Protection, General Health and Safety

A. IEEE 979, Guide for Substation Fire Protection
B. NFPA 850, Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations
C. UL 9540, Standard for Energy Storage Systems and Equipment
D. NFPA 1 Fire Code
E. NFPA 10 Standard for Portable Fire Extinguishers
F. NFPA 11 Standard for Low-, Medium-, and High-Expansion Foam
G. NFPA 30 Flammable and Combustible Liquids Code
H. NFPA 72 National Fire Alarm and Signaling Code
I. NFPA 101 Life Safety Code®
J. NFPA 110 Standard for Emergency and Standby Power Systems
K. NFPA 850 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations
L. NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems
M. ASME PTC 36- 2018 Measurement of Industrial Noise
N. OSHA 29 CFR 1910 General Industry
O. OSHA 29 CFR 1926 Construction

Fuel and Oil Management and Containment

A. IEEE 980, Guide for Containment and Control of Oil Spills in Substations
B. American Petroleum Institute API - 2610 Design, Construction Operation, Maintenance & Inspection of Terminal and Tank Facilities

C. API Standard 610: 1989 Centrifugal Pumps for General Refinery Services
D. API Standard 613: 1988 Special Purpose Gear Units for Refinery Services
E. API Standard 676: 1987 Positive Displacement Pumps- Rotary
F. API Standard 661: 1992- Air Cooled Heat Exchangers for General Refinery Services
G. API Standard 650 Welded steel tanks for oil storage
H. API Standard.653 Tank inspection, repair, alteration, and reconstruction
I. ASME/ANSI 816.1 - 1998- Cast Iron Pipe Flanges and Flanged Fittings
J. ASME 831.4- Pressure Piping I Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids
K. NFPA-30- Flammable and Combustible Liquid Code
L. 29 CFR 1910, 40 CFR 112 (latest revisions)- Oil Pollution Prevention

Emissions

A. 40 CFR Chapter I, Subchapter C, Part 60, Subpart II -Standards of Performance for Stationary Compression Ignition Internal Combustion Engines

Lightning Stroke Design

A. IEEE 998-2012, Guide for Direct Lightning Stroke Shielding of Substations

Insulation

A. ANSI/NEMA C29.1, Test Methods for Electric Power Insulators
B. ANSI/NEMA C29.1, Wet Process Porcelain and Toughened Glass Insulators Suspension Type
C. ANSIINEMA C29.9, Wet Process Porcelain Insulators- Apparatus, Post Type
D. ANSI/IEEE Standard 432-1976 IEEE Guide for Insulation Maintenance for Rotating Electrical Machinery {5 hp to less than 10,000 hp)
E. ANSI--IEEE Standard 576-1989 IEEE Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in the Petroleum and Chemical Industry
F. ANSI--IEEE Standard C57.12.56-1986 IEEE Standard Test Procedure for Thermal Evaluation of Insulation Systems for Ventilated Dry-Type Power and Distribution Transformers
G. IEEE Standard 1142-1995 ---IEEE Guide for the Design, Testing, and Application of Moisture-Impervious, Solid Dielectric, 5-35 kV Power Cable Using Metal-Plastic Laminates
H. IEEE Standard 1143-1994--- IEEE guide on shielding practice for low voltage cables
I. IEEE C62.82.1, Insulation Coordination - Definitions, Principles, and Rules
J. IEEE 1313.2, Guide for the Application of Insulation Coordination Communications
K. IEEE Standard 487, Recommended Practice for the Protection of WIre - Line Communication
L. IEEE Standard 1159.3-2003 ---IEEE Recommended Practice for the Transfer of Power Quality Data
M. IEEE Standard 1159-1995 ---IEEE Recommended Practice for Monitoring Electric Power Quality

1.5 New Functionality

The project is a microgrid system with several proven energy sources designed to meet the power loads of Vieques & Culebra while adding flexibility and resiliency to lower future risk of failure. The microgrid includes solar, generator and storage that will allow the integration of the submarine cable from the PREPA Grid.

The project has 2 phases: a first phase which will provide permanent power with medium cycle diesel generators; and a second phase which would include the construction of a solar PV System with BESS on each Island. The following details are relevant to the project:

- Hybrid Microgrid System will consist of the installation of a solar/ battery storage microgrid to work in an integrated fashion with the medium-speed diesel plant.
- The system would include 22 MWdc of solar, 64-megawatt hours (MWh) of battery storage along with a new 14 MW (10 MW guaranteed) medium-speed diesel plant on Vieques and 8 MWdc of solar and 24 MWh of battery storage on Culebra.
- The system would be managed by an advanced microgrid controller, interconnected with the 38kV transmission line, and will integrate the existing back-up diesel power plant on Culebra and power provided from the submarine cable to the main island if it is stable.

1.6 Expected Challenges / Risks

Permitting
Obtaining permits at the potential installation sites could be a challenge as many entities require review and approval. The project manager – Louis Berger – has mapped out the permits and related agencies to engage. Louis Berger has also developed a community outreach strategy to help with successful planning and execution.

1.7 Technical Dependencies

Since this project will result in a standalone microgrid, it is expected to have minor technical dependencies on other parts of PREPA's electrical system. The system will be interconnected with PREPA grid, and needs to comply with interconnection requirements. There are some technical interdependencies related to grid-tie operating mode

1.8 Maturity of Technology

Solar PV
Solar photovoltaics have been deployed since the 1950's and several hundred GW's have been deployed globally. The committee does not have any concerns with this technology.

Medium Speed Diesel Generators
Diesel generators are already used widely in Puerto Rico and the Caribbean. The committee does not have any concerns regarding their use.

Battery Energy Storage Systems

The proposed BESS system will use Li-Ion batteries. Approximately 1.5 GW of grid connected Li-Ion batteries have been installed in North America. The battery technology has been deployed for other uses (vehicles, communications, etc.) in much larger quantities.

Microgrid Controllers and Hardware
Approximately 4 GW of microgrids have been installed in North America with a variety of configurations and control schemes.

2. Proposed Financial Funding Justification

2.1 Project Benefits

Independent System
The Hybrid Microgrid will provide ability to supply electrical power generation to the residents of Vieques and Culebra in an event of a long-term interruption of grid power supply from the main island, such as what was experienced following the 2017 Hurricane season – without the need for using FEMA temporary power assets and FEMA/USACE contracting mechanisms for assessment, installation, operation and maintenance and de-installation and return to service. Furthermore, due to its distributed locations and a mix of different types of technologies (solar PV, battery energy storage and medium-speed diesel) with overlapping load-handling capacities, the proposed system can retain full operability even in case of damage to a portion of the power generation assets.

Resistant to Effects of Fuel Supply Disruption
A Hybrid Microgrid is by design less sensitive to difficulties with and interruptions of fuel supply that are characteristic for initial phases of a disaster response. With the PV/BESS in combination with load shedding/management techniques, the system will be able to continue providing power to critical infrastructure facilities even under conditions of complete interruption of fuel deliveries.

Independent Vieques and Culebra
The proposed system configuration will allow each islands to operate in full isolation in case of a damage to the submarine cable connecting the two islands and the loss of power supply from the main island.

Power Source Flexibility
The current 38 kV submarine cable coming from the main grid, although in operation, is unreliable given its fragility. This will eventually be resolved with the installation of a permanent 115 kV submarine cable loop which will be available at a later stage in approximately 10 – 12 years. However, this Hybrid Microgrid will serve as a safe and stable power option within 18 months for the people of Vieques and Culebra, ensuring continuity and reliability whether the power comes from the Microgrid or from the Main Grid.

Improved System Reliability
During normal non-emergency operation, the Hybrid Microgrid will allow far greater operational flexibility as compared to diesel-only, or grid+diesel back-up options. For example, outages of the diesel plant related to interconnection work/repairs, diesel plant main transformer or switchgear outage will not cause power supply interruption or operation with no back-up capability. The same applies to any transformer, interconnection or switchgear work (whether planned or unplanned). This will allow for a better planning and a better control of overall O&M costs and schedules.

Lower LCOE

The proposed system was designed to optimize the efficiency of each component using a levelized cost of energy model, with the overarching goal of lowering long-term energy costs to the residents of the two islands. The proposed combination of the PV, BESS and diesel facilities will allow achieving that goal.

Lower LCOE Volatility

Although current diesel fuel price projections predict a relatively low price increase in the long-term (adjusted for inflation), the historical data point to a possibility of significant price volatility for this commodity. Reducing the portion of the overall lifetime costs attributed to fuel (as achieved by the use of hybrid architecture with a high penetration of renewables) will limit the risk of cost increase due to short-term and long-term fuel price increases affected by the combination of economic, geopolitical or environmental factors. Additionally, any potential future carbon tax/carbon trading measures on the regional, national or international levels will not negatively impact the economics of a microgrid with a high percentage of renewables; to the contrary, such measures may present an opportunity of a cost reductions transferrable to the residents of the two islands.

Improved Sustainability and scalability

High renewables penetration: 67% renewable penetration is above the current average for any US State and territory and will help achieving goals stated in the several of the grid recovery plans. the proposed Hybrid Microgrid architecture can accommodate and fully leverage additional distributed energy resources (DER) added in the future. The localized, distributed renewable generation is gaining popularity and can be expected to significantly expand in the future. The energy storage and advanced microgrid control system that are integral part of the proposed system can easily accommodate integration of additional DERs. This can gradually displace the generation capacity of the diesel plant and allow for the eventual transition to full renewable generation at the end of useful life of the diesel power plant.

Reduced Environmental Impact

The proposed hybrid microgrid can allow reduce or eventually eliminate the use of diesel generators when operating connected to the PR grid, as well as with the future DER additions. This will reduce and then eliminate the air pollution associated with the diesel power plant and its effects on the community, as well as greenhouse gas emissions. Additional, indirect environmental benefits include the reduction of fuel and energy used for extraction, production and logistics associated with the fossil fuel cycle.

Full Compatibility with the Planned Grid Hardening and Transmission System Upgrades

Although the proposed Hybrid Microgrid does not require any improvements to the transmission or distribution network for its operation, it is at the same time fully compatible with the proposed measures in that regard. It will support reliable, resilient and sustainable power supply to the residents of Vieques and Culebra before, during and following the implementation of the grid hardening and transmission upgrade measures.

2.2 Estimated Timeline

The project will be broken into two phases that will occur parallel:

- Phase 1: Medium-Speed Diesel Generation Facility – 15 months
- Phase 2: Hybrid Microgrid – 19 months

The schedule for implementation will be developed in detail during the PFF stage.

2.3 High Level Cost Estimate

The following table summarizes the costs, per phase.

Project Phase	Scope	Estimated Costs ($M)
1. Medium-speed Diesel Generator Facility	• Prepare engineering design, secure construction permits, and submit operational and air permit applications. • Decommission and disassemble PREPA's existing power generation equipment at the Vieques power plant and transport it to designated location. • Complete excavation, civil, and structural work to expand the footprint of existing site on PREPA-owned land. • Procure, deliver, and install four, 3.5-MW packaged stationary medium-speed diesel generators and a new switchgear to provide continuous 10 MW of capacity, including all required mechanical, electrical, fire protection, and safety and fuel handling systems, and infrastructure. Designed and engineered to resist Category 5 hurricanes. • Procure and install additional fuel storage. • Procure, install, and connect a new tri-winding (13.8/38/115 kV) main transformer. • Connect generators and switchgear to existing fuel and new supply, and existing and new transformers; commission the new facility. • Provide training and transfer to an O&M vendor. • Provide parts and an extended 4-year warranty.	$37.3M
2. Hybrid Microgrid	• Sign site control agreements and secure sites, construction, and interconnection permits for solar PV and battery energy storage systems (PV/BESS) on Vieques and Culebra.	$117.4

	• Complete engineering design for the solar PV, BESS, and microgrid controls. • Complete civil and structural work. • Procure, deliver, and install microgrid with combined 30 MWdc solar PV, 88 MWh BESS, associated controls, switchgear, and transformers. • Designed and engineered to resist Category 5 hurricanes. • Integrate the Hybrid Microgrid with the Medium-speed Diesel Generator Facility (Phase 2) and PREPA's backup diesel power plant on Culebra. • Commission Hybrid Microgrid, provide training, and transfer to O&M vendor.	
3. Site Control, Project Management/Construction Management, Development Fees	• Sign site control agreements and secure site, construction, and interconnection permits for the solar PV and BESS on Vieques and Culebra. • Provide project and construction management services. • Cover site and project development fees.	$14.7M
	Estimated Taxes	$14.9
	Recommended FEMA Contingency for Section 428 Application	$12.3

The following items are presumed to be covered by the grid hardening scope of work and therefore are not included in this document:

- Electrical work on the high-voltage side of the transformers at the Medium-speed Diesel Generator Facility and the Hybrid Microgrid installations
- New transmission, sub-transmission, and/or express feeder lines to the point of interconnection at solar PV and BESS sites and step-up transformers supporting 38kV or 115kV.
- Fiber-optic communication network from solar PV and BESS interconnection sites

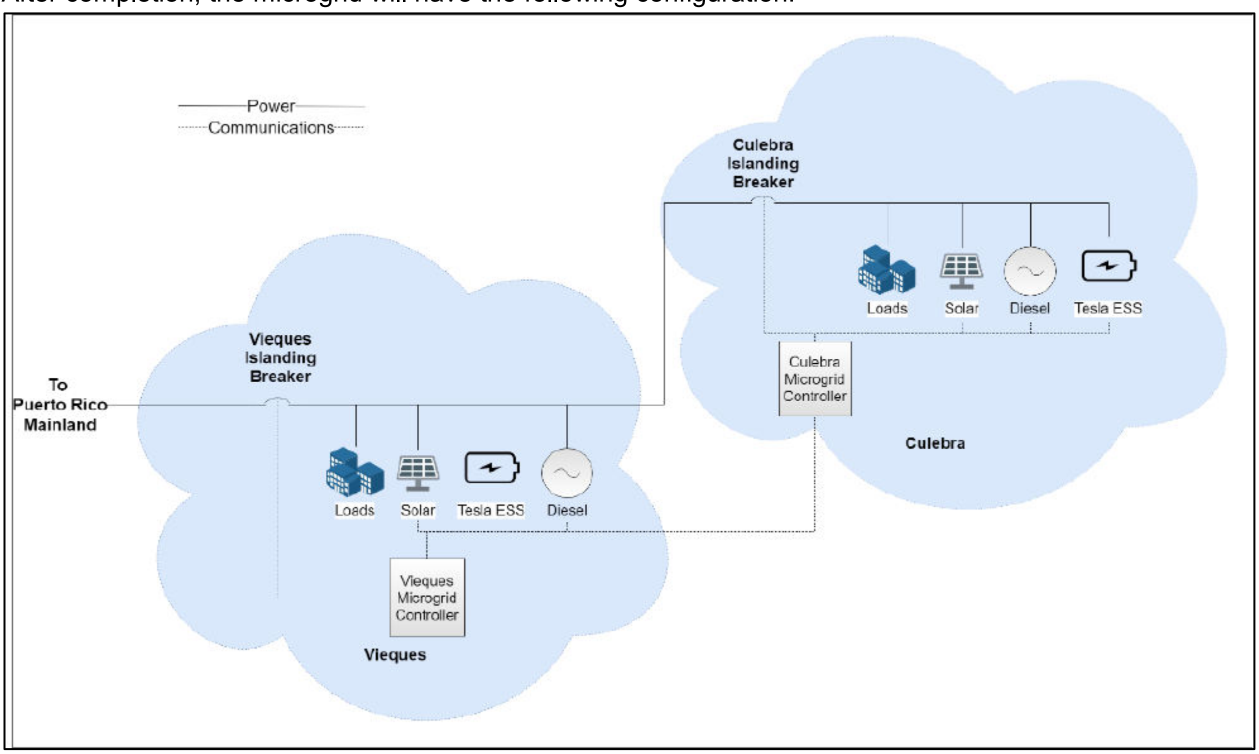
2.4 Roadmap / Process / System Diagram

The project will be divided into two phases.

Phase 1 – Medium-speed Diesel Generator Facility: Phase 1 would decommission PREPA's existing power plant on Vieques and install four, 3.5-MW medium-speed diesel generators on Vieques. The facility would feature a total installed capacity of 14 MW and a guaranteed minimum output of 10 MW using the proposed N+1 configuration. The facility would also include a new, 15 MVA main plant transformer capable of 38 kV or 115 kV output. The facility would be commissioned in approximately 15 months from the Notice to Proceed. The generators and other key equipment would comply with the Trade Agreement Act as well as applicable current emission standards.

Phase 2 – Hybrid Microgrid: Phase 2 would install a Hydrid Microgrid to work in an integrated fashion with the Medium-speed Diesel Generator Facility commissioned during Phase 1. The Hybrid Microgrid would consist of 22 MWdc of solar photovoltaic (PV) and 64 megawatt hours (MWh) of a battery energy storage system (BESS) on Vieques and 8 MWdc of solar PV and 24 MWh of BESS on Culebra. Based on peak loads with a small growth factor seen before Hurricane Maria, approximately 65 to 75 percent of the energy provided by the microgrid would be renewable, reducing the run time of diesel generators by an equivalent amount and resulting in both fuel and operation and maintenance (O&M) savings over the life of the installation. Under normal operations, the Hybrid Microgrid would operate in parallel with the Phase 1 Medium-speed Diesel Generator Facility and share generation and storage between Vieques and Culebra to meet loads indefinitely. During storm events where there is a disruption to the electrical system, the two islands could operate as independent microgrids and Culebra would utilize backup generators as an integrated microgrid component to maintain power. Following the eventual restoration of the submarine transmission link between Vieques and Puerto Rico, the Hybrid Microgrid could be operated as an integral part of the overall Puerto Rico electrical grid while still maintaining its inherent islanding capability in case of loss of connection to mainland Puerto Rico. Given the size of the batteries, this system would meet expectations for redundancy, allowing all of the diesel generators to be offline for service or repair, or due to lack of fuel. Similarly, in unlikely circumstances when the solar PV and BESS system are offline, the diesel generators would meet the coincidental peak load of both islands without using renewable or storage energy and support black start requirements. Commissioning of the Hybrid Microgrid is planned in approximately 19 months from the Notice to Proceed. The Hybrid Microgrid would improve resiliency, reduce environmental impacts associated with the use of diesel fuel for power generation, increase the useful life of the power supply system, and substantially reduce long-term operational costs.

After completion, the microgrid will have the following configuration:



2.5 Source of Funding

The primary source of funding is projected to be from FEMA funds. The Project Worksheet (PW) will be developed closely with FEMA and in close coordination with the existing project formulation and funding process for the PW for the Vieques & Culbera Distribution.

3. Technical Advisory Recommendation

ETAC recommends the this project proceed to the Project Formulation & Funding (PFF) stage.