Puerto Rico Public-Private Partnerships Authority

Desirability and Convenience Study:

Utility Scale Energy Storage Systems

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GOVERNMENT OF PUERTO RICO
Puerto Rico Public-Private Partnerships Authority

General Disclosures

This Desirability and Convenience Study (the "Study") has been prepared pursuant to the requirements of Act No. 29-2009, as amended, also known as the Puerto Rico Public-Private Partnerships Act ("Act") and the Regulation for the Procurement, Evaluation, Selection, Negotiation and Award of Participatory Public-Private Partnership Contracts under Act No. 29-2009, as amended ("Regulation"). This Study seeks to determine whether it is advisable and convenient for the Government of Puerto Rico ("Government") to procure a Public-Private Partnership ("P3" or "PPP") for the deployment of utility-scale energy storage systems for improving grid stability and delivering peaking capacity to the Puerto Rico Electric Power Authority ("PREPA") at various PREPA substation locations (the "Proposed Project").

The Study was formulated in accordance to Article 7(b) of the Act and the different sections of the Regulation regarding the Guidelines for Desirability and Convenience Study of the Puerto Rico Public-Private Partnerships Authority ("Authority"). The Authority conducted this Study as a result of receiving an unsolicited proposal pursuant to the Act from Tesla Inc. ("Tesla") dated November 7, 2017 entitled "Proposal for Replacing Peaker Plants with Utility Scale Energy Storage in Puerto Rico" ("Unsolicited Proposal"). Pursuant to the Act and Regulations, the Authority completed a preliminary evaluation of the Unsolicited Proposal on December 11, 2017. This Study was commissioned under the supervision of the Authority and in consultation with its technical advisor, Filsinger Energy Partners ("Filsinger"), financial advisor, Rothschild & Co ("Rothschild"), and legal counsel, Nossaman LLP ("Nossaman") (collectively, the "Advisors").

This Study is based on information provided by the Authority, PREPA and market information obtained from sources believed to be reliable. This Study includes information provided by Tesla and Tesla drafted portions of Sections 2.B, 3.B, 3.C, 4.B.i and 4.B.ii of this Study.

This Study is based on estimates and assumptions made by Filsinger and Rothschild. Actual results may vary from those anticipated in this Study. Changes in local, state and federal laws, or shifts in the overall economic condition of Puerto Rico may occur that can alter the assumptions and conclusions presented in this Study. It is recommended that further analysis and due diligence be conducted in subsequent phases of the Proposed Project.

In order to gauge industry interest in the Proposed Project, the Authority is asking for comments in connection with the Study. The comments must be submitted in writing to the following email: utilityscaleenergyproject@p3.pr.gov. The Authority will acknowledge receipt of those comments submitted by email within two (2) business days of receipt. The Authority may also, but will not be obliged to, respond or ask follow-up questions regarding the comments received. **The deadline for submitting comments is June 11, 2018 on or before 5:00 p.m. (AST).**

As new information becomes available, the Authority will continue to evaluate and analyze the desirability and convenience of the Proposed Project as a P3. The Authority does not make any representation or warranty whatsoever, including representations or warranties as to the accuracy or completeness of the information contained herein, including estimates, forecasts, or extrapolations. In addition, this Study includes certain projections and forward-looking statements with respect to future performance that reflect certain assumptions and are subject to significant business, economic and competitive uncertainties and contingencies, many of which are beyond the control of the Authority and PREPA. Accordingly, there can be no assurance that such projections and forward-looking statements will materialize. The actual results may vary from the anticipated results and such variations may be material. The Authority, the PREPA, and the Advisors expressly disclaim any liability for any representations or warranties, expressed or implied, contained herein or for any omissions from this Study or any related matters.

The Act and the Regulation, as well as all applicable Puerto Rico and federal laws and regulations, will govern the dissemination of this Stud

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1. EXECUTIVE SUMMARY

A. INTRODUCTION

In order to provide safe, reliable, and continuous electricity service to the citizens and visitors of Puerto Rico, there is a need to revitalize and modernize PREPA's assets and increase the efficiency and reliability of the current service. The deployment of utility-scale energy storage systems at a variety of critical PREPA substations that can provide grid stability and peaking capacity is a critical component of this effort. In order to achieve the desired objectives of the Proposed Project, the Authority is considering a public-private partnership ("PPP" or "P3") delivery method. This Study aims to determine the feasibility of the Proposed Project by comparing the traditional business as usual ("PREPA's Business as Usual") method with an innovative P3 delivery approach. The Advisors have facilitated the development of this Study at the request of the Authority, acting on behalf of the Government and PREPA.

B. Objectives of the Study

The purpose of this Study is to help evaluate the feasibility of procuring the Proposed Project through a P3 as an alternative to PREPA's Business as Usual. This Study describes the need and objectives for delivering the Proposed Project, assesses the value of the envisioned delivery model, describes the key assumptions behind the inputs utilized to develop a quantitative analysis, and quantitatively evaluates the preferred delivery model. Based on these items, the Study aims to demonstrate the rationale of the Authority in procuring the Proposed Project.

To address the major needs of revitalizing and modernizing Puerto Rico's electric utility infrastructure and addressing the current conditions faced by PREPA, the Authority plans to achieve a number of objectives through the procurement of the Proposed Project, including one of the major hurdles in procurement of an infrastructure project in Puerto Rico - the island's current fiscal and economic condition. The Authority's objectives include navigating these risks and procuring the Proposed Project in light of this situation by mitigating or transferring the majority of project risks, and reducing exposure to Government funding.

Given the deteriorating asset conditions of PREPA, which has been plagued by major maintenance backlogs and unreliable service, the Authority expects to enhance service reliability and system resiliency, and reduce costs through private sector innovation and expertise. Ultimately, the Proposed Project's procurement is expected to reduce the rate burden on the citizens of Puerto Rico required to efficiently operate the utility. By shifting the risks of the Proposed Project to a party who is best able to manage them, the Authority can seek to deliver better, more reliable electric utility service at a lower cost to ratepayers.

C. Project Need

PREPA has been challenged by the task of maintaining electricity generation, transmission and distribution assets in a state of good repair and providing consistent and reliable service desired by the people of Puerto Rico and its visitors. The operation of current peaking generation units is both uneconomical and creates stability issues for the electric utility as a whole.

Puerto Rico needs to embark on a restoration and recovery plan that modernizes the electric grid infrastructure and does not leave the Island's grid vulnerable to the next disaster. The Proposed Project represents an important step in the revitalization of Puerto Rico's grid. Energy storage technology can be deployed quickly, can allow the system to be operated at a lower cost, and with greater resiliency benefits than the status quo, making it a key component of the grid stability and modernization efforts allowing Puerto Rico to achieve a resilient and affordable energy future.

D. Qualitative Assessment

This Study evaluates the delivery models that may be available to the Government as procurement options for the Project. These include both PREPA's Business as Usual delivery model that PREPA currently employs to provide peaking energy supply, as well as an alternative P3 option, whereby utility-scale energy storage systems at a variety of critical PREPA substations provide grid stability and peaking capacity in place of conventional fossil fuel-operated units.

Under the P3 delivery model, the private party will be responsible for the design, construction, operation, maintenance, improvement, and management of the Project, maintain ownership of the Proposed Project assets, and provide the Government with committed capacity resources for the efficient operation of electric utility services. When evaluating the P3 approach, it was determined that the Proposed Project would deliver several benefits that would improve both the overall operations of PREPA and general economic conditions in Puerto Rico. Such benefits include increased grid stability and resiliency, greater operational flexibility, decreased fuel price volatility, increased renewable energy utilization and economic growth.

Therefore, following qualitative analysis of the two possible approaches, PREPA's Business as Usual model and the P3 delivery model, further work was commenced to quantify the benefits of the P3 approach.

E. Quantitative Analysis

The overall results of the analysis demonstrate that the P3 approach is estimated to provide a significant reduction in the total costs required to provide safe, reliable and continuous electricity service to Puerto Rico. The P3 approach is estimated to provide $12 million in annual benefits over PREPA's Business as Usual approach, at a total cost of $3.88 million a year, resulting in $8.12 million in annual savings. In addition, the P3 approach further provides incremental benefits that, although difficult to quantify, will add to the total economic benefit of the P3 approach. These include long term emission benefits and improved flexibility to avoid outages and provide better reliability as PREPA considers a variety of planned transmission upgrades and longer-term efforts to rebuild the hurricane damaged transmission and distribution systems.

2. INTRODUCTION AND SERVICE NEEDS

A. Introduction

The Government of Puerto Rico ("Government") and its public corporations are responsible for efficiently providing essential services at the lowest possible cost for the welfare of Puerto Rico. These services include public health and safety, education, and transportation services, among others. Due to fiscal budget deficits at the Government and public corporations levels and limited private investment in infrastructure, the Government has had to adopt non-traditional tools to help deliver these services to the people. On June 8, 2009, the Legislature of Puerto Rico approved Act No. 29, as amended to promote and allow the establishment of P3s in Puerto Rico for the purposes therein set forth. The Authority was created as a public corporation for the purpose of implementing the public policy of the Government concerning P3s as contemplated under the Act.

The Act requires the Authority to conduct or commission a Study of Desirability and Convenience, as defined in the Act, for each project selected by the Authority as a potential project for a P3. The study seeks to assure that a particular project meets the public policy and goals established by the Act and to determine whether the establishment of a P3 in connection with such a project is advisable. The scope of each study is determined by the Authority, on the basis of the particular facts and circumstances of each project being considered by the Authority for a P3. Each study will include, as deemed applicable by the Authority, the matters listed in Article 7(b) of the Act. The Authority may expand or reduce the scope of the study as it relates to any proposed P3 to include other matters not specifically listed in Article 7(b) of the Act, or exclude matters that are not relevant to a particular project, as appropriate.

In the aftermath of Hurricanes Irma and Maria, millions of residents of Puerto Rico were left without power and many still do not have access to electricity. Restoration efforts of the Government, PREPA, and utility crews from around the country are rapidly working to replace and repair the existing transmission and distribution system with estimates of costs in the billions of dollars. However, Puerto Rico needs to embark on a restoration and recovery plan that does not leave the region's grid vulnerable to the next disaster. With aging generation units (median age of 44 years, compared with 18 years for the US energy industry as a whole) and vital above-ground transmission lines that stretch across its mountainous interior, Puerto Rico's grid will need an overhaul to prevent the next storm from taking such a heavy toll.

PREPA and the Authority are interested in evaluating the viability of a long-term contract with a private operator to deploy utility-scale energy storage systems at a variety of critical PREPA substations that can provide grid stability and peaking capacity at a fraction of the cost of the current peaking units in PREPA's aging generation fleet.

B. Project Objectives and Benefits

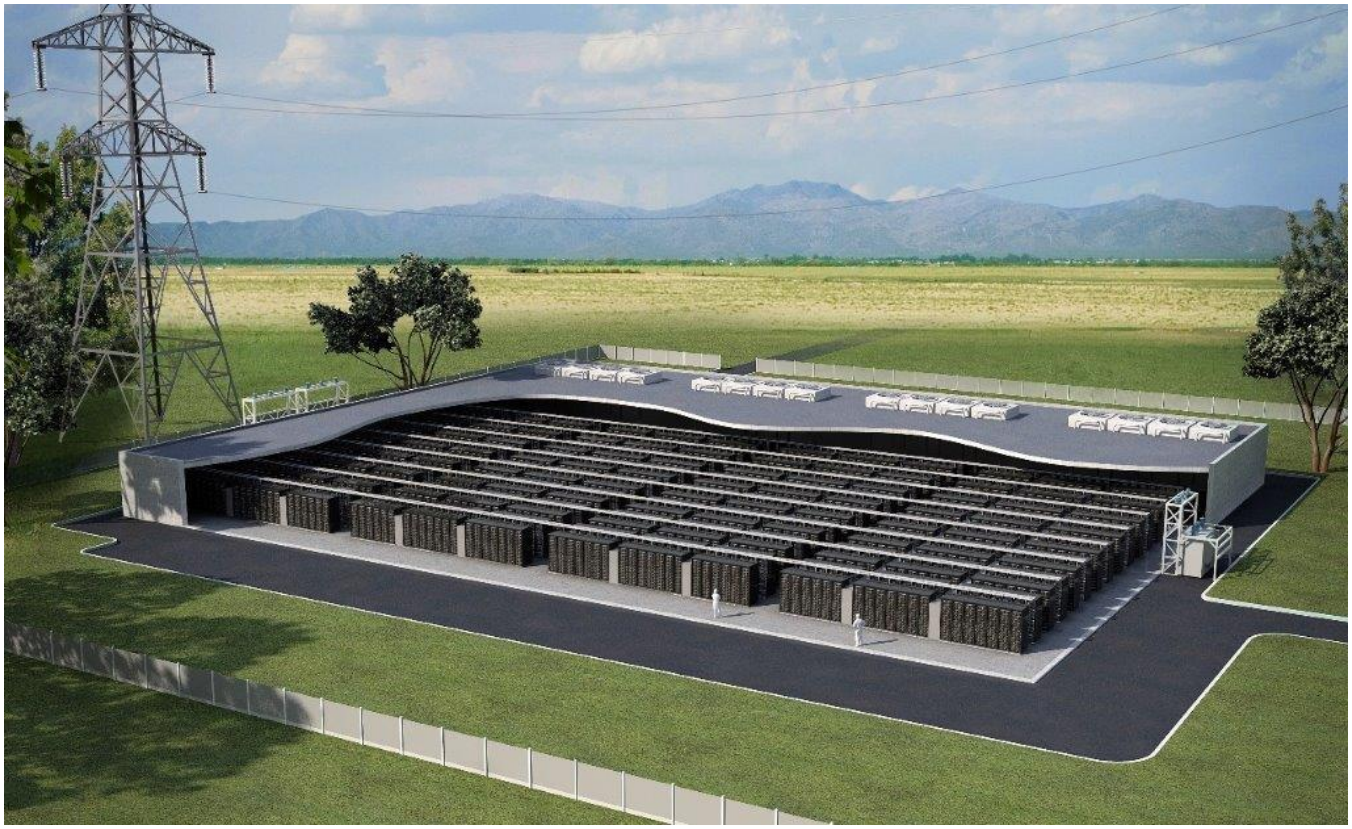
Puerto Rico needs to embark on a restoration and recovery plan that modernizes the electric grid infrastructure and does not leave the region's grid vulnerable to the next disaster. The Proposed Project represents an important step in the revitalization of Puerto Rico's grid. Energy storage systems technology can be deployed quickly, can allow the system to be operated at a lower cost, and with greater resiliency benefits than the status quo, making it a key component of the grid stability and modernization efforts allowing Puerto Rico to achieve a resilient and affordable energy future.

The primary objectives of the Proposed Project are to:

- Assist in the recovery and modernization of Puerto Rico's electric grid by constructing utility-scale energy storage systems to increase resiliency, thereby promoting the public interest and overall economic growth
- Reduce overall grid costs by increasing grid operational efficiency
- Help Puerto Rico meet its renewable portfolio standard targets in the future
- Foster energy storage expertise within PREPA, and develop PREPA's reputation as experts on the topic of utility-scale storage integration

The benefits of implementing the Proposed Project for grid modernization through a P3 include:

- Decreased electric grid operations costs
- Increased grid resiliency from both storms and natural disasters as well as transmission and generation failures
- Provides operational flexibility enabling grid modernization on an expedited timeline
- Transmission and distribution upgrade deferral
- Decreased fuel price volatility
- Economic growth
- Enhance grid stability during long term permanent work following the 2017 hurricanes



3. BACKGROUND AND SERVICE DELIVERY PLAN

A. General Overview of PREPA

PREPA is a public corporation and governmental entity of Puerto Rico, created pursuant Law 83 of May 2, 1941, as amended, with the duty of providing electric power in a reliable manner, contributing to the general welfare and the sustainable future of Puerto Rico, maximizing the benefits and minimizing the social, environmental and economic impacts.

PREPA is a government owned company, property of Puerto Rico, and is empowered to make contracts, sell/buy assets and real estate, borrow money and issue bonds. PREPA is also responsible for the establishment of an appropriate rate structure for its services.

PREPA's objectives include the following:

- Reduce energy cost
- Promote smart energy consumption
- Protect the environment
- Improve reliability

PREPA's strategies to achieve these objectives include the following:

- Reduce operating expenses
- Increase efficiency
- Minimize energy theft
- Diversify energy sources
- Establish smart grid for energy control and consumption monitoring
- Maximize use of advanced technology

B. Benefits for PREPA

The Proposed Project provides substantial benefits to PREPA and the people of Puerto Rico, which include the following:

- **Increased Grid Stability and Resiliency** – Battery systems can help provide valuable grid-services to regulate the grid's frequency and voltage. They can also help reduce the reliance of high-voltage transmission lines that connect generation to load. In the event that a load is isolated from distant generation, energy storage systems can be used to energize the local grid for short periods of time until service could be established. In the event that the area with isolated load has installed intermittent renewable generation, energy storage systems can be used to enable that existing renewable generation to serve consumers in the local area that would otherwise be without power.

- **Decreased Electric Grid Operations Costs -** By discharging to displace the most expensive generation in PREPA's fleet, and charging with the most cost-effective energy available, battery storage can reduce the marginal cost of generation while helping avoid the need to spend more fixed-capital on aging and inefficient generators.

- **Transmission and Distribution Upgrade Deferral** – Intelligent siting of energy storage systems can help defer or eliminate planned transmission or distribution upgrades by reducing peak loads in overloaded sections of the electric grid.

- **Decreased Fuel Price Volatility –** By supplanting fossil-fuel fired energy generation with energy storage systems, Puerto Rico will reduce its dependence on oil, natural gas, and diesel. Relying on these fuels requires expensive shipping, exposes PREPA to unnecessary swings in market prices, and places an unnecessary burden on PREPA's customers.

- **Economic Growth** – The construction of new energy storage systems creates jobs, injects money into local economy, and will help establish Puerto Rico as a leading authority on integrating cleantech into existing electric grids. The skills and knowledge gained during the process will be applicable across a broad range of future projects. Additionally, adding large energy storage systems to the grid will reduce peak energy rates, which will reduce energy costs for consumers and business across the island and result in increased economic activity.

- **Modularity and High Utilization** – The future electricity consumption patterns for Puerto Rico are far from certain, and the exact needs of Puerto Rico's grid will continue to evolve in the coming months and years. The speed with which smaller modular systems can be deployed allows planners to more precisely match infrastructure build-out with grid needs in the near-term, ensuring higher utilization of assets that get built.

- **Increased Renewable Energy** – Utility scale energy storage systems provides operational flexibility to enable additional renewable energy to be deployed on the grid without the reliability and stability impacts inherent with intermittent sources of generation. As penetration of renewable generation increases, battery systems can shift energy from periods of abundant generation to periods of high consumption.

C. Project Scope of Work

The Proposed Project consists of the deployment of a portfolio of one or more energy storage systems at strategic PREPA sites. The Request for Proposals ("RFP") for the Proposed Project will define general requirements for the contractor to submit a proposal for deploying energy storage systems and may request pricing for a number of different size configurations based on site conditions. The RFP will also clearly delineate a detailed scope of work. Below is a general description of responsibilities.

The contractor will provide:

- Financing and the energy storage system and associated balance-of-plant equipment
- Design, engineering, and construction for each specific sites provided by PREPA
- Operation, maintenance, ongoing capital improvement, warranties, training, and support

A. Technology Risk – The energy storage provider should ensure that the system be maintained properly and meet minimal technical specifications. In the event of an equipment failure, the storage provider should be responsible for replacing or repairing the storage system as covered by a system warranty or other provisions in the agreement.
B. Operational Risk – As the system operator, PREPA will be ultimately responsible for controlling the dispatch of the energy systems to maximize the grid benefits that they provide. Given varying market conditions, it is possible that the system operator may not always optimally dispatch the system to capture the maximum possible benefit from the storage systems.

C. Value Risk – Much of the value of the storage system is based on projections of the future needs of Puerto Rico's electric grid. Many factors, including changes to regulations, or other changes that may impact the fundamentals of the electric grid of Puerto Rico, could result in the value of the grid services being provided by these systems to be reduced.

PREPA will provide:

- Sites, access to the sites, site layouts and other relevant information
- Discretionary permits, if any, required for each site
- Interconnection to the PREPA grid up to specified interconnection voltage

The contractual approach for working with the contractor to identify and deploy the Proposed Project will be as follows:

1. PREPA identifies the optimum sites and battery storage capacity necessary for each of the sites
2. PREPA and the Authority prepares specifications and issues a request for proposals
3. PREPA provide site access to the proposers to evaluate for bidding purposes
4. Proposers submit proposals in response to the requests for proposals
5. Successful proposer is selected
6. The Authority/PREPA and successful proposer negotiate a contract
7. Successful proposer proceeds with implementation

4. PROJECT DELIVERY OPTIONS

A. PREPA's Business As Usual

The current PREPA electrical system faces several challenges. The system consists of older power plants with limited operational flexibility. The transmission and distribution systems have also been severely damaged by recent hurricanes and will require significant work to repair and harden for future reliable service. These conditions make it challenging to remove components from service to perform necessary maintenance while maintaining system reliability. In the current configuration, it is necessary to operate inefficient units to enable other work, resulting in increasing overall fuel cost.

Load following is currently accomplished by operating with a reserve margin in the normal operating output of thermal power plants, but these operating units cannot ramp up or down nearly as fast as a battery-based energy storage system which can provide the same service. Also, spinning and non-spinning reserves are reserve generating capacity that can be called upon to make up for unplanned capacity losses or demand increase on the electricity transmission system. Spinning reserve is currently achieved by operating larger units at part load which can be significantly less efficient than operating at full load.

Voltage Regulation and Volt Ampere Reactive Regulation ("Volt/VAR") is required on the electrical grid to maintain acceptable voltages and power factors at all points along transmission lines under all loading conditions. Volt/VAR is also required to support reactive power needs of the bulk power system in the event of system emergencies. Generators are required to operate within a specific power-factor band and historically have been the primary providers of voltage support. Variation in Volt/VAR is traditionally managed through capacitor banks, load tap changers, and static VAR compensators. Maintaining these parameters with the existing system configuration also results in operating units at lower efficiencies than could otherwise be achieved.

Because of contingency planning, many transmission and distribution systems and components must be oversized to allow for unplanned system outages. Much of the current PREPA generation resource is located in the south of the system where most of the load is located in the north of the island. If the load increases, or generation facilities in the north retire, additional investment in the transmission system would be required to ensure load flows from the south to the north are not constrained. Transmission congestion occurs when there is insufficient transmission capacity to meet calls for power at the transmission level. Over the long term, new transmission facilities need to be built to decongest the lines. Short-term, when transmission congestion occurs, generators must be re-dispatched to alleviate congestion. The operating profile of these re-dispatched generators is less efficient than the nonconstrained optimal economic plant dispatch. Accordingly, the units generate higher-cost electricity to meet load that, in the absence of transmission congestion, would be served by a set of lower-cost generation resources.

The current method to accomplish system black start in the event of a system wide loss of power is with older 1970s vintage combustion turbines that are at or near the end of their economic life. The units are inefficient and unreliable.

B. P3 APPROACH

Energy storage systems can be effectively used to meet peak electricity demand events. They are well suited to provide a source of grid support, follow load changes quickly and can provide real time spinning reserve services. All of these ancillary services can be provided without requiring the operation of a unit at part load. This capability can significantly reduce the overall system fuel cost while improving the overall reliability of the electrical system. Energy storage systems are well suited to Volt/VAR support close to the point on the system where they are needed.

i. Site Options

Energy storage systems can be sited at PREPA's existing substations. In conjunction with the selected contractor, PREPA will identify the suitable substations with available suitable land and interconnection where energy storage can provide the most value to PREPA's electric system. PREPA will analyze and identify specific substations of interest and will provide the energy storage provider with detailed information around the site.

ii. Sizing Options

One of the advantages of energy storage is its modularity which allows each energy storage installation to be customized to the exact needs of the site and provides expansion flexibility should conditions change in the future. The energy storage systems are expected to range in size from 10MW to 40MW with 1 to 4 hours of discharge at nameplate capacity. Ultimately, the optimal choice for each energy storage system will depend on a variety of factors, including available site space and electric grid needs. The specific size and site location(s) will be specified by PREPA and included in the request for proposals.

iii. Risk Allocation

The contractor will design, build, operate and maintain the energy storage systems and will deliver electric capacity and energy storage under a power purchase agreement. The power purchase and operating agreement will include a monthly capacity payment to the contractor. The contractor will have full responsibility to operate and maintain the energy storage systems and will be required to guarantee specified levels of capacity, energy and availability. PREPA will have full control to dispatch the energy storage system and will provide all of the energy to charge the system.

C. Comparative Assessment of Procurement Method

Project Objective Considerations	Delivery Method	
	Business as Usual	P3 Approach
Assist in the recovery and modernization of the electric grid	◐	●
Improve the quality of service and reliability	○	●
Decrease electric grid operations cost and enhanced reliability	○	●
Promote economic growth through reduced electric energy supply cost	◐	●
Allocate project risks and responsibilities to the party best able to manage them	○	●
Increase revenue by introducing and improving ancillary revenue sources	○	●
Reduce costs through innovation and private sector experience	○	●
Decrease the amount of public funding required to operate the Project by pricing the service to better reflect operating costs	○	◐
Reduce exposure to the current fiscal situation in Puerto Rico; reduce dependence on imported fossil fuels	○	●
Provide operational flexibility to enable introduction of more renewable energy	○	●
Provide a boost in economic activity for the entities involved in the operation, maintenance and other portions of the Project	◐	◐
Modernize public services and build a stronger and more reliable transmission infrastructure	◐	●
Become the first P3 energy project to be delivered after the financial crisis and adapt to current economic and fiscal circumstances	○	●
Achieve the Governor's priority of implementing the modern day and economic energy supply project as a P3	○	●

● Meets Objective ◐ Partially Meets Objective ○ Does Not Meet Objective

5. ECONOMIC FEASIBILITY ANALYSIS

A. Introduction

This section presents the economic feasibility analysis for an individual energy storage system. This analysis is conducted using an 'avoided cost' methodology that calculates the grid operation costs that an individual energy storage system could help PREPA avoid (i.e. storage system benefits), which can then be compared cost of the ESS itself. These benefit streams are analyzed over the lifetime of the energy storage system to determine the total net present value of the storage system.

While the following analysis attempts to quantify the opportunity of 'Decreased Electric Grid Costs', it does not attempt to quantify the benefits of the remaining five opportunities (Increased Grid Resiliency, Transmission and Distribution Upgrade Deferral, Decreased Fuel Price Volatility, Economic Growth). Despite the fact that these benefits aren't quantified, the value they provide should also be considered in addition to the quantified benefits below.

B. Present Value Analysis

Installing utility-scale energy storage systems on PREPA's electric grid will generate benefits that go beyond simply providing energy or capacity services. In order to accurately capture these benefits, the current state of Puerto Rico's grid, existing generation assets, transmission and distribution network, and energy demand has been analyzed. The following table describes five high-level categories where energy storage systems can help avoid grid costs:

Value	Description
Energy	Value of the peak energy from conventional generators that is avoided by energy storage
Capacity	Avoided fixed costs of maintaining aged thermal generation if displaced with storage
Ancillary services	Avoided cost of ancillary services due to storage systems
Transmission	Avoided transmission investment due to storage systems
Emissions	Value of emissions avoided due to storage systems shifting more efficient energy for use during peak times.

Energy Benefits

The energy savings from energy storage systems were quantified by looking at the cost spread between charging and discharging at various levels of Puerto Rico's generation fleet. The four generalized levels (and estimated current variable costs) are as follows:

1. Emergency/Peak Load Generation (2018 cost: ~$180 to $250+/MWh)
2. Moderate Baseload Generation (2018 cost: ~$105 to $120/MWh)
3. Efficient Baseload Generation (2018 cost: ~$40 to $90/MWh)
4. Otherwise-curtailed Solar or Wind Generation (2018 cost: $0/MWh – sunk cost)

The $/MWh benefit for the energy storage systems is defined by subtracting the charging cost from the discharging cost where the charging energy is commensurate to the price of more efficient baseload rates and discharging energy used to offset peak and expensive generation. If we assume the blended variable rate of the system at low load periods is $80 per MW-hour and we offset the peak load generation at an average of $200/MW-

hr, the total savings would be about $120/MW-hr. Assuming 40 MW charge/discharge every day at this differential cost, the total annual saving would be approximately $1.75 million per year.

Ancillary Service Benefits

Since PREPA is an island system all ancillary services must be provided by PREPA. Currently, there is a need for system operators to operate larger units at part load where the fuel efficiency is not optimum. Fast response battery storage provides this reserve without impacting the efficiency of other units. While difficult to quantify, there will be a fuel savings due to operating existing units at higher loads resulting in better efficiencies. The normal operating mode for the existing PREPA system is to operate one or more peaking units at least during the day on weekdays to ensure adequate voltage support in the north. Installing any level of battery storage in the north would offset the need to run these peaking units for that amount of capacity. Even though the batteries would not normally provide the system with energy, a connected battery would support the voltage levels without the need to burn fuel. Shutting down 40 MW of peaking units for 5 days a week and 10 hours a day would result in 104,000 MW-hrs per year that could be generated by baseload units that is currently being provided by peaking units. At an assumed differential cost of $120/MW, the resultant annual cost savings would be about $12 million per year.

Transmission Benefits

PREPA is considering a variety of planned transmission upgrades as well as a longer-term effort to rebuild the hurricane damaged transmission and distribution systems. During these periods, portions of the system will be required to be out of service. With these outages, the system will be even more fragile and susceptible to unplanned outages. Installing energy storage systems facilities will enable more flexible outages and ensure better reliability when systems must be removed from service for permanent repairs. Avoiding future transmission upgrades would result in savings of capital expenditure but avoiding outages such as the one experience on April 18, 2018. Outages result in lost revenues but more importantly negatively impact the customers and could ultimately result in the customer leaving or self-generating.

Emissions Benefits

Emissions benefits were calculated in much the same way as energy – by looking at the spread between the CO2-intensity of the charging source and the marginal unit offset while discharging. The emission savings (on a MT of CO2 per MWh basis) were multiplied by a conservative estimate of societal carbon cost to arrive at a $/MWh benefit, which was then multiplied by the yearly MWh throughput for the storage system and divided by the kW capacity of the system, resulting in a $/kW-year benefit.

Benefits

Using the approach outlined above and just considering the savings associated with shutting down peaking generation, the estimated benefits are as follows:

Storage Size	*Estimated Annual Cost ($millions)*	*Annual Benefits ($millions)*
40 MW/48 MWh	*$3.88*	*$12*

6. AFFORDABILITY ANALYSIS

As noted above, installing battery storage and connecting to the PREPA system provides significant operational and financial benefits to the PREPA ratepayers. The annual cost provided in the unsolicited proposal for a 40 MW capacity battery with an energy storage level of 48 MW-hours was approximately $3.88 million per year. The expected cost savings to PREPA ratepayers is estimated to be significantly greater that the proposed cost. In addition to the tangible cost savings, the benefits described above, as well as others, provide additional justification for a battery energy storage system in Puerto Rico.

7. CONCLUSION

Currently, PREPA does not adequately serve the needs of Puerto Rico's ratepayers. As such, PREPA has concluded that it needs to seek out new opportunities that will improve electric service and reliability in Puerto Rico at reduced cost to ratepayers. To do this, PREPA must leverage private sector expertise through a P3 framework to improve the delivery of electricity service to ratepayers.

PREPA has elected to implement a P3 and rely on private sector expertise through a long-term contract. A power purchase agreement between a private operator and PREPA would shift the appropriate risks to the private sector and achieve the needs and objectives of Puerto Rico.

A successful P3 with a private owner and operator of a utility-scale energy storage system will deliver the following results:

- Increased grid stability and resiliency
- Decreased electric grid operations costs
- Ancillary service improvements
- Transmission and distribution upgrade deferral, and minimization of any service disruption during necessary system improvement work
- Decreased fuel price volatility
- Economic growth
- Modularity and high utilization
- Increased renewable energy
- The potential for long term emission benefits

The Proposed Project provides an integrated solution for PREPA that should enhance the value of the electric utility as an infrastructure asset and attract significant investment for the benefit of Puerto Rico.

Timeline

Following the adoption of the Study in the second quarter of 2018, formal procurement will commence in June 2018with the issuance of the RFQ/P. The final steps of the P3 procurement process, project award and financial close, will be reached during the third and fourth quarter of 2018. The timeline below summarizes the expected next steps of the Project. The expected dates for each step are subject to change.