NEPR

Received:

Apr 14, 2021

10:05 PM

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

IN RE:

OPTIMIZATION PROCEEDING OF MINIGRID TRANSMISSION AND DISTRIBUTION INVESTMENTS

CASE NO.: NEPR-MI-2020-0016

SUBJECT:
LUMA's Motion Submitting Recommendations in Response to Questions to Stakeholders.

MOTION SUBMITTING LUMA'S RECOMMENDATIONS AND RESPONSES TO QUESTIONS TO STAKEHOLDERS 5 THROUGH 11, IN COMPLIANCE WITH RESOLUTION DATED MARCH 24, 2021

TO THE PUERTO RICO ENERGY BUREAU:

COME NOW, LUMA ENERGY SERVCO, LLC and **LUMA ENERGY, LLC** (collectively, LUMA), through the undersigned legal counsel and respectfully submit the following:

1. Pursuant to a Resolution and Order dated December 22, 2020, this honorable Energy Bureau initiated this Optimization Proceeding in accordance with the Resolution and Order approving the Integrated Resource Plan, Case No. CEPR-AP-2018.

2. In the December 22nd Resolution and Order, the Bureau announced that it would hold several technical workshops. As of this date, this honorable Bureau has held three technical workshops (January 21st and 22nd, 2021, February 23, 2021, and March 23, 2021). LUMA representatives participated in the technical workshops held on February 23rd and March 23rd, 2021.

3. On March 23, 2021, LUMA submitted comments and responses to questions posed by the Bureau throughout the proceedings and in preparation for the March 23rd Technical Workshop. *See* Exhibit 1 to Motion Submitting Corrected Exhibit 1 to LUMA's Motion

Submitting Comments and Presentation for the Minigrid Optimization Technical Workshop of March 23, 2021, filed on March 23, 2021. On even date, LUMA also submitted a Power Point™ presentation that LUMA personnel then offered during the March 23rd Technical Workshop. *See* Exhibit 2 to Motion Submitting LUMA's Comments and Presentation for the Second Minigrid Optimization Technical Workshop of March 23, 2021 and Request for Leave to Offer Power Point Presentation in the March 23rd Technical Workshop, filed on March 23, 2021.

4. On March 24, 2021, this honorable Energy Bureau issued a Resolution that included an Attachment with eleven Questions to Stakeholders ("March 24th Resolution"). The Bureau directed that stakeholders would have four weeks to file responses to questions one through four (due April 21, 2021), and three weeks to respond to questions five through eleven (due April 14, 2021). *See* March 24th Resolution at page 1.

5. In compliance with the March 24th Resolution, LUMA hereby submits as Exhibit 1 to this Motion, its responses to questions five through eleven included in Attachment A to the March 24th Resolution. Exhibit 1 also presents LUMA's position and proposed path on renewable energy, a response to the study filed with this honorable Bureau by CAMBIO and the Institute for Energy Economics and Financial Analysis (IEEFA), titled "75% Distributed Renewable Generation in 15 Years in Puerto Rico is Achievable and Affordable," and additional comments and recommendations. *Id.*

WHEREFORE, it is respectfully requested that the Energy Bureau **accept and consider** the filing of LUMA's responses to questions five through eleven included in the March 24th Resolution, as well as recommendations and responses to the CAMBIO study, all included in Exhibit 1, and **find** that LUMA timely complied with the March 24th Resolution.

RESPECTFULLY SUBMITTED.

In San Juan, Puerto Rico, this 14th day of April 2021.

I hereby certify that I filed this motion using the electronic filing system of the Puerto Rico Energy Bureau and that on this date, I will send an electronic copy of this motion to counsel of record for the Puerto Rico Electric Power Authority, Joannely Marrero-Cruz, jmarrero@diazvaz.law; and Katiuska Bolaños-Lugo, kbolanos@diazvaz.law.

Electronic notice of this motion and Exhibit will also be sent to the following stakeholders that are identified in the Bureau's March 24th Resolution and/or that have filed and served comments in this proceeding:

Elias.sostre@aes.com; jesus.bolinaga@aes.com; cfl@mcvpr.com; ivc@mcvpr.com; notices@sonnedix.com;leslie@sonnedix.com;victorluisgonzalez@yahoo.com;jcmendez@reichardescalera.com;r.martinez@fonroche.fr;gonzalo.rodriguez@gestampren.com;kevin.devlin@patternenergy.com;fortiz@reichardescalera.com;jeff.lewis@terraform.com;mperez@prrenewables.com; cotero@landfillpr.com; geoff.biddick@radiangen.com; hjcruz@urielrenewables.com; carlos.reyes@ecoelectrica.com;brent.miller@longroadenergy.com;tracy.deguise@everstreamcapital.com;agraitfe@agraitlawpr.com;h.bobea@fonrochepr.com;ramonluisnieves@rinlegal.com;hrivera@oipc.pr.gov;info@sesapr.org;yan.oquendo@ddec.pr.gov;acarbo@edf.org;pjcleanenergy@gmail.com;Jmadej@veic.org; nicolas@dexgrid.io; javrua@gmail.com; JavRua@sesapr.org; lmartinez@nrdc.org; thomas.quasius@aptim.com; rtorbert@rmi.org; tjtorres@amscm.com; lionel.orama@upr.edu; noloseus@gmail.com; aconer.pr@gmail.com; dortiz@elpuente.us; wilma.lopez@ddec.pr.gov;gary.holtzer@weil.com;ingridmvila@gmail.com; rstgo2@gmail.com; agc@agcpr.com; presidente@ciapr.org; cpsmith@unidosporutuado.org;jmenen6666@gmail.com cpares@maximosolar.com;CESA@cleanegroup.org;acasepr@gmail.com;secretario@ddec.pr.gov;julia.mignuccisanchez@gmail.com;professoraviles@gmail.com;gmch24@gmail.com;ausubopr88@gmail.com;carlos.rodriguez@valairlines.com;amaneser2020@gmail.com;acasellas@amgprlaw.com;presidente@camarapr.net; jmarvel@marvelarchitects.com; amassol@gmail.com; jmartin@arcainc.com;melitza.lopez@aep.pr.gov; eduardo.rivera@afi.pr.gov; leonardo.torres@afi.pr.gov ;carsantini@gmail.com; directoralcaldes@gmail.com; adam.hasz@ee.doe.gov; Sergio.Gonsales@patternenergy.com; energiaverdepr@gmail.com;

Arnaldo.serrano@aes.com; Gustavo.giraldo@aes.com; accounting@everstreamcapital.com; mqrpcorp@gmail.com; jczayas@landfillpr.com; auriarte@newenergypr.com; Jeanna.steele@sunrun.com; mildred@liga.coop; rodrigomasses@gmail.com; presidencia-secretarias@segurosmultiples.com; directoralcaldes@gmail.com; imolina@fedalcaldes.com; pedrosaade5@gmail.com; larroyo@earthjustice.org; jluebkemann@earthjustice.org; ckunkel@ieefa.org; LCSchwartz@llb.gov; thomas@fundacionborincana.org; cathykunkel@gmail.com; joseph.paladino@hq.doe.gov; adam.hasz@ee.doe.gov; Sergio.Gonsales@patternenergy.com; energiaverdepr@gmail.com; Arnaldo.serrano@aes.com; Gustavo.giraldo@aes.com; accounting@everstreamcapital.com; mgrpcorp@gmail.com; jczayas@landfillpr.com; auriarte@newenergypr.com; Jeanna.steele@sunrun.com; mildred@liga.coop; rodrigomasses@gmail.com; presidencia-secretarias@segurosmultiples.com,

DLA Piper (Puerto Rico) LLC
500 Calle de la Tanca, Suite 401
San Juan, PR 00901-1969
Tel. 787-945-9107
Fax 939-697-6147

/s/ Margarita Mercado Echegaray
Margarita Mercado Echegaray
RUA NÚM. 16,266
margarita.mercado@us.dlapiper.com

Exhibit 1

Resilience Optimization LUMA Response to Stakeholder Questions

NEPR-MI-2020-0016

Contents

1.0 Introduction

On June 22nd, 2020, Puerto Rico Electric Power Authority (PREPA) and Puerto Rico Public Private Partnerships Authority (P3A) entered into the Transmission and Distribution System Operation and Maintenance Agreement (OMA) with LUMA and commenced the Front-End Transition Period. Front-End Transition is the period between the OMA Effective Date and LUMA's start of O&M services.

Under the OMA, LUMA, as Operator, was engaged to *(i)* 'provide management, operation, maintenance, repair, restoration and replacement and other related services to (PREPA's transmission and distribution system [T&D System]) in each case as is customary and appropriate for a utility transmission and distribution service provider" and to *(ii)* "establish policies, programs and procedures with respect thereto ((i) and (ii), collectively, the "O&M Services""[1].

During the Front-End Transition Period, LUMA is tasked with completing a set of services in preparation for taking over full operation of the T&D system. LUMA's Front-End Transition deliverables address the multiple different objectives that have been set for the energy sector as part of public policy. LUMA adopted a three-phase approach to the development of the Front-End Transition deliverables consisting of *(i)* assessing, *(ii)* analyzing, and *(iii)* planning. Key deliverables detailing LUMA's plans for operating the system that resulted from the Front-End Transition activities, include Initial Budgets, System Remediation Plan, Performance Metrics, and System Operation Principles.

1.1 Resilience Optimization Proceeding Background

On December 22nd, 2020, the Energy Bureau issued an order initiating the Resilience Optimization Proceeding[2]. The objective of the proceeding is to initiate a sequential analysis process to compare resiliency solutions, such as MiniGrids, microgrids, and distributed energy resources (DERs). LUMA has attended the workshops held by the Bureau as part of the proceeding and appreciates the opportunity to join the collaborative conversations.

On March 24th, 2021, as part of the proceeding, the Energy Bureau issued a resolution including questions to stakeholders related to DERs and transmission investments. This document includes LUMA's response to technical questions included in Attachment A of that resolution[3].

---

[1] OMA, Section 5.1.

[2] Puerto Rico Energy Bureau, NEPR-MI-2020-0016 "In RE: Optimization Proceeding of MiniGrid Transmission and Distribution Investments", 2020.

[3] Puerto Rico Energy Bureau, "Questions for Stakeholders", NEPR-MI-2020-0016, March 2021.

This document also outlines LUMA's path to renewable integration through sustainable energy transformation. At the end of the document, we provide our response to the study submitted by CAMBIO and the Institute for Energy Economics and Financial Analysis (IEEFA) to the Energy Bureau in March 2021 and presented in the previous workshop, titled "75% Distributed Renewable Generation in 15 Years in Puerto Rico is Achievable and Affordable"[4].

2.0 LUMA's Path to Renewable Integration

Act 17-2019, known as the Puerto Rico Energy Public Policy Act, established the Renewable Portfolio Standard (RPS) to achieve 40% renewable integration by 2025, 60% by 2040, and 100% by 2050[5]. LUMA is committed to the renewable energy targets through advancing the Recovery and Transformation Goals and Objectives which are the outcome of the planning framework that is meant to establish and maintain a link from Puerto Rico's key policy drivers to LUMA's strategy and plans (Figure 2-1). As part of the Recovery and Transformation, LUMA is supporting recovering the grid in a meaningful way to support the transformation required as well as support ongoing activities to support integration of renewable resources (Section 2.3).

[4] Ingrid M Vila Biaggi, Cathy Kunkel, Agustín A. Irizarry Rivera, "We Want Sun and We Want More: 75% Distributed Renewable Generation in 15 Years in Puerto Rico Is Achievable and Affordable". CAMBIO, IEEFA. March 2021.

[5] Act 17-2019, Puerto Rico Public Policy Act. 2019.

Figure 2-1 Recovery and Transformation Goals

PRIORITIZE SAFETY
Reform utility activities to support a strong safety culture focused on employee safety and the safety of the people of Puerto Rico

IMPROVE CUSTOMER SATISFACTION
Transform operations to deliver a positive customer experience and deliver reliable electricity at reasonable prices

SYSTEM REBUILD AND RESILIENCY
Effectively deploy federal funding to restore the grid and improve the resilience of vulnerable infrastructure

OPERATIONAL EXCELLENCE
Enable employees to pursue operational excellence through new systems, processes and training

SUSTAINABLE ENERGY TRANSFORMATION
Modernize the grid and the utility to enable the sustainable energy transformation

Figure 2-2 Recovery and Transformation Phases

The Recovery phase begins with the restoration of the utility's infrastructure and processes to a well-functioning state (Figure 2-2). During this phase, LUMA will complete foundational and enabling investments to repair the grid in the near term. Recovery phase activities include:

- Remediating damaged and neglected assets to improve reliability and resiliency, and to ensure public safety,
- Creating business and operational processes (e.g. System Operation Principles and procedures),
- Training for high-performing workforce to operate modern grid,
- Transformation-enabling and modern-grid enabling technologies.

The transformation phase will begin alongside and in coordination with the Recovery phase and accelerate the transition to renewable integration and distributed energy resources, made possible through advanced operational systems and technologies designed for the utility of the future. Transformation phase activities include:

- Advanced grid modernization technologies and system automation,
- Increased procurement of renewable energy resources and battery storage,
- Advanced grid operations systems, controls, and processes,
- Flexible grid services.

One of the key goals of Recovery and Transformation is sustainable energy transformation including identifying cost-effective opportunities to integrate DERs as resiliency, capacity deferral and flexibility solutions, and improved and automated hosting capacity planning to provide customers access to information that will facilitate cost-effective safe DER integration. These objectives and activities will support the renewable targets through facilitating integration of DERs. Through recovery and sustainable energy transformation, a modern, distributed, smart grid platform, leveraging 100% renewable energy resources, will be achieved.

As part of LUMA's Front-End Transition Deliverables, LUMA developed, the System Remediation Plan (SRP) to remediate, repair, replace and stabilize foundational transmission and distribution system equipment, systems, practices, and services. The SRP initiatives address the highest risk business functions and asset gaps that are essential to the recover the T&D System and near-term resiliency, as basic electric delivery is in jeopardy given the fragile state of the T&D assets and System. Foundational remediation activities planned as part of the SRP that repair the highest risk damaged system assets and address foundational operational processes will allow for DER technologies and integration of renewables. Many of the SRP programs will not only restore Puerto Rico's grid to a well-functioning state, but also facilitate integration of distributed resources. These programs include:

- Distribution line upgrades and replacing distribution line transformers as part of Distribution line rebuild program,
- Distribution lines inspection,
- Inspection of transmission lines
- Distribution substation rebuilds,

In order to reach the 100% renewable target, LUMA envisions a combination of renewable resources at different scales, including utility-scale and behind-the-meter solar resources. Integrating high penetration of renewables creates planning, protection, and operational changes that need to be considered. LUMA's ongoing activities and coordination with US Department of Energy National Laboratories aims to scope activities that will help guide the integration of DERs and renewables.

In the following sections, we touch upon both the importance and value of the grid and the value of distributed energy resources (DERs) in reaching the Renewable Portfolio Standard targets and providing resiliency.

2.1 Value of DER

In addition to the distributed resiliency benefits of DERs which are also described in the CAMBIO study, DERs can be put to dual-use and provide energy and capacity-related services during blue sky days (days without major events). DERs can provide a range of values to customers that span direct benefits to the customers, transmission and distribution system, wholesale energy, social, and environmental benefits. For example, consumers can directly realize the benefits of DER in terms of energy cost savings, and the use of backup generation. In terms of the system, distributed battery storage resources can increase renewable energy hosting capacity, allowing more customers to install distributed generation, which will be essential to reaching the renewables targets. Other benefits can include ancillary services, such as reactive power compensation, regulation and ramping services, and decreased energy and congestion costs.

Several technical and other considerations related to DER integration need to be taken into account to provide overall benefits to the customers and avoid potential impacts. For instance, photovoltaics can add to voltage fluctuations causing flicker, create high voltage conditions, or cause backflow that requires protection upgrades. Without these upgrades, customer equipment could be damaged, or there could be a risk to public safety. The grid serves all customers, and any costs imposed by the DERs will directly or indirectly impact the customers.

In the remainder of this document, we enumerate technical and other considerations relevant to the integration of high-penetration levels of DERs. With relevant data, proper planning, and appropriate grid investments, the benefits of DERs will be realized without impacting the operations of the grid. LUMA's Recovery and Transformation improvement programs for the T&D System will create the foundation to meet Puerto Rico's renewable targets. DERs and traditional grid investments are complementary solutions, not mutually exclusive alternatives.

2.2 Value of the Grid

Puerto Rico can benefit from distributed resiliency solutions, such as DERs and microgrids, that can sustain power to customers during major outages. However, continued investments in the grid, including those identified in the System Remediation Plan and Initial Budgets, are necessary to improve resiliency and support the integration of renewable resources. Grid investments that restore the system and increase hosting capacity will be a key enabler for broader access to distributed and utility-scale renewable resources and support these resources' ability to provide ancillary services to the grid.

Line upgrades can facilitate the integration of DERs by increasing hosting capacity. Even microgrids that are developed to improve community resilience rely on the grid to reliably deliver power during blue sky conditions. In addition, the grid helps to enable “energy equity” by providing income constrained customers with opportunities to access to renewable energy.

A shortcoming in many analyses that make a case of DER as an alternative to investments in the transmission and distribution systems (e.g., non-wires alternatives) is in comparing the net *benefits* of DER to the *costs* of the traditional grid investment. The cost of the grid investment is considered as a cost to be avoided, and the benefits of the DER include multiple factors (reduced energy costs, reduced emissions, etc.) beyond that avoided grid cost. However, DERs can bring additional costs in terms of increased need for ancillary services and advanced operational systems/equipment that are typically not recognized but should be included in the benefit-cost analysis. There are examples in California where a high penetration of renewable resources increased the frequency regulation requirements.

These impacts can also occur as more flexible, dispatchable resources and reserve capacity are needed to mitigate the intermittency impact, increasing the overall production cost. The grid provides benefits in terms of flexibility, reserve capacity, and others that should be included as benefits in a comparative analysis. In reaching Renewable Portfolio Standards targets, future improved technologies in utility-scale resources should be taken advantage of.

In summary, grid investments are needed to ensure everyday reliability and resiliency of power supply, to facilitate renewable development at large scale, and to provide energy equity to all customers. It is completely reasonable today to require that any proposed investment in grid capacity considers non-wires alternatives, but a responsible cost benefit analysis of the alternatives must be prepared on an apples-to-apples basis that includes all identifiable benefits and costs. Regulatory frameworks and practices must also adapt to the changing needs and complexities of the modern grid and alternative technologies. It is not reasonable or prudent with regards to system stability and affordability to decide that all grid investments should be avoided in favor of a single mode distributed solar and battery storage solution.

2.3 LUMA’s Ongoing Activities to Support Renewable Integration

LUMA is committed to a future state of renewables that will be achieved through recovery and transformation. As depicted in the figure below, LUMA’s near-term action plan focuses on recovery while building the foundation for sustainable energy transformation.

Figure 2-3 Sustainable Energy Transformation

CURRENT STATE	NEAR TERM ACTION PLAN	MID-LONG-TERM ACTION PLAN	FUTURE STATE
Electric grid that is unreliable and highly vulnerable to future threats due to decades of damage, deferred maintenance, and underinvestment	**Recover while building the foundation for transformation.** 1. Remediate damaged and neglected assets to improve reliability and resiliency 2. Deploy modern grid enabling technologies 3. Increase interconnection of renewables and battery storage by streamlining the customer process 4. Begin delivery of energy efficiency and demand response programs 5. Collect data, conduct analysis and develop tools for improved operations and customer engagement 6. Train workforce to operate modern grid	**Accelerate transformation.** 1. Increased investment in advanced grid modernization technologies 2. Increased procurement of renewable energy and storage 3. Increased integration of advanced grid operations systems, controls, and processes	**Modern, distributed, smart grid platform leveraging 100% renewable energy resources**

LUMA is currently committed to activities that support the integration of renewable resources. A key LUMA effort to support integration of DERs is interconnection process and standards, for efficient and agile processing of customer applications. To facilitate renewable integration, a streamlined interconnection process is required to efficiently process the high volume of applications. Providing an efficient system that maintains the safety and reliability of the grid while responding quickly to customer and developer applications is an important part of reaching the renewable goal. LUMA is currently reviewing the existing interconnection process to look for improvements that will help to quickly resolve the backlog and help expedite the adoption of renewable energy sources.

In December 2020, the Energy Bureau issued a resolution which requires the development of a three-year demand response plan[6]. LUMA is also committed to developing demand response programs which can provide increased flexibility in the distribution grid, hence facilitating the integration of renewable resources.

In compliance with the proceedings related to renewable integration and Distribution Resource Planning[7], LUMA will provide feeder level solar hosting capacity maps and information publicly. This information will improve the visibility of available hosting capacity thus reducing photovoltaic interconnection cost and operational issues. Hosting capacity maps will provide useful information for solar providers in identifying the most cost-effective investment locations to increase the integration of DERs.

LUMA's hosting capacity plan will begin with publishing voltage level heat maps followed by rudimentary interconnection capacity information intended to lead solar developers to those circuits with available room to interconnect solar resources. The interconnection capacity analysis will then be enhanced by performing hosting capacity analysis. This analysis relies on information that will be gathered through field walkthrough inventory of distribution assets, which will collect essential data to update GIS and power system data to create foundational power flow models. These models will enable LUMA to conduct technical analyses for planning and operations such as hosting capacity studies, distributed generation impact studies, protection coordination, reliability assessment, area planning, DER valuation, battery storage applications, among others. The following essential data will be collected during this inventory:

- Number of photovoltaics and capacity per feeder section,
- Voltage regulation equipment data (e.g., reverse power flow capability),
- Feeder three phase load profiles,
- Number of customers per service transformer,
- Branch and service transformer phasing.

In addition, substation capability to set in reverse power flow operation and protection system to handle back feed are some of the minimum data required to be collected and registered in GIS and the power system data repository. The hosting capacity analysis will also serve to identify where investments may be needed to facilitate renewables development and deployment.

[6] Puerto Rico Energy Bureau, "In RE: Regulation for Energy Efficiency and Demand Response", NEPR-MI-2019-0015.

[7] Puerto Rico Energy Bureau, "Process for the Adoption of Regulation for Distribution Resource Planning", NEPR-MI-2019-0011, 2019

3.0 Responses to the Questions for Stakeholders

3.1 Questions 5-11

NO-REGRETS OPTIONS – DERS – QUESTIONS

QUESTION 5:

What are the best "no-regrets" distributed energy solutions for Puerto Rico? Why? How should they be deployed, implemented, or procured? Please be specific in your response as is possible, including identifying the scale and type of distributed resource solution, and the likely physical locations (i.e., e.g., rooftops, substations, brownfields, greenfields) and any other relevant attribute of consideration.

RESPONSE:

As a part of the improvement programs in the Initial Budgets and System Remediation Plan, LUMA has identified many investments that will improve the resilience of the grid and enable more hosting capacity for distributed energy solutions. The initial focus on the restoration of high-risk transmission and distribution facilities and guiding focus of the Recovery and Transformation Framework will not only improve near-term reliability and resilience of the grid by targeting damaged and high-impact facilities, but ensure that newly restored facilities will be built to more resilient standards and support the integration of high-penetration distributed energy solutions.

In terms of distributed energy solutions to support resilience, "no-regrets" solutions will share the following characteristics:

- Require minimal to no T&D system upgrades including site development and grid infrastructure,
- Sited to support grid and customer needs not addressed by planned infrastructure improvements,
- Be an economically viable, proven technology,
- Align with Puerto Rico's Renewable Portfolio Standard targets,
- Not introduce safety concerns.

Given the possible distributed energy solutions on the market and industry experience, demand-side management and photovoltaic plus battery storage offer the best mix of lifetime cost, availability, alignment with IRP targets, resilience, and safety. Table 3-1 compares each potential solution across these critical attributes.

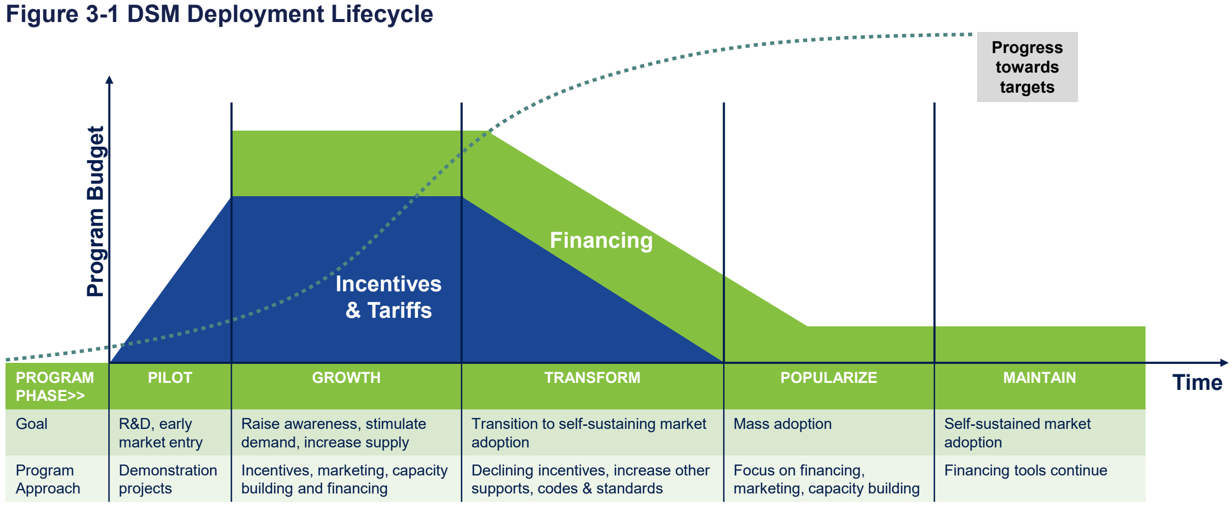
Table 3-1 Comparison of Types of DERs

Category	Demand Side Management		Renewable					Fossil Fuel-Fired	
DER Type	Energy Efficiency	Demand Response	Photovoltaic	Battery storage	Photovoltaic + Battery storage	Small-scale wind	Fuel Cell	MicroTurbine	Internal Combustion
Capital Costs	Lowest capital cost and lowest LCOE	Lowest capital cost and lowest LCOE	Lowest capital cost and lowest LCOE	Significant but dropping rapidly	Best choice for PREPA	Higher than PV	Higher than PV	Competitive	Lowest capital cost and lowest LCOE
O&M Expenses	Low	Low	Low	Low	Low	Moderate	Requires fuel	Requires fuel	Requires fuel
Alignment with RPS	Yes	Yes	Yes	Yes	Yes	Yes	Questionable	No	No
Complexity and Infrastructure / support development	Complex. Trained installers needed	Complex. Trained installers needed	Trained installers needed	Trained installers needed	Trained installers needed	Trained installers and maintenance needed	Complex, cutting edge	Requires on island maintenance	Familiar technology
Reliability	High	Low-Moderate	99%	High	High	Moderate	Moderate	Moderate	Moderate
Resiliency	High	High	Depends upon roof hardening and installation	Depends upon installation - good	See photovoltaic and storage above	Hardening unlikely	Fuel supply a concern	Dependent on fuel supply	Dependent on fuel supply
Controllability	No	Yes	Yes, with smart inverters & telecommunications infrastructure	Yes	Yes	Yes	Yes	Yes	Yes
Ability to sustain "neighbors" via grid	No	No	Yes, with smart inverters and microgrid control	Yes	Yes	Yes, with storage	Yes	yes	Yes
End-of-Life Disposal	N/A	N/A	Some recycling options available, but facilities required	Will require on island facility	See photovoltaic and storage above	N/A	Unknown	N/A	N/A

Category	Demand Side Management		Renewable					Fossil Fuel-Fired	
DER Type	**Energy Efficiency**	**Demand Response**	**Photovoltaic**	**Battery storage**	**Photovoltaic + Battery storage**	**Small-scale wind**	**Fuel Cell**	**MicroTurbine**	**Internal Combustion**
Safety	Not an issue	Not an issue	Not an issue	Lithium batteries create fire risk, but they are commercial technology. Other chemistries create hazardous material risks.	See photovoltaic and storage above	N/A. Avian disruption a question	Depends upon fuel storage	Depends upon fuel storage	Depends upon fuel storage
Suitability for rooftop, community, commercial, grid scale	Yes	Yes	Yes	Yes	Yes	Yes	Yes, but not currently grid scale	Yes	Yes

Targeted procurements of non-wire alternative (NWA) solutions for grid needs can be viable approaches to encourage investment. Demand side management is generally considered the lowest cost distributed energy resource and has been deployed as an NWA at smaller scales, often in geo-targeted applications. The primary mechanism for deploying DSM is through customer incentive and financing programs. Figure 3-1 presents LUMA's suggestion for how DSM and other DERs should be deployed in Puerto Rico. These programs can be complex to fund and administer and can present technical difficulties in measuring and monitoring energy reductions achieved.

Figure 3-1 DSM Deployment Lifecycle



Photovoltaic plus battery storage can be deployed at various scales and can be situated with load to minimize impacts on the grid. Effort should be made to identify optimum potential sites that have the required space for the panels and storage facilities that coincide with sufficient infrastructure to interconnect the facilities without requiring significant upgrades.

LUMA will be supporting the integration of both large scale solar and rooftop solar. Through our Integrated Resource Planning process, we will analyze how to achieve balance between large scale solar and rooftop solar for all consumers, including commercial and industrial, to improve resiliency and balance the cost. Incentives and tariffs can be developed that encourage customer choice and spur investment in these resources.

QUESTION 6:

How should the resiliency value of specific distributed resource solutions be gauged?

RESPONSE:

Both the Institute of Electrical and Electronics Engineers (IEEE)[8] and Department of Energy (DOE) provide guidelines to estimate metrics for resilience, measuring different aspects including preparedness, adaptation, withstanding disruptions, and rapid recoverability. Among these metrics are the following:

- Loss of utility revenue
- Cost of grid damages (e.g. Repair or replace lines, transformers)
- Cost of recovery
- Avoided outage cost
- Loss of asset and perishables
- Business interruption costs
- Impact on gross municipal product or gross regional product

A recent report by Lawrence Berkley National Laboratory provides a good summary of the current methodologies for estimating the value of enhanced power system resilience and notes the challenges and limitations with current approaches.[9] The following is a useful summary on this topic from the report:

> *There is a well-established literature on understanding the direct costs of localized and relatively short-duration power interruptions. Utilities are experienced in using tools, like Berkeley Lab's Interruption Cost Estimate (ICE) Calculator, which can estimate the cost of localized, short-duration power interruptions, to justify future investments in reliability. However, far less is known about the costs of widespread and long-duration (WLD) power interruptions, especially the indirect costs and*

[8] Resilience Framework, Methods, and Metrics for the Electricity Sector, PES-TR83 https://resourcecenter.ieee-pes.org/publications/technical-reports/PES_TP_TR83_ITSLC_102920.html

[9] https://eta-publications.lbl.gov/sites/default/files/hybrid_paper_final_22feb2021.pdf

related economy-wide impacts of these events. As a result, the costs of WLD power interruptions are generally not or only incompletely considered in utility planning activities

Based on the limitations of conventional approaches like the ICE calculator, the report recommends a sophisticated approach involving customer surveys to estimate region-specific power interruption costs as inputs for a calibrated regional econometric model. However, this approach does not consider the nuanced differences in valuing the resilience of DER in all its various configurations, procurement/deployment strategies and installation scenarios.

Not every DER can contribute to improving resilience. For example, depending on DER's ownership, it may or may not be able to have any impact on utility's loss of revenue. Similarly, cost of grid damages cannot be mitigated by DER solutions. Another factor is the operational characteristics of specific DER technologies. For example, photovoltaics is limited in its capability to sustain supply depending on the time of the day and/or weather condition. Resources such as battery storage that are energy-limited have different values depending on their energy rating relative to the outage durations and whether or not they are coupled with other resources that enable them to re-charge during sustained outage events. Finally, the vulnerability of DER during different outage events is another consideration. Like T&D assets, if not hardened properly, these resources can also suffer from weather-related damages. Their performance can also be compromised in extreme temperature and/or weather conditions. Fuel-fired DER can face the challenge of interruption in fuel supply during severe events. These are examples of considerations in addition to safety standards to successfully integrate different types of DER to the system.

This an emerging topic in rethinking utility regulatory practices that is gaining momentum on the heels of many recent natural disasters in the US and further driven by renewable energy targets. Regulators like the Energy Bureau are investigating innovative frameworks to adapt to the energy transformation, though few if any solutions can yet be found to the challenge of providing a robust, equitable, fulsome benefit-cost framework for comparing T&D investments to non-wires alternatives.

QUESTION 7:

How can the Energy Bureau support the most rapid deployment of distributed energy solutions for increased resiliency?

RESPONSE:

Standard Interconnection Requirements – The Energy Bureau can support a process with LUMA to develop interconnection requirements that differentiate from "normal" requirements (ensure safety and grid interconnection without causing problems) and "resilient" requirements. Such standardized interconnection would ensure safety, reliability, and resiliency. Certain requirements for DER to increase resilience should be established:

- Capability of islanded operation, grid forming, grid support and export to a utility Microgrid formed via intentional islanding.
- Capability of accepting control signals from a micro/mini/system control center.
- Technology-specific criteria such as storage duration, amount of on-site fuel storage, etc.
- Adoption or development of smart inverter standards (e.g., IEEE 1547-2018)
- Hardened installation criteria for particular DER types. For example, roof and installation strength, wind resilience for rooftop solar.

As part of this process, LUMA can make available feeder-level solar and battery hosting capacities to minimize potential operational issues.

Incentives for Resilient DER – Incentive programs may offer another mechanism for rapidly deploying resiliency solutions by accelerating customer demand. For instance, California has recently approved regulatory plans for a Microgrid Incentive Program that will accelerate commercialization of microgrids for wildfire resiliency purposes.[10]

In general, incentive programs are designed to cover a portion of the upfront equipment cost, to stimulate customer demand. However, a specific resiliency incentive must be somehow targeted specifically to the incremental "resiliency" value offered by the DER solution, distinct from the "normal" or blue-sky value. Value of DER including blue-sky benefits is discussed in detail in Section 2.1.

Incentive programs are typically funded through rate-payer cost-recovery mechanisms, the implementation of which itself could be a hurdle to rapid deployment. These programs offer many benefits and opportunities for open, equitable, market-based solution but they require careful consideration through an annual cycle of planning, implementation and evaluation.

QUESTION 8:

What is PREPA's role or LUMA's role in facilitating DERs for resiliency? Please comment on each of the following potential roles for PREPA or LUMA.

a. Should PREPA or LUMA be responsible for analysis of microgrid options? Why or why not?

RESPONSE:

The grid operator, PREPA and soon to be LUMA, is in the best position to do the analysis given its responsibility to operate a reliable grid. LUMA through the OMA is already tasked with

[10] https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M360/K370/360370887.PDF

planning and conducting supporting analyses (e.g., optimal microgrid locations, DER hosting analysis, etc.) LUMA has the operational and technical expertise and data required to run computational models and data because of its role. Moreover, LUMA will be responsible for system operations including the integration of microgrids into normal operations and energy dispatching, system restoration after outages which includes microgrid reconnection.

b. Should PREPA or LUMA directly participate in the installation and maintenance of distributed photovoltaic systems with storage? Would this be in alignment with Act 17-2019 and other Puerto Rico public policy that supports "prosumers"?

RESPONSE:
As the utility operator, LUMA will not participate in generation installation and maintenance. This is to maintain its independence. LUMA will be involved in the following actions:

- Development of interconnection standards (see Question 7 above)
- Certification of photovoltaic plus storage installers and provide certification of installation and interconnection

QUESTION 9:
In general, concerning the best microgrid candidate sites across Puerto Rico:

a. Comment on the number, size, facility type, and resource configurations identified at the microgrid sites in the Sandia microgrid report (159 sites) and in PREPA's Appendix 1 IRP filing ("50 potential zones").

RESPONSE:
More detailed evaluation of the microgrid sites, infrastructure and the proposed generation mix is required. The microgrid design is only performed from the energy consumption perspective – and does not incorporate operational and technical feasibility of day to day operation based on load and weather variations. However, for a microgrid to work, technical aspects of the microgrid system—generation to load ratio, voltage and frequency stability, age of the infrastructure and failure rate of assets and equipment inside a microgrid, visibility analysis, communication infrastructure requirement for adequate situational awareness—should be evaluated and ranked. Additionally, it is vital to evaluate the capabilities of the T&D grid to identify and address any potential limitations that may prevent the microgrid from fully delivering its intended benefits to customers and the overall power system. LUMA is in the process of developing a microgrid screening process. The proposed microgrid screening approach will incorporate some of the key technical requirements in prioritization as well as suggesting strategies to engage customer and microgrid developers.

b. Should all these sites be specifically targeted for microgrid development for resiliency reasons? Explain why or why not.

RESPONSE:

As stated above, a more detailed framework with detailed assumptions is needed to make specific recommendations. The proposed microgrid screening process will address several aspects of this question. The ranking and prioritization process includes a range of reliability, resiliency and operational efficiency related criteria to properly evaluate each candidate based on location and size, and to rank different sites based on their present and expected reliability. In terms of the microgrid use case, outage management and serving critical load come first. For resiliency, all aspects of recovery time, self-healing, frequency of occurrence, and load serving duration should be evaluated together. As Stated above, LUMA is in the process of developing Optimal microgrids deployment and technical interconnection requirement framework that presents:

- Prioritizing potential locations for microgrids along with optimal sizing in each location
- Screening and evaluating candidate microgrids
- Customer outreach and engagement
- Developing microgrid interconnection processes.

These processes have been designed to be consistent, holistic, practical and flexible to ensure the optimal selection and deployment of the microgrids.

c. Comment on how microgrid applications should be paid for, differentiating between “public” and “private” microgrids.

RESPONSE:

Based on the ownership model, the sources of funding for microgrid development and operation and maintenance expenses would be different. If the microgrid serves one customer, the customer would pay for it, if the private microgrid make resources available during catastrophic events, there a need for a mechanism to be developed for the private microgrid to get compensated. Public microgrid that serves a larger areas or community should be paid through a similar mechanism of transmission and distribution.

Microgrids can be classified into the following use cases:

- **Personal microgrids:** Energy produced by this type of microgrid is primarily for the consumption of its owner. Personal microgrids would be paid by the customer it’s servicing.

- **Third-party microgrids:** Third-party microgrids have owners or primary purpose of engaging in the sale of energy services and other grid services to the customers. These microgrids would be paid by the third-party owners.

- **Utility microgrids:** These are further divided into community and feeder type microgrids. Community type microgrids provide critical services to multiple customers in a neighborhood or town during emergency conditions. Feeder type microgrids provide services to all communities that are connected to selected distribution feeders during emergency conditions. As described above, these type of microgrids should be paid through a similar mechanism of transmission and distribution.

QUESTION 10:

In general, concerning stand-alone DER solutions (i.e., not microgrids) across Puerto Rico:

a. How should stand-alone DER solutions be procured or paid for?

RESPONSE:

Several procurement mechanisms can be designed and implemented:

- Competitive RFP
- Tariff-based incentives
- Customer incentive programs (e.g. demand-side management)
- A combination of procurement mechanisms

The choice of procurement mechanism depends on multiple factors such as the scope of the solution needed, funding source requirements, lead-time, and cost of administering the procurement program. Depending on the level of benefits from DER solutions and what portion of customers would benefit from the services provided by DER solutions, the cost can be either paid by the utility (e.g., in the case of replacing grid upgrades – this would be eventually socialized across all or subset of customers), or by the subset of customers who benefit from DER (e.g., level of resilience above the "standard" provided to certain customers).

Traditional demand-side management incentive programs offer a very well-established model for an effective procurement mechanism. This topic requires more extensive discussion than can be incorporated in this context. There are numerous extensive best-practice manuals available for planning, designing, implementing and evaluating incentive programs.[11]

[11] https://www.epa.gov/sites/production/files/2015-08/documents/resource_planning.pdf

b. Should the Energy Bureau differentiate between resiliency provided by public purpose DER solutions (e.g., town centers, municipal buildings, water and sewer facilities), and private purpose DER solutions, when considering alternative deployment and procurement vehicles for these resources?

RESPONSE:

This question is best answered by establishing a framework to assess the value of resilience and the benefits each category of resilience (public vs. private) would provide to the community. The two methods used to calculate the value of resilience can be broadly categorized as bottoms-up approaches and economy-wide approaches[12]:

- **Bottom-up approaches** – surveys and interviews to ask customers about their intended or actual behavior during interruptions and use real-world data to estimate a valuation of non-market goods.
- **Economy-wide approaches** – analyze the effects of power interruptions on regional economies using economic output and employment indicators, including.

QUESTION 11:

Provide any other additional comment, response, or supporting documentation that will help the Energy Bureau determine the optimum combinations of distributed resources and more conventional wires hardening approaches for providing resiliency for Puerto Rico load.

RESPONSE:

The determination of the optimal combination of distributed resources and conventional hardening approaches should not be determined without first establishing resilience planning objectives, metrics, and a risk management framework. The resilience objectives, coupled with Renewable Portfolio Standard targets and other objectives for the grid, should inform planning metrics and screening criteria used to identify areas of need across the grid. The solutions are dependent on the types of needs on the grid, the planning objectives and metrics, and the available budget.

Optimal planning requires taking into account several parameters (some competing) while making decisions between different solutions, especially since certain categories of grid hardening cannot be achieved with DER solutions. The following Non-Wires Alternative (NWA) screening criteria are useful for comparing DER and conventional grid solutions:

- **Type of project** – in other jurisdictions (e.g., New York and California), there is a screening process where criteria is established to identify the suitability of DER solutions to replace

[12] Resilience Framework, Methods, and Metrics for the Electricity Sector, PES TR-83, IEEE, Oct 2020.

conventional grid solutions. For example, infrastructure and security improvements (which contribute to resiliency improvement) are typically excluded from NWA analysis.

- **Timing** – does the lead time of the solution align with timing of the grid need? For example, in areas with existing damaged grid infrastructure where restoration time is critical, timing of grid investment might be more favorable than waiting for DER deployment.

- **Relative costs and vulnerability of DER solutions to damage in severe weather compared to grid** – for example, to improve the resilience of a remote village fed by a single sub-transmission line where the grid hardening costs could be high, a local microgrid (solar + storage, combined with some demand response/load shedding) could be more economical. Also, installing a second sub-transmission feed for redundancy would be cost prohibitive while stockpiling spares and installing reserve is more feasible. Conversely, in built-up areas, undergrounding overhead distribution could be more cost effective per customer than hardening rooftops that host solar and installing sufficient storage resources.

A systematic approach to assess the cost and benefit of each decision would help with having a robust decision-making process. An iterative approach where the replacement of conventional grid solutions can be evaluated by comparing the deferral and/or avoided cost benefits against the benefit from reducing the outage risk (as a measure for resiliency) is an option. If the deferral benefit outweighs the benefit of outage risk reduction, the decision would be to go ahead with microgrid deployment instead of the conventional grid solution.

In the long-term, the ultimate approach is to develop holistic planning functions to optimize investments between different resources and solutions, across generation, transmission and distribution.

4.0 Response to the CAMBIO Study

4.1 Background

In March 2021, CAMBIO and the Institute for Energy Economics and Financial Analysis (IEEFA) submitted a joint filing of Puerto Rico grid modeling studies (hereafter referred to as the CAMBIO report) to the Energy Bureau for consideration in the Resiliency Optimization Proceeding[13]. The report summarized the results

[13] Ingrid M Vila Biaggi, Cathy Kunkel, Agustín A. Irizarry Rivera, “We Want Sun and We Want Mode: 75% Distributed Renewable Generation in 15 Years in Puerto Rico Is Achievable and Affordable”. CAMBIO, IEEFA. March 2021.

of grid modeling studies[14] that were performed to investigate the technical aspects of the 2018 Queremos Sol proposal. Queremos Sol put forward a policy proposal in 2018, emphasizing energy efficiency and distributed renewable resources as a strategy to provide resilience to homes in future blackouts. The CAMBIO report evaluates the cost and operation of the grid under high levels of penetration from distributed photovoltaic resources—25%, 50%, and 75% of total electricity consumption (kWh)—coupled with a 25% reduction in consumption from energy efficiency. The 75% penetration by 2035 scenario models the installation of 2.7kW of photovoltaic generation with 12.6 kWh battery backup systems on 100% of the homes in Puerto Rico.

LUMA has reviewed the CAMBIO report and provides comments on the report below.

4.2 Key Goals of the CAMBIO Study

The CAMBIO report demonstrates the potential of behind-the-meter resources to meet clean energy targets and to improve household-level resilience in Puerto Rico. One key goal of the study is to put the grid on a trajectory to achieve 100% clean energy by 2050 which is in line with Renewable Portfolio Standard targets set in Act 17-2019 and in line with LUMA's Recovery and Transformation Goals. Behind-the-meter solutions are valuable resources to advance Puerto Rico public policy including resiliency. DER solutions have multiple benefits including advancing Renewable Portfolio Standards targets, and resiliency and reliability for the customers.

LUMA agrees with the CAMBIO report that understanding the operational, transmission, and distribution opportunities and challenges associated with DER integration is required. As both Telos and EE Plus studies in the CAMBIO report stated, additional studies are needed to evaluate other options for grid stability under high penetrations from DER. LUMA supports performing such studies. A study from NREL[15] confirms that detailed modeling is required for the transition to a forward-looking approach with integrated assessment of necessary distribution infrastructure upgrades. These include accurate modeling of DERs' behavior and their interactions, time-series behavior of DERs and their time-dependent impacts, which in turn puts great emphasis on increasing data collection and collaborating across organizations. LUMA currently has ongoing efforts to enhance system data upon commencement for use in planning functions, among others.

Telos Energy in the CAMBIO study states that "Integrating significant levels of distributed energy resources can be accomplished in an economic manner that improves reliability, resiliency, and grid stability. However, this transition will require changes to operational practices as well as investments in generation, transmission, distribution, and enabling technologies". LUMA agrees with CAMBIO on the changes required

[14] Technical modeling was conducted by Telos Energy and EE Plus.

[15] NREL, "An overview of Distributed Energy Resource (DER) Interconnection: Current Practices and Emerging Solutions".

in the generation, transmission, and distribution system as well as practices to allow for high penetration from DERs. Enabling technology requirement of DERs include various advanced system operations, communication and control tools. LUMA is committed to enabling technology deployment, such as Distributed Energy Resource Management System (DERMS) and Advanced Distribution Management System (ADMS) as part of the mid-long-term action plan of sustainable energy transformation.

As a mitigation solution to system changes mentioned above to accommodate high adoption from DERs, Telos Energy in the CAMBIO study stated that “Load flexibility will also be an important aspect of DER integration. Investments made to utilize loads for conventional demand response (reducing load during peak demand period) and grid services will be an important aspect of grid reliability with fewer fossil units available”. LUMA agrees with the CAMBIO report and believes that load flexibility through demand response programs is an important aspect of reaching the future state of 100% renewable resources. As such, LUMA’s near-term action plans as part of the sustainable energy transformation strategy include demand response efforts.

While the CAMBIO report shows the potential of DERs as a valuable resiliency solution in Puerto Rico, there are several items that were not considered in the analysis supporting the report. These considerations are described in Sections 4.3 and 4.4 below and are critical to a successful deployment of high-penetration DERs.

4.3 Technical Considerations

LUMA is supportive of the goals of the CAMBIO report and with the overall structure of the analytical approach used. There are some technical considerations that require further investigation that in order to validate key findings of the report, including “[a]chieving 75% distributed renewable energy generation in 15 years is feasible with minimal upgrades to the distribution system.”

Presented below are some of the technical considerations that could have a direct impact on the findings of the report:

- **Current state of the grid in Puerto Rico post Hurricanes Irma and Maria** – great effort was taken to model the impacts of the scenarios in the CAMBIO report, in particular EE Plus’ creation of distribution feeder models for most of the island from limited GIS and asset data. However, the models are limited by the data provided, and the assumptions used to fill in many data gaps were taken from PREPA standards. Assessments performed by LUMA and other independent firms identified the need for significant investment to bring the grid back to its pre-Hurricane state, and those estimates do not consider the impacts of the levels of renewable penetration studied in the CAMBIO report.

- **Current state of distribution feeder models** – as described in Section 2.3 above, LUMA is committed to providing hosting capacity maps to facilitate DER interconnections. However, the current state of the distribution feeder models is insufficient to publish maps that correctly identify the level of DER penetration that can be supported by the feeders without adverse impacts. Those same limitations impact the analysis performed in the CAMBIO report.
- **Necessary distribution network upgrades** – EE Plus performed several types of analysis on the distribution models they created to determine the need for infrastructure upgrades. These steady-state analyses identified the need for upgrades due to the thermal limitations of the distribution lines, service transformers, and substation transformers. As mentioned by EE Plus, upgrades to the protection system were not considered. Also, the use of a top-down allocation of loading based on the Telos Plexos model will not include the localized intermittency impacts of the distributed solar (e.g., clouds passing over an area abruptly reducing generation output) which can be an additional driver of upgrades and present operational challenges.
- **Lifetime costs of photovoltaic and battery energy storage systems** – the CAMBIO report focuses on the initial capital costs of installation. Since the CAMBIO report evaluates the Queremos Sol proposal as an alternative to grid infrastructure solutions, a full comparative analysis of the installation, operational, maintenance, replacement, and disposal costs of these systems over the lifetime of the equivalent grid infrastructure solutions should be performed. Another concern is the vulnerability of solar panels to extreme weather events and the cost associated with hardening the solar systems as well as the rooftops to withstand severe storms. In Puerto Rico, hurricanes Irma, and Maria shattered many solar systems, including utility-scale solar plants[16].
- **Inverter capabilities** – both Telos and EE Plus identified technological limitations present in the inverters currently used in the industry that would need to be overcome but were not considered in the cost analysis of the Cambio report. Inverters at the scale described in the proposal typically have anti-islanding protections in place that disable generation when there is no grid source present. These protections exist to prevent unknown sources from feeding distribution circuits as crews troubleshoot and repair damaged lines. To provide the household-level resiliency described in the CAMBIO report, the anti-islanding protections would need to be disabled. At the transmission-level, the analysis performed by Telos included assumptions related to the visibility, aggregation and control of the resources that are not currently achievable without upgrades to communication and control systems.

[16] Peter Farley, “Why Solar Microgrids May Fall Short in Replacing the Caribbean’s Devastated Power Systems”. Oct 2017. https://spectrum.ieee.org/energywise/energy/the-smarter-grid/should-a-devastated-caribbean-leap-forward-to-renewable-power-and-microgrids

- **Protection system impacts** – both Telos and EE Plus acknowledged the need to evaluate existing protection schemes and systems but did not consider it in their analyses. For example, high-penetration levels of DERs create the potential for the misoperation of line-distance relays that would lead to outages. Also, as the ratio of inverter-based generation increases relative to conventional resources, the reduced short-circuit strength could drive the need for synchronous condensers or curtailment of inverter-based resources.
- **Operational impacts** - both Telos and EE plus identified operational challenges present with the high-penetration scenarios analyzed in the CAMBIO report. Telos described the need for more flexibility across the fossil fleet of generators which would be required to cycle on and off more frequently. The high-penetration scenarios also showed a need for operational reserve from synchronous generators or grid-scale storage. As mentioned by Telos, there is a need for additional dynamic analysis of the stability of the grid under normal and emergency operating conditions in the scenarios modeled.
- **Power Quality impacts** – high-penetration levels of inverter-based resources can create voltage flicker and introduce harmonics on the distribution system which can impact customer equipment. These impacts, and potential mitigations, were not included in the analysis.
- **Communications infrastructure** – Many of the capabilities required to support the levels of penetration in the CAMBIO report are dependent on robust communication infrastructure. A recent whitepaper from Southern California Edison (SCE)[17], puts great emphasis on advanced grid control and management solutions to ensure power quality under high adoption of DERs. The whitepaper acknowledges the requirement of ultra-rapid communication technologies with vast number of DERs, which exceeds the bandwidth of currently deployed communications systems. LUMA also recognized the need for communications to support renewable integration and has included investments in communication infrastructure as a part of its Initial Budgets.
- **Supply chain and workforce readiness** – a deployment at the scale described in the CAMBIO report will require a significant workforce with the skills to harden installation sites, install and maintain the systems, and provide ongoing support. It can take time to develop this type of workforce which could impact deployment efforts. Similarly, a supply chain would need to be established to support the volume of equipment needed for installation and any disposal and recycling efforts. Disposal and recycling of photovoltaics and batteries at-scale could require investments in on-island infrastructure.

[17] Southern California Edison, "Reimagining the grid". December 2020.

4.4 Other Considerations

In addition to technical considerations described above, there are contractual and policy considerations that were not studied in the CAMBIO report:

- **Impacts on real estate** – the CAMBIO report does not include impacts on real estate, such as the cost of leasing roof space and the potential impacts on title and property rights.
- **Customer willingness to participate** – the CAMBIO report assumes that all residential customers will participate but does not address whether the customers will have a choice. Customers could have concerns about the location of the equipment and providing access to maintenance personnel.
- **Contract responsibilities** – in order for the DERs to connect to the grid and provide the services described in the CAMBIO report, contracts need to be developed that value the resources and support operational needs. These contracts will impact multiple stakeholders as P3A is responsible for procurement, PREPA is the owner of the impacted grid infrastructure, LUMA is the operator of the infrastructure, and the system would be installed on customer property.

4.5 Learnings from Other Jurisdictions

As part of LUMA's ongoing work to prepare for sustainable energy transformation, LUMA has reviewed the experiences of other jurisdictions and utilities who have adopted similar Renewable Portfolio Standard targets with progressive timeframes. The experiences in these jurisdictions offer insight that Puerto Rico should consider when integrating high-penetrations of inverter-based resources.

LUMA has reviewed the experiences of the following jurisdictions to understand the challenges they faced and solutions they implemented:

- **Hawaii** – is an island electric system like Puerto Rico that had a proliferation of rooftop solar going back to 2008-2011. Due to shared challenges between Hawaii and Puerto Rico with regards to lack of interconnections to export generation and load imbalances to, learnings from Hawaii's rooftop solar adoption are essential to review for considerations for Puerto Rico.
- **California** – has set similar Renewable Portfolio Standard targets as Puerto Rico and became the first US state to mandate rooftop solar to be installed in single- and multi-family dwellings, condos, and apartment buildings up to three stories, subject to exceptions. Experiences from California's high solar adoption level and phenomenon observed such as the "duck-curve" are reviewed.
- **Germany** – experienced an exponential increase in solar adoption over the course of a decade which led to operational problems. Germany is a case study of the types problems that can occur with rapid increases in DER penetration and different approaches to mitigating those challenges.

In addition to understanding implementation experiences from other jurisdictions, Puerto Rico must also adapt solutions to the current state of the grid post-Hurricanes Maria and Irma.

4.5.1 Hawaii

Between 2008–2011, the number of annual rooftop solar installations in Hawaii increased by 900 percent. The high adoption rate highlighted the challenges of integrating intermittent renewable resources to an island grid[18].

In 2013, it was stated that "the grid was not built for renewables" and that Hawaii was getting to a point where grid operators had to pay renewable energy providers not to produce power[19]. The concerns of the impact of solar on the grid was shared by pro-subsidy solar advocates such as Sierra Club[18]. One of Hawaiian Electric Company's (HECO) solutions was to end net metering. HECO argued that solar system owners could end up paying nothing to the utility while still relying on the grid for when solar supply wasn't sufficient for their demand.

In August 2013, the Hawaii Public Utility Commission initiated an investigation into the feed-in-tariff program in Docket No. 2013-0194; the program is currently closed to new applications[20]. In 2015, the Public Utilities Commission declared the net metering program fully subscribed and closed to new customers. HECO still provides support for existing customers and have a new option (Net-Metering Plus) for current net metering customers who would like to add additional non-export capacity to their systems. Furthermore, new rooftop solar programs have been designed which allow "customers to take advantage of new energy storage technology and help ensure safe, reliable service and fair treatment for all customers" [21]. The end of the net metering program was attributed to overbidding[22].

In 2018, HECO announced negotiations on seven new solar farms that total to 260 MW, each incorporating 4 hours of battery storage[23]. In March 2019, six projects (total 247 MW and almost 1 GWh of battery storage) were approved by the Commission[24].

---

[18] Institute for Energy Research, "Sunny Hawaii Highlights Challenges of Solar Adoption"., December 2013. https://www.instituteforenergyresearch.org/renewable/solar/sunny-hawaii-highlights-challenges-of-solar-adoption/

[19] Evan Halper, "Power struggle: Green energy versus a grid that's not ready". Los Angeles Times, December 2013. https://www.latimes.com/nation/la-xpm-2013-dec-02-la-na-grid-renewables-20131203-story.html

[20] Feed-In Tariff Program, HECO. https://www.hawaiianelectric.com/clean-energy-hawaii/selling-power-to-the-utility/feed-in-tariff

[21] Net Energy Metering, HECO. https://www.hawaiianelectric.com/products-and-services/customer-renewable-programs/private-rooftop-solar/net-energy-metering

[22] Caroline Cournoyer, "End of Hawaii's Solar Credit Program Spells Trouble for Industry". March 2016. https://www.governing.com/archive/tns-hawaii-solar.html

[23] Robert Walton, "Hawaiian Electric plans 7 solar + storage projects, adding 260 MW solar", October 2018. https://www.utilitydive.com/news/hawaiian-electric-plans-7-solarstorage-projects-adding-260-mw-solar/539410/

[24] Joshua S Hill, "Hawaii approves six low-priced solar and battery storage projects". April 2019. https://reneweconomy.com.au/hawaii-approves-six-low-priced-solar-and-battery-storage-projects-32014/

In Hawaii, there are four programs currently available for new customers to install rooftop solar. According to HECO, "Some programs work better with battery storage and others may restrict exporting during certain times or when circuit capacity is reached to ensure grid stability" [25]. These programs are listed here:

- **Customer Grid-Supply Plus (CGS Plus)** "systems must include grid support technology to manage grid reliability and allow the utility to remotely monitor system performance, technical compliance and, if necessary, control for grid stability".
- **Smart Export** "customers with a renewable system and battery energy storage system have the option to export energy to the grid from 4 PM – 9 AM. Systems must include grid support technology to manage grid reliability and system performance".
- **Customer Self-Supply (CSS)** "is intended only for private rooftop solar installations that are designed to not export any electricity to the grid. Customers are not compensated for any export of energy".
- **Customer Grid-Supply (CGS)** "participants receive a Public Utilities Commission (PUC) approved credit for electricity sent to the grid and are billed at the retail rate for electricity they use from the grid. The program remains open until the installed capacity has been reached".

Additionally, technical issues caused by rooftop solar drove Hawaiian utilities to restrict some customers that had solar panels from turning on their systems[26]. Some customers had to be put on multi-year waiting lists to install solar systems since the grid could not accommodate additional solar production.

CONSIDERATIONS FOR PUERTO RICO

Apart from high electricity rates due to dependence on expensive petroleum import, the lack of power lines linking Hawaii's grid with the rest of the mainland means that the Hawaiian utility has nowhere to dump excess solar power and no access to backup electricity generation from the mainland. If the existing power plants don't have the flexibility to make up for the variability introduced by solar, there is simply nothing the grid operator can do to access other, more flexible electricity resources. The adverse impact on customers would be expensive electricity rates, compromised power quality, black-outs and slower restoration. This challenge is shared by Puerto Rico and other island electrical systems.

Since the higher than mainland rates make customer adoption of photovoltaic systems more cost-effective, careful consideration needs to be taken when structure tariffs and contracts to ensure that the full capacity of the resources can be utilized without creating operational challenges. Similar to Hawaii, Puerto Rico is

[25] https://www.hawaiianelectric.com/products-and-services/customer-renewable-programs/private-rooftop-solar

[26] Robert Fares, "3 Reasons Hawaii Put the Brakes on Solar--and Why the Same Won't Happen in Your State", December 2015. https://blogs.scientificamerican.com/plugged-in/3-reasons-hawaii-put-the-brakes-on-solar-and-why-the-same-won-t-happen-in-your-state/

more susceptible to system operations issues than interconnected systems, as the imbalance caused by solar ramping, for instance, cannot be “exported” to an interconnection. Management of system frequency is more critical and mitigations to intermittency should be a priority. Lack of adequate redundancy in the system and interconnectivity with neighboring system renders the system more vulnerable to load balancing and frequency control.

4.5.2 California

The State of California has been setting progressively more aggressive Renewable Portfolio Standard targets since the early 2000s. The latest senate bill that was signed into law set renewable targets at 60% by 2030 and 100% by 2045 with interim targets. The latest reported renewable penetration levels from the California Public Utilities Commission show that retail sellers of electricity met or exceeded the 31% target they had for 2019 and were on track to reach 33% by 2020[27].

On the behind-the-meter side of things, in 2018, California passed a law requiring houses built from 2020 to include rooftop solar, becoming the first US state to make it mandatory for solar energy to be installed in single- and multi-family dwellings, condos, and apartment buildings up to three stories[28].

California has about 34GW of installed capacity of utility scale renewables in 2021 as estimated by the Energy Information Administration. Of that, about 13GW was solar photovoltaic. Adding an estimated 10.7GW of installed small-scale solar photovoltaic, the total solar installed capacity comes up to almost 24GW. Note that the total utility scale installed capacity of all generation types is slightly short of 80GW. The large, almost even, contribution of small scale solar to the total solar is an advocate for the fact that using solar at smaller or larger scale is doable and already has a tried-and-true application. The advantage of combining both smaller scale and utility scale solar resources would provide a solution that balances out the trade-offs for all customers. Rooftop installations can deliver generation to the individual household adopter and neighboring non-adopter houses in the case of excess generation and if the grid can support the transaction. On the other hand, the utility scale solar would offer a more controllable solution that could deliver power to a broader set of customers as well as grid services with advanced controls at a lower cost by taking advantage of economy of scale.

In California, post-heavy solar integration, the midday demand is lower than generation, a phenomenon commonly described with the term “duck curve”. In order to avoid power quality issues due to oversupply,

---

[27] California Public Utilities Commission, “2020 California Renewables Portfolio Standard Annual Report”. November 2020. https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/2020%20RPS%20Annual%20Report.pdf

[28] Umar Ali, “California: renewables on the frontline”. January 2020. https://www.power-technology.com/features/california-renewables-on-the-frontline/

curtailments are made by the Independent System Operator (ISO). These curtailments can be horizontal through the jurisdiction or localized for congested areas.

On the other hand, in the evening, solar production decreases rapidly while demand does not, making for a steep shift from using mostly solar power in the afternoon to using primarily firm capacity in the evening. The inability of firm generation to ramp up as fast as needed can be a bottleneck, as indicated by the rolling blackouts in the state in summer of 2020. Loads were still high in the evening due to extremely high heat, solar and wind ramped down and there was not enough supply to meet the load. This creates a domino effect in essence, where solar is further curtailed during its high production hours, so that the firm generation can be online at its minimum and be able to ramp up faster in the evening. This highlights the need for a comprehensive 8760-hour analysis instead of just the peak as well as the need for this analysis to be intertemporal.

A recent NREL study on the state of renewables in California links curtailments to grid flexibility and describes them as inversely related[29]. Storage or other dispatchable resources increase grid flexibility. In this direction, bridging flexibility with clean resources, California has already issued mandates to its three utilities for investment in storage facilities. Further, developers have started building collocated storage and solar. Other measures taken so far to increase flexibility are generation scheduling on finer timescale (15 minutes versus hourly), time-of-use pricing and the creation of an energy imbalance market expanding outside the state borders. This once again highlights the need for temporally granular analysis.

CONSIDERATIONS FOR PUERTO RICO

The learnings from this US-leading state in terms of renewables can be summarized as follows:

(i) Increased intermittency must go hand-in-hand with increased system flexibility to sustain existing system reliability. Storage, especially longer duration options, are a good fit. While this finding is based on the experience in California, it has stronger implications for an island grid like Puerto Rico.

(ii) In a high-DER penetration environment, granular, temporal analyses need to replace traditional peak-focused analyses. These analyses also need to be intertemporal.

[29] "Overgeneration from Solar Energy in California: A Field Guide to the Duck Chart", National Renewable Energy Laboratory, https://www.nrel.gov/docs/fy16osti/65023.pdf

4.5.3 Germany

The German Renewable Energy Sources Act came into effect in 2000 and included incentives that led to an exponential increase in installed power from distributed solar systems over the next decade[30].

In order to prevent overgeneration until grid's primary control systems had time to recover, low-voltage interconnection rules in Germany in 2008 required immediate shut-down of the solar inverters if the grid reached 50.2 Hz threshold[30,31]. However, the 50.2 Hz threshold rule caused a "yo-yo effect", where the threshold rule caused a sudden loss of solar generation exceeding the total balancing capacity for primary frequency control. Once the frequency was brought back down to 50.2 Hz, this was followed by all solar systems coming back online and causing the frequency to reach the 50.2 Hz threshold again.

As a result, in 2012, low-voltage interconnection standards were updated and mitigation measures were implemented through retrofitting, including updating the software or changing the frequency settings of the inverter[31,32]. In addition, frequency settings of the external frequency protection at grid function points was adjusted when appropriate.

The impact is summarized as the following[32]:

- It was determined that around 400 thousand solar systems with size 10 kW or larger must have been retrofitted,
- The effort required to implement the retrofitting measured limited the number of retrofits to about 8500 to 11000 per month,
- In a 2011 study, the total cost for the retrofitting of the solar systems were estimated at 175 million Euro (244 million 2011 US dollars), plus associated administrative costs for inverter manufacturers and distribution network operators.

CONSIDERATIONS FOR PUERTO RICO

Based on the experience of Germany, Puerto Rico should consider the implementation of the following tools and technologies to support the integration of high-penetration renewables:

- **Distributed Generation data collection** – tracking data for as many sites as possible is crucial to correctly estimate the impact of the resources on both transmission and distribution networks.

---

[30] The German 50.2 Hz problem. https://www.dnv.com/cases/the-german-50-2-hz-problem-80862

[31] SI Staff, "North American solar seeks to learn from Germany's grid integration trials". March 2014. https://solarindustrymag.com/north-american-solar-seeks-to-learn-from-germanys-grid-integration-trials

[32] Michael Döring, "Dealing with the 50.2 Hz problem". January 2013. https://www.modernpowersystems.com/features/featuredealing-with-the-50.2-hz-problem/#:~:text=On%2026%20July%20a%20new,the%20%2250.2%20Hz%20problem.%22&text=In%20a%20worst%20case%20scenario,frequency%20increased%20to%2050.2%20Hz

- **DER management** – two-way power flow capability on distribution network is required.
- **Monitoring and control systems** – smart meter technology can fulfill the need for real-time data and control.

4.6 Conclusions

LUMA agrees that improving system resiliency and meeting 100% renewable energy targets is critical for Puerto Rico and has structured the Recovery and Transformation Framework around those and other goals. LUMA also agrees that distributed photovoltaic systems paired with energy storage is a tool to meet those goals and that overall energy costs will decrease with the provision of all energy from renewable generation paired with storage.

LUMA recognizes that the overall analytical approach used in the report is sound. However, LUMA notes that the technical and other considerations described in Sections 4.3 and 4.4 highlight key areas of focus that need to be addressed that could alter the conclusions of the CAMBIO report. These technical and other considerations need to be resolved before the results of this report can be deemed feasible or prudent for Puerto Rico.

The other jurisdictions reviewed in Section 4.5 highlight the need to align investments in the grid with the deployment of distributed resources to prevent operational challenges. These other jurisdictions, with well-maintained and functioning grids and with renewable penetration levels well below those proposed in the CAMBIO report, experienced significant impacts to the grid and customers due to rapid integration. Investments proposed in LUMA's Recovery and Transformation framework are meant to, among others, strengthen the grid in order to support the integration of renewables. The approach presented in the CAMBIO report has not been attempted on this scale anywhere in the world. As such, the approach inherently has significant risks and should only be considered after careful and fulsome analysis and rolled out in a measured and deliberate way.

LUMA's commitment to improve system resiliency, safety, and reliability and support the 100% renewable energy future of Puerto Rico includes a vision of the grid as a key enabler of achieving that goal. This includes enabling all manner of renewable deployment, not just one mode of behind-the-meter solar and storage. Where innovative developers can propose cost-effective community or grid scale renewable development, or where local conditions dictate such, the grid will support these as well as all behind-the-meter proposals.