COMMONWEALTH OF PUERTO RICO
PUERTO RICO ENERGY COMMISSION

IN RE: ENERGY COMMISSION INVESTIGATION REGARDING THE STATE OF PUERTO RICO'S ELECTRIC SYSTEM AFTER HURRICANE MARIA	No. CEPR-IN -2017- 0002 Subject: Request for Public Comments

Preliminary Responses to Request for Public Comments

TO THE HONORABLE COMISSION:

COMES NOW, Enlace Latino de Acción Climática, El Puente de Williamsburg, Inc. and Comité Dialogo Ambiental, Inc., before the Puerto Rico Energy Commission through the undersigned legal representation and respectfully state and pray:

I. Introduction

Enlace Latino de Acción Climática (ELAC) is a community-based group organized by El Puente de Williamsburg, Inc., composed of residents of Puerto Rico concerned about the impacts of climate change on the Island. ELAC's objectives are to promote multisector discussion on the predictable effects of climate change in Puerto Rico, disseminate studies and information on climate change scenarios, generate discussion of mitigation and adaptation alternatives and their viability for Puerto Rico, and determine optimal parameters for planning for climate change, sea-level rise, food security, water availability, and impacts of power generation on climate change. Comite Dialogo Ambiental, Inc. (Dialogo) is a community environmental group composed of residents of the Municipality of Salinas and the Guayama Region and organized as a nonprofit corporation under the laws of the Commonwealth of Puerto Rico since 1997. The organization provides education and capacity building to restore the environment and promote conditions under which human beings and the environment can exist in harmony to fulfill economic, social and other needs of present and future generations. ELAC and Dialogo (hereinafter jointly referred to as ELAC) promote alternatives to fossil fuel generation and long-distance energy transmission, such as solar community microgrids, rooftop solar, energy demand management, time of use incentives and energy literacy and efficiency programs. In the aftermath of Hurricane Maria, ELAC has distributed solar lamps and other items to familiarize Puerto Rico residents with the benefits of solar energy.

Pursuant to the Regulation on Adjudicative, Notice of Non-Compliance, Rate Review and Investigation Proceedings (Regulation No. 8543) the Honorable Commission commenced the above-captioned investigation on the status of the Puerto Rico electric grid. The investigation should also consider how the Puerto Rico electric system is impacted by the placement of the Puerto Rico Electric Power Authority (PREPA) under Title III, the bankruptcy-like section of the Puerto Rico Oversight Management and Economic Stability Act (PROMESA). On November 10, 2017, the Honorable Commission issued an extensive Resolution and Order requesting public comments on distributed generation and microgrids as alternative models to restore electric service in Puerto Rico, post-Hurricane Maria. ELAC consulted with various experts in the field including faculty members at the University of Puerto Rico, Mayaguez campus and Arizona State University. The comments are due on or before November 20, 2017. ELAC submits these preliminary comments and respectfully requests that the Honorable Commission provide additional opportunity to submit further comments on the important issues raised in the November 10th Resolution.

II. Responses to Commission Requests for Comments

A. **Response 1.1**

The Amendments to the Energy Diversification Through Alternative and Sustainable Renewable Energy Public Policy Act (Law 133-2016, August 5, 2016) relate specifically to microgrids and modify three Puerto Rico statutes on renewable energy: the Net Metering Act (Law 114-2007), the Energy Transformation and Relief Act (Law 57-2014) and the Energy Diversification Through Alternative and Sustainable Renewable Energy Public Policy Act (Law 82-2010). Article 1 of the Amendments modifies Article 1.4 of Law 82-2010 by adding subsection 21, which defines a microgrid as a group of interconnected loads and distributed energy resources within clearly defined parameters, that acts like a unique controllable unit with respect to the Authority's (PREPA's) transmission and distribution system. The objective of a microgrid is to reduce electric consumption based on fossil fuels through the local renewable generation and strategies and strategies to reduce electric consumption. "Microgrids shall have the capacity to connect and disconnect from the Authority's transmission and distribution system, in such a way as to be able to operate interconnected as well as off grid" [Article 1.4 (21)]. The Commission has primary jurisdiction to regulate microgrids. Article 2 of the Amendments modifies Article 2.1 of Law 82-2010 and provides that the Commission shall issue orders, resolutions, and regulations to achieve compliance with the purposes of the Amendments that shall be applicable to all persons subject to the Renewable Portfolio Standard and to any person that buys, sells or otherwise transfers a Renewable Energy Certificate issued pursuant to Law 82-2010, as amended. Article 8 of the Amendments modifies Article 9 of Law 114-2007 and provides that the public policy of the Commonwealth of Puerto Rico is to guarantee interconnection procedures to the PREPA's electric system by distributed generators that shall be effective in terms of cost and processing time and specifically establishes that interconnection procedures for distributed generators with generating capacity of up to 5 MW participating in the Net Metering Program shall use the Small Generator Interconnection Procedures (SGIP) and the Small Generator Interconnection Agreement (SGIA) in FERC's Order No. 2006, as amended and any other amendments to these procedures adopted by the Commission. It also provides that the Honorable Commission may require reliability studies for interconnection of generators between 500 kilowatts and 1 MW. Article 10 of the Amendments modifies Article 6.3 of Law 57-2014 by adding various subsections including subsection qq which provides that the Honorable Commission, in collaboration with State Energy Public Policy Office (OEPPE) shall study and determine interconnection of renewable distributed energy and large scale renewable energy to the Authority's distribution and transmission system to ensure the "mayor balance and equitable access." Subsection rr calls for Commission collaboration with the OEPPE, the Independent Consumer Protection Office (OIPC) and comments from interested persons and organizations to establish a regulatory framework to guide PREPA in the development of solar communities and microgrids. Subsection ss authorizes the Honorable Commission, with input from PREPA to determine the maximum capacity and other requirements for a solar community guided by recommendations from IREC and NREL and similar organizations and as adapted to the Puerto Rico context.

Some provisions in the amendments grant primary authority to OEPPE with ancillary duties to the Commission. Article 9 amends Article 3.4 of Law 57-2014, subsection ii mandates that the OEPPE shall formulate strategies and make recommendations to the Commission to improve the electric service in low resource communities by studying, promoting and developing solar communities using recommendations from IREC and NREL and similar organizations as a guide and adapted to the Puerto Rico context with input from PREPA and representatives of relevant community, professional and academic organizations. Subsection jj provides that OEPPE, in collaboration with the Commission and PREPA shall study the electric industry best practices and establish a plan for the development of microgrids. Subsection kk indicates that OEPPE, in collaboration with the Commission shall determine the format and specific information that each microgrid shall share.

Various provisions in Law 57 place general authority in the Commission to implement Puerto Rico's public policy on electric power which includes integrating "clean and efficient energy and using modern technological tools that promote economic and efficient operations and diversified energy sources and high efficiency electric power generation" [Law 57, Section 1.2. (e), (g)]. The Energy Commission oversees and ensures execution and implementation of the electric power service public policy, establishes regulations in consultation with OEPPE regarding electric power service companies, transactions, actions or omissions relating to the electric power grid and infrastructure and implements the rules and strategies to achieve the objectives of Law 57, and requires that the "prices included in any power purchase agreement, wheeling rate, and interconnection charge are fair and reasonable, consistent with the public interest, and compliant with the parameters established by this Commission through regulations" [Section 6.3. (a), (b), (f), (g)]. The Commission is charged with overseeing compliance with any mandatory standard or goal under the Renewable Energy Portfolio mandated by legislation or regulations [Section 6.3. (r)]. The Commission has the authority to issue certifications to all electric power companies in Puerto Rico which meet the requirements set by the Commission [Section 6.13 (a)]. The Commission regulates recordkeeping and ensures, in conjunction with the Environmental Quality Board that every certified electric power company complies with Federal and Commonwealth environmental regulations, and with any applicable Federal law [Section 6.3. (p), (s)]. Wheeling rules and conditions are to be established by the Commission to ensure that wheeling does not affect nonsubscribers of wheeling services and exempt businesses (Section 6.30). The Energy Commission evaluates and determines whether to approve agreements between PREPA and any electric power service company and independent power producers, including power purchase agreements "whereby an independent power producer shall provide energy to PREPA for its distribution by the latter" [Section 6.33 (a)]. Law 57 requires the Commission to adopt and promulgate regulations, with input from PREPA, the OEPPE, independent power producers, and the public in general to establish the guidelines and standards governing the agreements between PREPA and any independent power producer and the terms and conditions that must be included in power purchase and interconnection agreements, including a reasonable cost per kilowatt-hour (kWh) according to the type of generation technology [Section 6.33 (c)]. The Commission has jurisdiction over the construction or expansion of electric power facilities [Section 6.35 (a)]. Finally, Law 57 grants to the Energy Commission "all those additional implicit and incidental powers that are pertinent and necessary to enforce and carry out, perform, and exercise all the aforementioned powers and to attain the purposes of this Act.," in addition to the powers specified in the statute.

Puerto Rico's RPS requires PREPA to generate 12 percent of electricity from renewable sources starting in 2015, achieving 15 percent by 2020 and 20 percent by 2035 (Law 82). Solar Community microgrids could contribute to the achievement of the RPS legal mandate. Large-scale photovoltaic rooftop solar projects have been recommended by the University of Puerto Rico's Instituto Tropical de Energia, Ambiente y Sociedad (ITEAS, http://iteas.uprm.edu/; http://www.uprm.edu/aret/docs/Ch_1_Summary.pdf, pgs. 1-13 to 1-14). Schools and other government facilities that operate almost exclusively during daylight hours would be good sites for rooftop solar installations without requiring large investments in battery storage systems. During the public hearing in the Aguirre Site case, there was testimony to the effect that the cost of rooftop solar is close to 10 cents per kWh and would go down to 7-8 cents per kWh with the Renewable Energy Fund and the Rural Energy for America Program. The National Renewable Energy Laboratory (NREL) recommends the siting of utility scale solar energy facilities at closed landfills in Puerto Rico. These projects could also be developed on brownfields and other previously impacted areas (http://www.nrel.gov/docs/fy11osti/49237.pdf).

Two post-Hurricane Maria Executive Orders exempt contractors and any other public or private person from all government contracting provisions (EO-2017-053) and the modification or installation of photovoltaic equipment from applicable legal provisions (EO-2017-064). Executive Order 2017-003 declares an infrastructure state of emergency and provides an expedited process for approval and implementation of critical infrastructure projects. Executive Order 2017-004 creates an interagency group to streamline permitting and regulatory approvals for critical infrastructure projects. Act 18-2017 enacted reforms to the existing permitting law and expedites the permitting process in processing requests for all permits, licenses, inspections, complaints, certifications, consultations, or any other authorization related to the operation of businesses in Puerto Rico. The Participative Public Private Partnerships Act (Act 1-2017) similarly enacted reforms to the existing P3 legal framework to facilitate critical infrastructure investments. These legal provisions could be invoked to support solar community microgrids. ELAC proposes the cooperative ownership of microgrids by the people whom that infrastructure will serve. The Commission should establish an expedited process by which communities can apply for special status and waivers to deploy, own and operate community microgrids.

B. Responses 1.2-1.5

Solar community microgrids could be organized under various sections of the Puerto Rico General Corporations Act, including as non-profits and worker owned corporations. They might also be created or organized as cooperatives, which in Puerto Rico are regulated under various statutes, including the Commission for Cooperative Development Organic Act (Law 247, August 2, 2008), the Cooperative Societies General Act (Law 239, September 1,2004), and the Cooperative Development Investment Fund Act (Law 198, August 18, 2002), among others. Puerto Rico has had vast experience with various types of co-ops, and financial cooperatives are a vital economic sector.

The National Rural Electric Cooperative Association (https://www.electric.coop/) has documented the most salient features of electric cooperatives that ELAC asserts also apply to nonprofit and worker owned corporations: Electric cooperatives, nonprofits and worker owned corporations provide energy to the communities they serve, and draw on the energy of their members and owners. The power of people to provide stewardship to the co-op and advocate for the greater good of their community is at the heart of these models. The energy landscape is changing in ways that favor the alternatives to the for-profit model. Co-ops, nonprofits, and worker-owned corporations are more than providers of electricity; they are partners. They promote community participation and make decisions collectively. They integrate innovations that increase reliability, improve members lives, and respond to their needs.

Due to their business structure, electric cooperative nonprofits and worker-owned corporations are required to put the well-being of their members first. They must anticipate and prepare, respond quickly and capably, and learn from their own experiences and from those of other similar organizations. Member-owners exercise their civic duty as engaged participants in the governance of their cooperative. Each member has a voice, which the organization amplifies. "In the United States, electrical co-ops enjoy high customer satisfaction. Strong showings from electric cooperatives, as well as greater satisfaction among all electric consumers, are among the highlights of a new J.D. Power report. The firm's 2017 Electric Utility Residential Customer Satisfaction Study shows several co-ops with top-of-the-chart scores besting many investor-owned and municipal utilities. On the co-op segment of the study, SECO Energy is the leader for the second consecutive year, notching a 789 on a 1,000-point scale. That's up 20 points from last year, and 40 points from 2015. In 2015 SECO captured the ranking of highest in satisfaction among midsized utilities in the South, before J.D. Power put co-ops in their own category. One point behind SECO on this year's co-op list is Northern Virginia Electric Cooperative. The Manassas-based co-op recorded a score of 788, up 40 points in a year. In the No. 3 spot is Sawnee EMC, which scored 786. The highest-ranked non-co-op on the list was Clark Public Utilities in Washington state, scoring 776. Besides SECO, NOVEC and Sawnee, two other co-ops beat that score: Southern Maryland Electric Cooperative and Georgia's Walton EMC each scored 783. Seventeen co-ops notched scores above the overall average of 719.

Non-profits and member-owned electric cooperatives use loans, grants and private financing to establish, maintain and modernize systems and meet power demands. Co-ops can access RUS (Rural Utilities Services – a program administered by the USDA) loans and grants and other affordable financing. Electric cooperatives rely on public and private financing to maintain and upgrade their systems and serve 12 percent of all U.S. electric consumers. Member-owned, not-for-profit electric cooperatives develop infrastructure that benefits entire communities. The availability of financing to maintain and expand this infrastructure is critical to improving quality of life and economic development in the areas they serve." National Rural Electric Cooperative Association. https://www.electric.coop/.

The following responses were drafted by Marcel Castro-Sitiriche, Efraín O'Neill-Carrillo, and Eduardo Ortiz, Professors of Electrical and Computer Engineering at the University of Puerto Rico-Mayagüez (UPRM).

Introduction

The implementation of microgrids in unserved areas must respond to two crucial issues pertaining to the context of Puerto Rico today: (i) microgrid implementation needs to contribute to the restoration of the electric service in the shortest possible time, in general, but particularly for the most remote areas in the rural mountain communities. (ii) microgrid implementation needs to be aligned with long term sustainable energy models that best provide for the needs of households, businesses, industry, and the Puerto Rican society at large.

The main purpose of CEPR-IN -2017- 0002 is to receive comments regarding Microgrids in Unserved Areas. However, as the Commission receives, analyzes, and uses those comments to develop regulatory actions for microgrids, it is important to emphasize that Act 133-2016 orders the Commission to establish the regulations necessary for both microgrids and solar communities, in collaboration with the OEPPE. Although there might be diverse types of microgrids and solar communities, (as a matter of fact Act 133-2016 encourages regulations that facilitate as many types as possible), the basic premise of using local energy resources is common. The main difference between microgrids and solar communities is that the former have enough internal energy resources to operate disconnected from the utility, whereas solar communities do not disconnect from the grid (although, the net consumption from the utility can be zero at times). It is vital that the regulatory actions established now for microgrids in unserved areas do not hinder the chances for the development of microgrids and solar communities in areas that have already received power after María. Furthermore, Act 133-2016 encourages the use of the first microgrids as testing or pilot projects, that might serve not only to solve the immediate need of providing power to remote areas, but also to study what regulatory actions make sense in the context of Puerto Rico's infrastructure. It is also important to realize that many terms are used to describe areas that operate independently from the grid: microgrids, nanogrids, stand-alone systems. The definition of microgrids given in Act 133-2016 covers all those different types and makes no distinction based on the size of the system (it can be a few houses, a whole neighborhood, an industrial complex, a commercial district among others).

The current restoration model is based in the traditional steps of working on the three pillars of the electric system: 1) generation, 2) transmission, and 3) distribution. This model goes in one direction from the restoration of the centralized generation, rebuilding of the transmission lines, and working through the distribution system to each point of use that includes clients, public illumination, street lights, and others. The appropriate implementation of microgrids in unserved areas will pave the way to build an electric system that can apply a two way restoration model: the traditional way and also a bottom up restoration process. The bottom up restoration model includes three steps: (i) individual distributed generation in houses and buildings (preferably rooftop solar systems, but could include other types of distributed generation as long as it enables more local energy sources to be used), (ii) integration of individual generation and additional ones at the distribution level with microgrids, and (iii) interconnection of clusters of microgrids to improve reliability and stability even before a reconnection with the grid is possible. Both restoration efforts would run in parallel and independently, even though a minimum of coordination will be required to optimize the re-electrification effort. The implementation of microgrids in unserved areas can work as a testing ground to study the broader implementation of the microgrid model for a resilient electric power system in Puerto Rico.

1. Microgrid Organization:

1.1. Act 133-2016 orders the Commission to establish regulations for microgrids and solar communities, in collaboration with OEPPE, and in consultation with PREPA.

1.2. Undergraduate students from UPRM, working with Dr. O'Neill, studied three of the main management options available for solar communities and microgrids (E. O'Neill-Carrillo, R. Santiago, Z. Méndez, H. Vega, J. Mussa, J. Rentas. "Capstone Design Projects as Foundation for a Solar Community," *Proceedings of the 47th ASEE/IEEE Frontiers in Education Conference*, Indianapolis, IN. October 2017). In a non-profit model, an entity would be in charge of the procurement and management of the solar community/microgrid. This entity would engage a third party that would be responsible for designing, permitting, installation, and maintenance of the photovoltaic system in the community. To finance the project, the community would work with a local financial cooperative, a philanthropic foundation, or a non-profit organization. *In a Utility-Sponsored Project, the* utility would install, maintain, and manage the community system. Not all households would have PV panels, but all in the community would benefit equally from the systems. The energy used by the community would be measured and billed by the utility. The energy storage could be in the substation that serves the community. The Sacramento Municipal

Utility District is an example of this type of arrangement. The third model is a *Special Purpose Entity,* where the community would join a nonprofit entity that mainly works with community projects. This entity would initiate, motivate, and support activities in and for the community to find donations to finance the project. The nonprofit entity and the community would have to seek third party participation to acquire the equipment and to be responsible for installation and maintenance. Afterwards, the community would negotiate with the third party on fixed monthly payments in exchange for the services and benefits of the system. The service from the third party would generate a profit and the residents would not own the equipment. In this scenario the PV systems are installed on the rooftops. As an example, Energy Solutions, an energy company in Washington, asked the Winthrop Community to join as a host for a solar community project; the ownership eventually passed to the community (J. Coughlin, J. Grove, L. Irvine, J. Jacobs, S. Johnson, A. Sawyer, J. Wiedman. *A Guide to Community Shared Solar:Utility, Private, and Nonprofit Project Development*, 2012. http://www.nrel.gov/docs/fy12osti/54570.pdf). IREC's "Model Rules for Shared Renewable Energy Program" states that as of March 2013, 30 out of 38 programs were run by utilities or a utility-sponsored third party. That does not mean the other models are not useful. This information acknowledges the fact that it is much easier to establish microgrids and solar communities if the utility facilitates the process. Since PREPA is government-owned, operating without profit, microgrids and solar communities should be a key strategy for the transformation of Puerto Rico's electric infrastructure into a resilient and sustainable tool for local socio-economic development.

1.2.1. All microgrids that would serve vulnerable communities must be established following transparency, fairness, and sustainability values. Profit cannot be the main driver.

1.3. Currently the power infrastructure is owned by PREPA. If microgrids are to be established, they would use existing power lines, transformers, and other utility equipment from PREPA. That property would have to be purchased, leased, or grid services paid to PREPA. Furthermore, PREPA has the "right of way" for power lines, thus the legal issues are not trivial. However, while a "final" solution is devised, cooperation from PREPA could facilitate the transition to microgrids, especially for those communities that will not receive power in the traditional way for many months.

1.4. PREPA could manage the microgrids for vulnerable communities, currently unserved, providing maintenance and service. Since PREPA is bankrupt, an RFP might be needed to identify private investors willing to provide the initial capital. PREPA would have to present an emergency case to the Commission, to establish an appropriate rate that would include grid services and a portion to pay investors. For those microgrids where a community is able to identify funding and manage it themselves, the Commission should assume "hands-off" regulation (dealing mainly with compliance with safety standards and the rights of the members of the community microgrid) similar to the hundreds of non-PRASA community water systems in the island.

1.5. First and foremost, community microgrids and solar communities need to be "bottom-up" efforts. Even if the original idea of establishing a microgrid comes from PREPA, each targeted community must be involved from the start. Residents must understand their new roles, their new reality and their new responsibilities as "active participants" of their energy future. This is a paradigmatic shift in the way people use electricity, and it must be approached with sensibility, acknowledging the hesitation this will produce from communities. On the other hand, IREC suggests that the utility be involved in any plans for shared renewable systems. If PREPA is not actively involved and supportive of microgrids and solar communities, it would be a very difficult, almost impossible feat to accomplish. If solar communities and microgrids are managed as if they were just “businesses,” instead of a tool for local socio-economic development, and a true transformation of our infrastructure, it will be very difficult to get the “buy-in” from key stakeholders within PREPA other tan the Director, or the top managers, or the Board (which change too often) but rather the employees that work in the field, those that provide customer service, operations people, and planning engineers, among others.

2. Microgrid placement and availability:

2.1. Act 133-2016 provides that different microgrid and solar community models can be explored and facilitated. However, Act 133-2016 indicates that microgrids and solar communities should be accesible to vulnerable communities. Thus, under the existing conditions after María, regulatory actions related to microgrids must give priority to those economically-challenged communities that are still unserved, and would remain without service for many weeks/months.

It is important that the Commission develop standards for different energy portfolios based on the Puerto Rico reality. Research work at Argonne National Laboratory and University of Southern California by Dr. Eduardo I. Ortiz-Rivera has shown that the development of energy portfolios (present and potential) is an essential tool in the development of optimized microgrids with diversified energy sources (i.e. wind, solar, fossil) in a specific geographic location. For example, a hybrid wind/photovoltaic/generator system could provide an energy portfolio of 40%/60%/0% under normal operations (i.e., available sun and wind) then 40%/40%/20% under variations of solar irradiation with energy compensated by diesel generators and 50%/0%/50% at night.

2.2. *See Answer to question 2.4.*

2.3. Drs. Castro-Sitiriche, O'Neill and Ortiz understand that this question was not formulated correctly, as each developer must decide its own financial assurances. Any investment presents risks, investors must make their individual decisions on when, how much, and where to invest. Microgrids and solar communities in Puerto Rico should not be focused on "assuring" profit to investors, but rather on providing service and a tool for local socio-economic development. Those who seek private investors must determine the best ways to make their projects attractive to private capital. Furthermore, regulation should not be used to guarantee private financial gain; there will always be risks in investments. On the other hand, if a foundation or NPO is the financier, they might not require financial assurance. The correct question should be, to truly address public interest: for those microgrids that require private developers, what kind of profit margin would be allowed?

2.4. In the effort to facilitate universal service restoration with microgrids in unserved areas three crucial approaches should be considered: (i) fastest restoration possible to the largest portion of the population considering the time required to get a microgrid online and the expected time to provide electricity in relatively densely populated areas, (ii) implement short term key upgrades to the system that do not prolong the restoration time but improve the robustness of the system and resilience for future events, and (iii) give priority to microgrid location in the most remote communities that will be connected last to the main grid.

3. Microgrid Regulation

3.1.1. The Commission should revise its definition of energy providers to ensure those regulations do not present an obstacle to community microgrids that are self-managed. Systems that operate without profit cannot be treated the same way as systems that generate profit for non-residents.

3.1.2. For microgrids in "stand-alone" mode, regulations must emphasize a safe operation for equipment and citizens, and the fair treatment of participants. However, it must be as "hands-off" as possible, as one of the drivers for stand-alone systems is the ability to decide one's own energy future. When interconnected to the grid, or to other microgrids, regulatory actions need to be expanded, as the actions from one microgrid can affect others. The exchanges of power, and other energy services, between the microgrid and the utility, or among microgrids, need to be regulated. Eventually, once microgrids reach a substantial participation in Puerto Rico's energy mix, a "Transactive energy market" or a similar framework will probably be needed. The Commission would have to establish the necessary regulations for such a structure.

3.1.3. The main advantage would be the protection of citizens and infrastructure from unqualified organizations. The disadvantage might be that the Commission sets the financial conditions that turn into entry barriers. Only large developers would be able to install, maintain, and operate microgrids, thus impeding small, local businesses, or community cooperatives from establishing and serving community microgrids.

3.1.4. Any developer must meet minimum qualifications related to the technology and type of work needed for the microgrid/solar community. Microgrids ARE NOT just the installation of a rooftop PV system (residential, commercial or industrial). They require expertise in power flow, fault analysis, distribution lines, and transformers, among other areas in power engineering. They also require understanding load management, billing, and energy storage. Thus, technical competence must be proven as a first step in the evaluation of developers interested in microgrids.

3.2. Standards IEEE 1547, NEC Article 690, and UL 1741 should apply to islanded microgrids but adapted to the Puerto Rico context. Based on the reality of Puerto Rico and the availability of the solar energy resource, it is highly recommended to consider prioritizing Solar Islanded Microgrids (SIMs). There are technical standards for SIMs.

Additional PV and Interconnection-Related Technical Standards that should apply are:

TITLE	PURPOSE
ASCE 7-05	Minimum Design Loads for Buildings and Other Structures.
IEEE Std 519-2014	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE Std 937-2007	Recommended Practice for Installation and maintenance of Lead-Acid Batteries for Photovoltaic (PV) Systems
IEEE Std 1013-2007	Recommended Practice for Sizing Lead-Acid Batteries for Stand-Alone Photovoltaic (PV) Systems
IEEE Std 1187-2013	Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications.
IEEE Std 1361-2014	IEEE Guide for Selecting, Charging, Testing, and Evaluating Lead-Acid Batteries Used in Stand A-Alone Photovoltaic (PV) Systems.
IEEE Std 1526-2003	Recommended Practice for Testing the Performance of Stand-Alone Photovoltaic Systems
IEEE Std 1547.2-2008	IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems.
NFPA 70 Article 690 (NEC)	Solar Photovoltaic Systems
NFPA 70 Article 705 (NEC)	Interconnected Electric Power Production Sources
UL Std 1703	Flat-Plate Photovoltaic Modules and Panels
UL Std 1741	Static Inverters and Charge Controllers for use in PV Power Systems

The current practices involving disconnection of distributed generation following a disturbance will no longer be a practical or reliable solution. As a result, the IEEE Std. 1547 provides for the creation of islanded solar microgrids and distributed generating systems (DGs). [Balaguer, Irvin J.; Kim, Heung-Geun; Peng, Fang Z.; Ortiz, Eduardo I.; "Survey of Photovoltaic Power Systems Islanding Detection Methods" 34th Annual Conference of the IEEE Industrial Electronics Society, November 10-13, 2008].

3.2.1.1. Yes, but additionally all the standards presented in the previous question should be included as part of the consideration of microgrids. Additionally, the most current version of the National Electrical Code/NFPA 70, is the 2017 NEC (http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70). Development of local regulations and standards based on the Puerto Rico context is recommended. It is important to note that many authors define micro-grids as small power stations in the range of 10kW up to 10MW [1]; in the order of less than 10kW it is considered as a nanogrid [2], but in reality the definition of a micro grid (and nanogrid) could be flexible depending on the author and the selection of the load size, generation resources (e.g. wind, thermal, solar), DC or AC operation, etc. The development of local standards for micro-grids should be based on the amount of electric power generation, energy storage, type of loads (i.e., residential, commercial, industrial, or combinations of different kinds of loads), and connection ad operation to the utility centralized grid. Puerto Rico should have a strong utility grid such that the microgrids can operate normally without affecting the utility grid in the single points of common coupling with the utility grid. It is critical to use the appropriate islanding standards and proper use of islanding detection methods (e.g. PV systems [1]).

[1] Balaguer, Irvin J.; Lei, Qin; Yang, Shuitao; Supatti, Uthane; Peng, Fang Z.; "Control for Grid-Connected and Intentional Islanding Operations of Distributed Power Generation" IEEE Transactions on Industrial Electronics Year: 2011, Volume: 58, Issue: 1 Pages: 147 – 157

[2] Hebner, Robert; "Nanogrids, Microgrids, and Big Data: The Future of the Power Grid", IEEE Spectrum, March 31, 2017, (https://spectrum.ieee.org/energy/renewables/nanogrids-microgrids-and-big-data-the-future-of-the-power-grid as revised on November 19, 2017)

[3] Balaguer, Irvin; Ortiz-Rivera, Eduardo I.; "Survey of Distributed Generation Islanding Detection Methods" IEEE Latin America Transactions, October 2010 vol. 8 No. 5

3.2.3. Residential microgrids would connect at the distribution level. The main idea of microgrids is to have local energy resources within a geographic area, that might operate independently from the grid. Drs. Castro-Sitiriche, O'Neill, and Ortiz are of the opinion that generation assets connected at transmission levels DO NOT constitute a microgrid, even if serving a particular area. A connection at a transmission voltage (115 or 230 kV) would include losses in the grid and would imply grid services that would have to be included in the rate. Such a connection is better served through a traditional power purchase agreement with the utility or Wheeling. Microgrid operation CANNOT be confused with WHEELING, nor can microgrid regulations be used to circumvent wheeling regulations or fees.

Connecting at sub-transmission level (38 kV in Puerto Rico) is a difficult issue to address, as many industrial and large commercial users are connected to 38kV in populated areas. Their generation or storage assets could become a key element in a microgrid, if their connection at 38 kV occurs near a PREPA substation. Thus, Drs. Castro-Sitiriche, O'Neill, and Ortiz suggest that those 38 kV connections be studied individually to ensure that, microgrid operation is supported.

3.3. To ensure a fair distribution of the available resources for restoration efforts, two main criteria should be used to determine the community location for microgrids in unserved areas: (i) number of people and business that are impacted and (ii) length of expected waiting period to re-establish PREPA electric service in the community. Restoring the service first to densely populated areas is standard procedure and doesn't need to be emphasized. However, remote rural communities, with many obstacles to re-establish the electric service from PREPA, provide the best testing ground for what could lead to building a smart grid with microgrid service universally available to all customers regardless of their locations. Another reason to focus on the most remote rural communities is that the Act 133-2016 specifically mandates that the vulnerable communities are given priority in the implementation of microgrids and solar communities. The short term benefit of establishing the first microgrids in the most remote communities are greater if the operation of the microgrid serves the community that is expected to accumulate many hours of outage during the next months through 2018. One way to look at it numerically is to estimate the number of customer hours of lost electricity service that could be prevented with each microgrid. The ongoing power outage in Puerto Rico has already been declared the largest in U.S. history with more than 1,000 million customer-hours of lost electricity service by October 26 (http://rhg.com/notes/americas-biggest-blackout).

Priority should also be given to existing government buildings including public industrial properties that are presently not used by Fomento Industrial. Opportunities are in high density geographical locations (e.g., photovoltaic distributed systems on residential rooftops).

3.3.1. Act 133-2016 states that the Commission has the authority to determine a maximum size for microgrids. It might be impractical in some locations to have a microgrid that serves more than 50 houses, whereas in other places hundreds of houses might form a microgrid. From the definition in Act 133-2016, the single control area criterion would be the main driver to determine the size of each microgrid.

It is important to determine as part of a local standard if the power produced by a microgrid will be limited to the different individual loads, or if any amount of power will be provided to the loads without any limitation. For example, if a microgrid provides 20kW to 4 residential houses whether the 20kW should be available to the 4 residential houses or if the power should be provided as a maximum of 5kW per residential home, or maybe the 4 residential homes could be guaranteed the amount of 4kW per residential house and the remaining 4kW should be available to the 4 residential homes as a type of energy pool with a higher fee to the customer.

3.3.2. Drs. Castro-Sitiriche, O'Neill, and Ortiz do not recommend that the Commission issue franchise right for microgrids. Based on the experience of other sectors like telecommunications (e.g., history of Bell Labs/Pacific Bell/ATT), franchise rights would limit:

1. the development and use of new technologies related to microgrids;
2. the reduction in prices;
3. availability of microgrid technology to new customers and low-income communities;
4. the amount of competitors with these "de facto" monopolies.

Franchise rights will affect the potential market for microgrids and in the end will destroy the potential benefits.

3.4.1.1. Drs. Castro-Sitiriche, O'Neill, and Ortiz suggest a rate equal or less than PREPA rates. However, two caveats are included to make sure that this regulation doesn't prevent microgrids to be operational in the short term with private investment nor to hamper the ability to implement an aggressive demand response program at the microgrid level. Caveat #1: The possibility of charging a higher than PREPA price to microgrid users in remote areas could be available for a short term of no more than a year, particularly to enable technologies that could provide solutions that are cost effective compared to widely used emergency diesel/gasoline electric generators. On the other hand, the cost should not be more than other existing alternatives. Caveat #2: The possibility to achieve a lower average rate than PREPA through a demand response program should be available, particularly in the longer term. However, a lower than PREPA rate should not be guaranteed to provide the flexibility needed to implement effective demand response programs. Successful demand response programs that have been documented are beneficial for both, the utility or microgrid provider and the customer (See as an example the work of Silver Spring Networks in Oklahoma – http://www.silverspringnet.com/customer/oklahoma-gas-electric/).

Drs. Castro-Sitiriche, O'Neill, and Ortiz strongly believe that the Commission MUST make a distinction between for-profit microgrids and those that are non-profit and community based. For example, too many fees, charges, licensing fees, or any other tax will discourage local socio-economic development activities that may be supported by community microgrids. Treating all microgrids "equally," in the sense of financial burdens, would indeed be an injustice and an inequality since the bigger, for-profit developers would have the financial ability to cover those regulatory expenses in their profit margins, while the smaller, community-based, local organizations may not.

3.4.2.1. Act 133-2016 explicitly supports a diverse spectrum of microgrids and solar community models. Standard contracts would go against the spirit of the law. Thus the regulations should not force standard contract terms, but rather encourage the use of contract elements that most favorable to the public interest. Furthermore, it is VERY important not to confuse microgrid operation, and the interaction among microgrids, with Wheeling and wholesale transactions. Microgrid operations (if any) usually occur at the distribution level, and are thus retail transactions. Even sales to PREPA from microgrids are retail. However, an industrial microgrid (one that exists within the confines of a company's grounds) or a large commercial microgrid (e.g., a Large Mall) could sell electricity to PREPA under a power purchase agreement at a wholesale level. But those large transactions should not be mixed with the smaller microgrids, especially community-based microgrids.

3.4.2.3. Those systems are really "power producers" not microgrids. They should enter into a power purchase agreement with PREPA if they want to be in the business of selling power, using PREPA's infrastructure. And they should pay appropriate regulatory fees to the Commission.

3.4.2.6. If a resident, or a commercial user does not agree to be part of a microgrid, the decision to be part of a microgrid should be voluntary. The Commission should give each community microgrid the freedom to establish its own rules and processes.

3.4.2.7. No. However, each community must decide what percentage of participation is needed to make their community microgrid viable. If a person does not want to be part of the microgrid, and the community decides to go ahead with the community system, that person should be given all the services as if he/she was still connected to PREPA. However, if the PREPA system fails, and the community microgrid keeps operating, that person must pay for those services provided by the microgrid. If the microgrid fails, but PREPA is still operating, then that person would have to be compensated for the time he/she is without power.

3.4.3. Of course these would vary. Even within a customer group, e.g., residential customers.

3.4.4. Each community microgrid must be allowed to develop its own rules. The Commission might provide some general guidelines.

3.5. Each client within a microgrid must pay fixed charges and variable charges. Fixed charges are split among the microgrid users, whereas variable charges would be mainly individual consumption. Each microgrid could have rules for energy use, an energy cap, or penalties, that should be decided within the community. Also, see answer to question 3.4.1.1.

3.6.1. Yes

3.6.2. Yes.

3.6.3. Yes.

3.6.3. Yes. The type of technology to be used and evidence of existing projects using the proposed technology are also recommended. Also, evidence of previous related projects developed in the past by the microgrid developer including a company/firm background check. In the case of microgrids, unknown companies can present projects without the necessary experience or the financial capacity in a project.

6. Coordination of Islanded Microgrids with PREPA:

6.1.3. See comments on question 1.2 related to "utility-sponsored."

6.1.5. See answer to question 3.3.

6.2. Act 133-2016 orders to begin the microgrid efforts in economically-challenged areas.

8. First, the Commission should consider the use of expert human resources as a tool to advise, analyze, prevent, mitigate, and minimize the areas without electric service. Close collaboration with academic experts, and professionals in the area of power and electric energy systems in Puerto Rico is vital. Collaborations with the University of Puerto Rico-Mayaguez (https://ece.uprm.edu/people/faculty, specifically the Power and Energy Systems Committee /)

that belong to the UPRM's Department of Electrical and Computer Engineering could be an excellent bridge to analyze, advise and study mid and long-term projects related to energy systems. Additional collaboration especially for long term projects with UPRM could be done with the collaboration of expert researcher from national laboratories such as Argonne National Laboratory (e.g. Dr. Guenter Conzelmann – Director of ANL's Center for Energy, Environment, and Economic Systems Analysis), Sandia National Laboratory (e.g. Dr. Abraham Ellis – Principal Member of Technical Staff, Photovoltaics and Grid Integration Department), and the Electric Power Research Institute (EPRI). Examples of useful software tools to help the Commission analyze areas without electric service are:

1- GRIDPV Toolbox by Sandia National Laboratory (SNL) (https://pvpmc.sandia.gov/applications/gridpv-toolbox/) - for analysis on distributed photovoltaic systems (Free Tool).
2- PV_LIB Toolbox by Sandia National Laboratory (SNL) - provides a set of well-documented functions for simulating the performance of photovoltaic energy systems (Free Tool).
3- System Advisory Model by the National Renewable Energy Lab (NREL) (https://sam.nrel.gov/) – for analysis of hybrid and distributed power systems (Free Tool).
4- NREL's PVWatts (http://pvwatts.nrel.gov/) – determination of potential energy availability given a geographical location (Free Tool).
5- Electricity Market Complex Adaptive Systems (EMCAS) by ANL (http://ceeesa.es.anl.gov/projects/emcas.html) – Desicion level simulator for complex power systems including macrogrids, microgrids, distributed generation systems, and traditional power systems.
6- HOMER (https://www.homerenergy.com/homer-pro.html) – software for optimizing microgrid design.

UPRM researchers that belong the Power and Energy Systems Committee have used these tools [1], [2]. The Commission could benefit from their experience.

[1] Perez-Santiago, Anthony; Ortiz-Dejesus, Randy; Ortiz-Rivera, E.I.; "HOMER: A Valuable Tool to Facilitate the Financing Process of Photovoltaic Systems in Puerto Rico", 2014 IEEE Photovoltaic Specialists Conference, June 8-13, 2014; Denver, CO.

[2] Perez-Santiago, Anthony; Reyes, Miguel; Ortiz-Rivera, E.I.; "Work in Progress-HOMER: An Educational Tool to Learn About the Design of Renewable Energy Systems at the Undergraduate Level" 2012 IEEE Frontiers in Education Conference, Seattle, WA.

8.1. Based on the current situation in Puerto Rico, there is either a short supply of technical resources or poor distribution of available resources. Every year during the non-hurricane season (e.g. January to May) an inventory of resources should be completed, by regions and municipalities.

8.2. Yes. The Commission should be the contact point for the information. Any firm (including existing or new to Puerto Rico) should be certified on the different processes and standards related to microgrids, in order to ensure firms update their internal resources (workforce and tools) as well as keep up to date in industry best practices. This would represent a revenue-stream for the Commission. Workforce development activities should be offered regionally, to ensure participation, e.g., Arecibo, Aguadilla, Mayaguez, Ponce, Caguas, Humacao, San Juan, Barranquitas, Fajardo.

III. Designing Microgrid Development in Puerto Rico (Questions 1.2-1.5, 2.1-2.2, 2.4, 3.1-3.4, 4.1-4.5)

The following comments were drafted by Kris Mayes, Maren Mahoney, and Clark Miller, Professors at Arizona State University.

We offer the following set of considerations for designing microgrid development in Puerto Rico: (A) addressing Puerto Rico's immediate humanitarian crisis through an "outside-in" strategy of microgrid development in rural and isolated communities; (B) anticipating the potential for microgrids to advance Puerto Rico's long-term needs for improving its electricity infrastructure to implement smart grids, decarbonize, improve resilience, and contribute to economic revitalization; and (C) reducing poverty and inequality among Puerto Rican citizens and communities. In addition, we identify (D) strategies for successful design and implementation of microgrids; (E) a classification of microgrid types; and (F) a classification of microgrid ownership models.

A. Microgrids policies should be developed to help Puerto Rican citizens respond to the current humanitarian crisis by adopting an "outside-in" strategy of microgrid development.

The Puerto Rico Energy Commission should develop policies that establish and accelerate an "outside-in" re-electrification strategy to complement the current "inside-out" strategy adopted by PREPA and Fluor. Sensibly, the "inside-out" strategy starts with grid-reconstruction on the major transmission infrastructures that link power plants to urban areas and then moves on to progressively smaller transmission and distribution lines and smaller communities. Unfortunately, this strategy will leave many small, isolated and rural communities without power for long periods of time (perhaps a year or longer; perhaps never for some communities, depending on the cost-benefit ratio of rebuilding grid lines to their location). Grid reconstruction is extremely expensive and time consuming, especially where long distances are involved. Because of the rapid declines in prices for both renewable energy generation technologies and battery and other types of storage technologies, microgrids are now likely cost competitive for many rural and isolated communities, especially with small populations. An "outside-in" strategy would build microgrids in these communities and thus relieve the current energy crisis in these communities at lower cost and more rapidly than grid-reconstruction. Such a strategy could be done at the same time as grid reconstruction, coming in from isolated and rural communities toward larger communities and eventually meeting the grid reconstruction effort in the middle. Moreover, such a strategy could be done in stages, with communities receiving initial modest microgrid installations (to relieve immediate and critical energy services needs) that could then be expanded over time to provide higher generation and a greater variety of energy services. In other words, an "outside-in" strategy could be adaptable, flexible, and nimble—meeting emergency needs quickly, adapting and strengthening the microgrid systems over time—thus allowing money to be invested in stages and with proper consideration for longer-term issues and design criteria as the microgrid systems grow.

B. **Microgrid policies should be anticipatory with regard to the transitions Puerto Rico will face in the coming years.**

Regulatory policy development often proceeds with a focus on the current problems and challenges, and the current crisis warrants that kind of consideration, as documented in section A. In this case, however, regulatory policy should also be developed in a forward-looking manner, with foresight, considering the considerable longer-term challenges and transitions that Puerto Rico will face in the coming decades. In this case, we suggest that microgrid strategy should address four broad near-term future transitions that are expected to be essential in the electricity generation and use system:

a. **Smart grids**: Electricity grids are increasingly integrated with information systems to promote more robust and flexible power generation and distribution, leading to lower construction time and costs and better control of demand and supply, including increased opportunities for improving efficiency, providing demand management, being more responsive to customer needs, etc. Microgrids are expected to play a key role in smart grid design and development.

b. **Climate change**: Decarbonization of the electricity system is essential, as is decarbonization of other energy sectors, such as transportation, cooking, water heating, space heating, etc., which are expected to increasingly rely on the electricity sector to replace primary energy fuels. Microgrids can play a key role in helping to integrate renewable generation technologies and storage technologies reliably into the grid infrastructure.

c. **Climate resilience and disaster preparedness**: Climate change is anticipated to create more frequent and extreme weather, including Atlantic Ocean hurricanes. Microgrids have a potentially highly significant role to play in increasing the resilience of Puerto Rico's energy system to future climate and weather risks, including: faster shut-down and black-start capabilities, localized redundancies, diversified portfolio of generators, closer integration to critical services, and faster decision-making matrix.

d. **Economic recovery and revitalization**: In the wake of Hurricane Maria and immediate recovery efforts, Puerto Rico is likely to face significant economic damage and an ongoing economic recession. Microgrid development has the potential to help provide long-term economic revitalization, e.g., through utilizing local resources, manpower, and skill development that fosters small businesses and labor. Because microgrids will use locally sourced natural resources and locally owned energy generation (e.g., solar, wind, hydro, wave, etc.), they will also help reduce debilitating fossil fuel imports that drain critical financial resources from Puerto Rican families and businesses to purchase carbon from the rest of the world.

C. Microgrid policies should be designed to foster local social welfare and economic growth.

Microgrids offer a unique opportunity to tailor electricity systems to the needs and opportunities of households and communities for energy services that can enhance local social and economic development. To accomplish this goal requires more sophisticated approaches to electricity system design at the community-scale than is typically done for electricity grids, which tend to treat households and businesses as commodity electricity consumers, unless they are very large industrial customers with specialized needs. In particular, designing microgrids effectively requires attending carefully to the social dimensions of electricity system design, integrated into the technical dimensions of the design. Here we present a conceptual approach for doing this integrated socio-technical design process. The approach is grounded in the measurement and assessment of the ability of energy systems to enable individuals, households, businesses, and communities to create value using energy, which we term the *social value of energy*.

a. **Social Value of Energy**: Substantial evidence exists that simple access to energy (e.g., an electricity line runs to a village or a house) is insufficient to guarantee meaningful social outcomes from electrification. Instead, a deeper examination is necessary of whether energy systems provide energy in a fashion that enables individuals, households, and communities to use energy to create substantial social value, encompassing but extending beyond just economic or financial value. This requires understanding the full array of benefits derived from energy consumption (including, e.g., improved business opportunities, increased revenue generation, improved health and education, improved food security), the costs of energy, and the risks or burdens entailed by energy systems and energy use. Energy might be available, for example, but too costly to be used or create burdens that detract from social and economic development. When summed, the benefits, costs, and burdens/risks of energy systems amount to the social value of energy. Microgrids should be designed using a user-centered design approach that works with users of each microgrid to maximize their ability to derive benefits, minimize costs, and minimize risks and burdens.

b. **Energy Services**: Social value is not created by energy but by energy services: the work that energy enables to be done. Energy services include lighting, heating, cooling, cooking, work, charging of devices, etc. There is a need, therefore, to translate opportunities for social value creation into a portfolio of socially valuable energy services. Microgrid designs must thus answer the question: what energy services do users need in order to create value?

c. **Socio-Technical Systems**: To deliver socially valuable energy services requires a suite of integrated socio-technical systems: *technical*, in the sense that the energy system must deliver energy services, in a technologically effective way, but also *social*, in the sense that people must be able to access the energy service where, when, and how they need it and also to undertake specific actions for that energy to be effectively delivered as an energy service. For example, they must plug in the device or the computer, turn on the heat or the light, fuel the car and drive it to school, etc. And they must be able to access the energy (e.g., the utility or some other entity must not have cut off their power) and to pay for it. These technical and social dimensions of microgrid design must be integrated, so that they work effectively together, e.g., so that payments for energy are sufficient to pay for energy generation, operations, and distributions (or are supplemented by other appropriate funds), and so that people can use the energy they have available to generate the energy services they need to create value.

d. **Energy Enterprises**: The socio-technical systems that underpin socially valuable energy service delivery do not automatically happen. They must be designed (ideally in a user-centered design process), installed, operated, maintained, and expanded. This requires an organizational or enterprise dimension to energy provision that can employ and train the proper workforces and undertake the energy systems work, as well as ancillary elements that we haven't discussed above, such as organize supply chains, maintain accounting systems, etc.

e. **Ownership, Reinvestment, and Extraction**: One of the most challenging facets of distributed energy system development is understanding how and the extent to which the energy system reinvests in local communities. This is particularly true as investor interest in remote energy systems ramps up. The goal, after all, is not merely to run electricity wires but to effectively catalyze and support local social and economic development. This can include a variety of strategies from creating local jobs that are filled via local hiring to local purchasing of materials to investing in local businesses that can benefit from energy provision to providing opportunities for local ownership and profit-retention in local communities. Aligned against this are the pathways via which energy systems extract financial and other resources from communities in ways that detract from their ability to advance development, e.g., by providing outside investors with annual returns on investment that derive from community income, creating or reinforcing corrupt ownership or governance regimes, etc.

f. **Policy and Governance**: The final facet of the model are the broader policy and governance arrangements that both support (or impede) the development of effective, distributed socio-energy systems that catalyze and advance local social and economic development. Policy and governance must incorporate both appropriate incentives (or avoiding of costly disincentives) to encourage energy development as well as appropriate regulatory frameworks and institutions that ensure performance abides by proper norms and rules. Policy and governance need to facilitate anticipatory capacities and processes to envision sustainable, socially valuable energy systems; to design or contract for them; to enable appropriate local input into decision-making processes; and to hold energy enterprises accountable for both practices and outcomes.

D. Microgrid implementation policies that follow this model have been demonstrated to be effective.

The characteristics described in section C. were found to be fundamental to successful cases of microgrids around the world, including in an urban microgrid feasibility study in the Greater Buffalo area of New York,[1] post-disaster response in Higashi-

[1] Assessment of an Urban Microgrid (Final Report), July 2017. Prepared by: Electric Power Research Institute. Palo Alto, CA.

Matsushima City, Japan,[2] and successful rural and remote electrification projects in India.[3] These studies highlight a set of additional benchmarks for operational processes required, decision-making, evaluation of outcomes, and responsibilities of governing institutions. Together, these principles steward the design, operation and governance of the system on a sustainable trajectory.

a. Legitimate stakeholders, local level institutions and asset ownership with decision making powers.
b. Supply ecosystem: Harmonized co-existence of local, regional and national supply/sourcing chains, market players and service providers.
c. Participatory and collectively established demand-supply flows, decision processes and operational guidelines.
d. Economic opportunity, capacity building and incentivizing productive use of electricity leading to improved living conditions for people. Secondary economic activity like food production and storage, public transport, small and micro manufacturing enterprises should be encouraged to solidify base electricity demand and revenue.
e. Tariff, billing and payments: should reflect financial viability of infrastructure from diversified revenue or capitalization portfolio, including municipal, industrial and critical services supported by the power system

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[2] Microgrid Introduced in Disaster-hit Area Along With PV System, Battery. Kenji Kaneko, Nikkei BP CleanTech Institute. August 2016 (http://techon.nikkeibp.co.jp/atclen/news_en/15mk/082200781/?ST=msbe). Born from Disaster: Japan Establishes First Microgrid Community. Junko Movellan, May 2015. (http://www.renewableenergyworld.com/articles/2015/05/born-from-disaster-japans-first-microgrid-community-represents-future-of-energy.html).

[3] Microgrids for Rural Electrification: A critical review of best practices based on seven case studies. Published by the United Nations Foundation, January 2014.

f. Appropriate technology matching: diversity of generators, load priority and forecasts, site selection and network design, etc., to reflect the four anticipated long-term transitions described in section B.

The above principles for successful design and implementation of microgrids can be operationalized through an action agenda. Below is a broad identification of decision variables and parameters for planning purposes, reflecting the core principles.

a. Design Dimension: **Technology**

Decision Variable	Parameters
Load	Domestic
	Services
	Commercial
	Forecasts
	Variability
	Criticality
Distribution	Length of network
	Robustness
	Safety
Generators	Location
	Diversity & Ecological footprint of resources
	Black-start capability
	Redundancies
	Voltage & Frequency control
Control	Isolation/Islanding
	Bidirectional communication
	Remote operation
Grid tie and storage	Generation variability
	Criticality and redundancy demands of network
	Unit commitment capacity and economics to grid
Cost	Tariff range
	Redundancy costs
	ROI requirements (not always least cost!)

b. Design Dimension: **Regulatory**

Decision Variable	Parameters
Ownership	
Operational protocols	
Technology and service standards	
Safeguards	Profiteering
	Affordability of service
	Ownership and control
	Financial viability
	Representation and decision making processes

c. Design Dimension: **Society**

Decision Variable	Parameters
Stakeholder consultation	Legitimate stakeholders
	Communication platforms and content
	Collective vision for desired outcomes
Energy as a public good	Accounting for the weakest
	Anticipating dispossession or injustice
	Including socio-ecological benefits and disaster preparedness in the cost-benefit calculations
Context based solutions	Incorporating local geographical, economic and human capacity
	Socio-cultural aspirations
Decision making	Equal and equitable representation
	Transparent processes
	Evaluation framework for sustainability of outcomes
Consumer behavior	Locked-in consumption behavior
	Consumption pattern change propensity

	Participation and adoption in prosumer/ responsive consumer programs

d. Design Dimension: **Market and Economics**

Decision Variable	Parameters
Supportive ecosystem	Complementary supply/sourcing chains
	Fair competition
	Incentivizing social value creation
Tariff and Billing	Use based tariff determination
	Incentives for productive use
	Flexible and interactive billing systems
Secondary services	Expanding user base and revenue via secondary use
	Integrating renewable generation with primary use of space
	Secondary products from renewable energy generation facility (Solar greenhouses, Bio-charcoal etc.)

E. **Classification of Micro-grids: Applicability and characteristics features**

Microgrids may be categorized based on their location and function in terms of fostering a new energy paradigm for Puerto Rico. Given the present scenario where electricity production is costly compared to most states in the US, the transition to renewable energy microgrids is economically viable and socially promising. It would enable a dedicated attention to local needs and an ability to incentivize productive activities in cities, towns or villages, thus creating greater social value than the power system has historically resulted in. Below is a classification of types of microgrids and what objectives it can potentially fulfill, in given contexts. Associated operational characteristics for each type are listed.

Microgrid Type	BAU objectives	Social Value creation	Load Profile/Diversity	Generator Diversity/ Redundancy	Suitable RE generators	Tariff/ Service Levels
Urban (commercial)	Energy supply for businesses and essential services in a limited area	Back-up supply, export to grid, public services during off-peak (charging stations, lights, Entertainment systems etc.)	Low variability day time load, lower evening load/Large inductive loads with periodical operation	Usually single source primarily due to space and siting constraints/ Storage or grid back-up desired	Solar PV (rooftops, parking structures etc.), BIPV	ROI based tariff setting, demand charges/Regulator mandated service levels
Urban (residential)	Energy supply for neighborhoods or behind the meter backup	Charging stations, water heating, export to grid	High daytime-evening use and weekends variability/ seasonal load diversity and shifting peak hours.	Primarily behind the meter sources on homes or public spaces/ localized storage and/or grid interfacing	Solar PV (rooftops, parking structures etc.), BIPV, Waste to Energy	ROI based tariff setting, net metering, low or no demand charges/Regulator mandated service levels
Industrial	Supply for one or cluster of industrial loads	Unit commitment to grid or PPA with load cluster in proximity	Low variability, predictable profile/Large inductive loads, high peak current	High reliability primary unit/Quick start backup or storage	Solar PV, Bio-gasifier, Waste to Energy, Pumped hydro	ROI based tariff setting/Regulator mandated service levels

			requirement			
Sub-urban/Rural	Enabling affordable energy services for homes and municipal services	Supply small and medium enterprises during off-peak hours for load curve smoothing	High daytime-evening use and weekends variability/ seasonal load diversity and shifting peak hours.	Multiple units, local feedback control/localized storage or grid interfacing	Solar PV (commercial and rooftop), Bio-gasifier, Waste to Energy (municipal, animal, agro waste), Pumped hydro, mini/micro hydro	Differential tariff plans, flexible demand charges, tariff offset through secondary revenue/ regulator aided, stakeholder defined load management and service protocol
Remote	Creating sufficient energy access at low costs for homes and essential services	Generating revenue for reinvestment in community development programs, direct and ancillary employment	High variability, low off-peak usage in BAU scenario/ disaggregated loads, high voltage and frequency variation sensitivity	Multiple distributed units, local feedback control/localized storage	Solar PV (commercial and rooftop), Bio-gasifier, Waste to Energy (municipal, animal, agro waste), Pumped hydro,	Affordability centered tariff setting, cross-subsidization for lowest consumption slab/ stakeholder defined load management protocol

					mini/micro hydro	

F. **Classification of Micro-grids: Ownership and governance**

Given the variety of application, location and objectives microgrids can be customized to, it is necessary to complement them with a suitable ownership structure. A mismatch in the ownership and functional goals of the system may lead to greater consequences instead of positive outcomes, over the long run. Below is a snapshot of a variety of business/ownership models that fit well with given contexts and supplements the classification in earlier sections.

Business/ Ownership Model	Business focus	Capital	Asset Ownership	Stakeholders and regulations	Operating basis	Profitability basis	Suitability
Utility owned & operated	Asset-customer	Market /Public equity	Investor owned	Mix of appointed and elected, representations of consumers, centrally regulated	Reliable and uninterrupted power supply	Regulated ROI	Densely populated regions and large industrial load centers.

Licensed service providers	Services	Licensee	Licensee, civil society share-holding through institutions	Empowered civil society groups and licensee representatives, regulator guidelines for service levels and exclusivity rights for service period	Energy services	Collectively negotiated ROI	Jurisdictions with established history of civic society engagement and institutions, higher per capita income and service needs
Public-Private partnerships at village cluster/city/ county	Services	Grants, low interest loans, public equity, private investors	Shared	Local agency: independent or part of local government. Regulatory guidelines on service levels	Municipal and Energy services	Collectively negotiated ROI/ payments for services	Municipal services weak or in need of upgrade, median income communities, reasonably strong local governance institutions and access to technology markets.
Community co-op	Community development, improving living conditions and economic opportunity	Development grants, endowments, community redevelopment/revitalization funds	Com-munity	Local redevelopment agency; elected, local government, non-government, academic	Facilitate com-munity services, household supply and econo	Non-profit operation: maintenance of service levels and revenue targeting	Diverse demographics, remote locations, in urgent need of socio-economic revitalization.

				representation. Regulatory facilitation through technical and legal capacity transfer.	mic growth	based on community re-investment goals	
Anchor load (community co-op)	Community development, improving living conditions and economic opportunity	Development grants, endowments, community redevelopment/revitalization funds, integrating small or medium commercial development investments with energy system	Community	Local redevelopment agency; elected, local government, non-government, academic, industry representation. Regulatory facilitation through technical and legal capacity transfer, energy sharing protocol	Facilitate com-munity services, household supply and agro/food processes, ancillary manufac-turing, services clusters.	Collectively negotiated ROI/ payments for services	Coastal, farming, animal husbandry communities. Small and medium scale commercial operations opportunity .
Anchor load (private ownership)	Assets, cus-tomers	Private equity, Corporate Social Res-ponsibility funds	Investor owned	Investor - customer representative agency. Regulatory intervention for service levels and tariff determination.	Sale of excess capacity of captive re-newable /CHP units to domestic	Collectively negotiated ROI/ payments for services	Places located close to large, energy intensive businesses.

					load centers in proxi mity of anchor load.		

IV. Legal and regulatory barriers and lessons learned related to microgrid development in other jurisdictions

A. Microgrid deployment throughout the U.S. faces similar need for legal and regulatory definition and clarity

Microgrids are most often developed according to local needs and contexts, and as such, regulators in localities without relevant statutes or regulations have been found to lack a clear definition of this infrastructure.[4] [5]As has been identified by the California Public Utilities Commission ("CPUC"), the Microgrid Institute,[6] and others, uncertainty surrounding microgrid definitions and relationships to regulatory commissions and legacy utilities often stymies microgrid deployment. The Commision has taken an important first step to facilitate microgrid deployment in communities throughout the Island, by defining microgrids in subsection 21, Article 1.4 of Law 82-2010.

B. Protections should be implemented to ensure fair contracting and environmental protections

[4] Hisham Zerriffi & M. Granger Morgan, The Regulatory Environment for Small Independent Micro-Grid Companies, 15 Elect. J., Nov. 2002, at 52, 53.

[5] Douglas E. King, Electric Power Micro-grids: Opportunities and Challenges for an Emerging Distributed Energy Architecture 60 (May 2006) (unpublished Ph.D. dissertation, Carnegie Mellon University). Available at: https://wpweb2.tepper.cmu.edu/ceic/pdfs_other/Doug_King_PhD_Thesis_2006.pdf

[6] Burr, et Al. "Minnesota Microgrids: Barriers, Opportunities, and Pathways Toward Energy Assurance. Prepared by Microgrid Institute for the Minnesota Department of Commerce, September 30, 2013. Retrieved from http://mn.gov/commerce-stat/pdfs/microgrid.pdf.

Regulators need to be assured that microgrid operator/owners will fairly contract with microgrid customers and that the operations will not negatively impact the local environment. With respect to question 3.1.4, existing consumer protection laws and land use, air quality and environmental protection laws may generally be adequate for most microgrid projects, but need to be adequately enforced by the Commission.[7] Any gaps in consumer and environmental protection should be identified by this Commission's proceedings and covered by new contract provisions.

C. Other entities have investigated legal and regulatory barriers and opportunities for development of microgrids

Though much work remains to be done by most states to encourage and facilitate the adoption of microgrids, a few states stand out for their work in this arena, including most notably, Minnesota, California and New York. We provide the following information to the Commission about these states' efforts as a potential guide for its future regulatory efforts around community solar and microgrids.

a. Minnesota: As noted by the Microgrid Institute, microgrids could be deployed in a variety of design structures, such as "in nested and connected circles, providing layers and webs of integrated generation and energy management systems…It could be the foundation of a new industry, with economic development and competitive benefits" (at 10). Such an integrated deployment, however, requires robust regulatory oversight and coordination. While not all of the recommendations in the report are relevant to the emergency needs of Puerto Rico, some policy implementation and regulatory reform

[7] Monopoly Money: Reaping the Economic and Environmental Benefits of Microgrids in Exclusive Utility Service Territories 34 Vt. L. Rev. 975 (2009-2010) by Kari Twaite.

suggestions can be applied to Puerto Rico and this Commission's efforts. The report first recommended that interconnection standards and tariffs be updated to conform to IEEE 1547 and the Federal Energy Regulatory Commission's Small Generator Interconnection Procedures and Agreements; as noted above, Article 8 of the Amendments which modifies Article 9 of Law 114-2007 requires these standards. Other relevant recommendations include implementing financial incentives for microgrids, such as bond financing and system benefits charges. The report authors further recommend regulatory clarity over whether microgrids would be treated as public utilities and be subject to the same level of regulatory oversight. Such a finding could level significant administrative risk and burden on microgrids.

b. California: The California Public Utilities Commission (CPUC) has conducted an investigation into barriers and opportunities of microgrid deployment, resulting in reports and workshops, the most recent of which took place this year. In its 2014 report,[8] the CPUC identified certain points of clarity that are critical for commissions to establish in order to lay the groundwork for third-party microgrid operators. According to the report, commissions should require open standards and open access for microgrids to connect into a monopoly utility's grid. Open standards will allow a broad array of microgrid components to compete, and provide a level ground for consumer pricing comparisons. As a protective measure for consumers serviced by third-party owned microgrids, commissions should require third-party microgrid

[8] Villarreal, et al. "Microgrids: A Regulatory Perspective." California Public Utilities Commission Policy & Planning Division. April 14, 2014.

operators to meet a standard certification to ensure safe, reliable operations as well as positive service interactions with customers.

c. New York: In 2010, New York State Energy Research and Development Authority (NYSERDA) drafted a white paper investing microgrid development policy and regulatory issues in New York.[9] The examination of microgrid ownership models and service models, (section 3.0) as well as the analysis of value streams and monetization opportunities (5.0), could be instructive to this Commission. ELAC believes that Joint Ownership/Cooperative model, described on S-8 of the NYSERDA paper, would be the most attractive model for microgrid development in Puerto Rico. This model has been developed in Puerto Rico, and as we discuss above, already has significant legal and regulatory frameworks. Value streams of microgrids include reduced power outages and avoided major system outages, voltage stability, lower demand and energy losses, reduced system congestion costs, higher T&D capacity use, reduced operating reserves, and lower emissions. These value streams can be monetized through costs savings from actions such as reduced fuel purchases or through decreased capital investments.[10]

In Salinas, Puerto Rico, on November 20, 2017.

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[9] Razanousky, Mark P. "Microgrids: An Assessment of the Value, Opportunitites and Barriers to Deployment in New York State." Prepared for NYSERDA. September 2010. Retrieved from https://microgridknowledge.com/white-paper/microgridpolicy/