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Implementation Roadmap to 75% Distributed Renewable Energy by 2035 in Puerto Rico

Introduction

In March 2021, CAMBIO released detailed grid modeling studies of Puerto Rico's electrical system under scenarios of high distributed renewable energy penetration, following the Queremos Sol proposal. The studies specifically focused on providing a minimum level of resiliency to homes through solar and battery storage systems and found that achieving 75% distributed renewable energy with 100% of homes equipped with small-scale solar and battery systems by 2035 was both technically and economically feasible. In addition to providing resiliency benefits to individual homes, the transformation of the island's electrical grid to decentralized renewable energy would reduce dependence on long-distance transmission and greatly reduce the consumption of imported fossil fuels, the largest driver of rate increases and rate volatility. Furthermore, the studies concluded that the use of approximately $9.6 billion in federal funds to buy down the cost of this strategy would result in average electrical rates in 2035 of approximately 15 cents/kWh. In order to implement this strategy CAMBIO identified the importance of public sector intervention in deploying a residential solar rooftop and storage program.

Coinciding with the release of the modeling studies, LUMA Energy was entering the last transition quarter before taking over the operation of the Puerto Rico Electric Power Authority's transmission, distribution, power dispatch, customer service and administrative functions on June 1st under a 15-year concession arrangement. Under the terms of the contract, LUMA Energy will operate as the manager of federal FEMA funds destined for the recovery of the electrical system. LUMA has expressed that they have no interest in deploying a network of PREPA-owned distributed generation assets, as proposed by Queremos Sol.[1] Instead, PREPA and LUMA's plans for the use of billions of dollars of available federal funds has focused on hardening the existing centralized transmission and distribution system, despite the risks involved in this approach.[2]

[1] Motion Submitting LUMA's Recommendations and Responses to Questions to Stakeholders 5 through 11, in Compliance with Resolution Dated March 24, 2021, Puerto Rico Energy Bureau Case No. NEPR-MI-2020-0016, April 14, 2021, p.22.

[2] These risks include: risks of early failure, expensive long-term replacement costs, and failures due to liquefaction and seismic instability. See Affidavit of Ray Harold filed in Puerto Rico Energy Bureau Case No. NEPR-MI-2020-0016, April 14, 2021.

PREPA is conducting an ongoing RFP process for solar and battery storage systems, which includes carveouts for distributed systems.[3] However, the upfront costs and credit requirements required to obtain distributed systems from private third-parties are out of reach for a large fraction of Puerto Rico residents, 44% of whom live below the poverty line. Neither PREPA, LUMA nor the Puerto Rico Energy Bureau, which regulates both PREPA and LUMA, have focused on the equity implications of relying on the private market to deliver distributed solar solutions.

The large amount of federal funding destined for the rebuilding of Puerto Rico's electrical system (more than $14 billion in FEMA funds, plus $2.7 billion in HUD funds[4]) creates an opportunity for a more equitable solution that extends the resiliency benefits of distributed solar and storage solutions to low-income residents. FEMA has stated in response to Congressional inquiries that funds can be used for renewable energy, storage and microgrids.[5]

This follow-up briefing note proposes in more detail how PREPA could design a rooftop solar and storage program to take advantage of federal funding. Because FEMA funds have to be used to build assets owned by the public utility, this approach would require PREPA or LUMA to run a distributed solar program. Utility-run rooftop solar programs are not without precedent in the continental United States. Public utilities, including the Sacramento Municipal Utility District and Los Angeles Department of Water and Power, as well as private utilities, including Arizona Public Service and Tucson Electric Power, have experience running programs in which the utility manages the installation and owns solar systems installed on residential roofs.[6] We draw on lessons from those programs, as well as the experiences of existing community projects and private installers in Puerto Rico to propose the implementation of a utility-run rooftop solar and storage program for the island.

Benefits of a PREPA-run rooftop solar program

As described in the March 2021 modeling studies, we propose a model in which PREPA owns and manages the process of installing small-scale residential rooftop solar and storage systems, with contracted assistance from local rooftop solar installers. Specifically, we propose standardized systems providing 2.5-3.5 kW of solar and 11-15 kWh of storage, depending on available technologies.[7] We

[3] PREPA's Tranche 1 RFP was for 1,000 MW of renewable energy capacity and at least 500 MW of energy storage capacity, including at least 150 MW of distributed renewable energy virtual power plants.
[4] This includes $1.9 billion of CDBG-DR funds for Electrical System Enhancements, as well as $300 million in CDBG-DR funds for community energy and water resilience installations and another $500 million in CDBG-MIT funds for community energy and water resilience installations.
[5] Letter from FEMA to Senator Chuck Schumer, February 8, 2021.
[6] See: Arizona Public Service's Solar Partners and Solar Communities programs, Tucson Electric Power's Residential Solar Program, Sacramento Municipal Utility District's Solar Pioneers I program, and Los Angeles Department of Water And Power's Solar Rooftops Program.
[7] We envision this as a standardized system for homes. For public housing and apartment complexes, systems would likely need to be designed to utilize covered parking areas, as well as roof space. We present a range of possible sizes to allow for flexibility in obtaining the best price per panel and per battery.

estimate that such a system would be able to provide for critical household needs in the event of a prolonged grid emergency.[8]

The deployment of such systems by PREPA would prioritize low-income, mid-income and rural customers and would occur in parallel with the continued private adoption of solar solutions by (typically higher income) households. We are also interested in ensuring upper income households install rooftop solar and storage as the objective is to reach 1,000,000 homes by 2035; however, we anticipate that many will likely already have installed solar before the program reaches upper-income households, or would be interested in using private funds to install additional solar and storage beyond the small-scale systems that PREPA would offer. But the program would still be available for those interested.

The widespread deployment of such systems by PREPA has the potential to provide many benefits relative to relying exclusively on residential solar and storage adoption via private third parties:

- PREPA would be able to prioritize outreach to households most in need of the resiliency benefits of rooftop solar and storage, including low-income households and/or those that waited the longest for their service to be restored after Hurricane Maria.[9]
- Low-income households would be able to participate in the resiliency benefits of rooftop solar and storage. As stated previously, 44% of Puerto Rican households fall below the federal poverty line. Such households are highly unlikely to be able to afford the upfront costs or financing costs for solar and storage systems.
- PREPA would be able to engage and employ thousands of former electrical system workers displaced by the LUMA Energy contract, many of whom have years of experience working on Puerto Rico's distribution system. For the Commonwealth as a whole, this would be revenue neutral, given that these employees are currently performing unrelated jobs within the Puerto Rican government. The work of PREPA employees would complement installation work to be performed by the private solar industry.
- PREPA would be able to take advantage of economies of scale from bulk purchasing the components of residential solar and storage systems, lowering overall costs and making most effective use of federal funds. The Sacramento Municipal Utility District deployed a bulk purchase model for the procurement of standardized solar systems that, despite being much smaller than the proposal envisioned here, was very effective in rapidly lowering costs.[10]
- In contrast to relying on the private market to deliver rooftop solar and storage, PREPA would be able to target deployment along specific feeders. As demonstrated by the comprehensive

[8] Irizarry-Rivera et al., A Case Study of Residential Electric Service Resiliency thru Renewable Energy Following Hurricane Maria. 2018.

[9] Marcel Castro-Sitiriche, Yonatan Cintrón-Sotomayor, Jonathan Gómez-Torres, The Longest Power Blackout in History and Energy Poverty, University of Puerto Rico – Mayaguez.

[10] SMUD conducted solicitations for between 0.5 and 1 MW of solar systems each year from 1993 to 1998. This produced cost declines of nearly 11% per year in installed costs and by 1999 SMUD reported that its installed cost of solar was about half that of residential installations elsewhere in California. (https://eta-publications.lbl.gov/sites/default/files/case-study-bulk-purchases.pdf)

distribution system modeling released by CAMBIO in March 2021, this approach results in a lower level of distribution system upgrades required.

In the next section, we discuss in more detail how such a program could be implemented in Puerto Rico.

Implementation of a utility-run rooftop solar program in Puerto Rico

The following table presents an estimate of the number of households that could be reached via a utility-run rooftop solar and storage program using a portion of available federal funds:

	$9.6 billion FEMA funds[11]
Size of residential solar/storage system	2.5-3.5 kW (AC) PV and 11-15 kWh storage
Total of number systems installed	940,000
Length of program (years)	10
Average[12] number of residential systems installed per year	94,000
Annual distributed solar generation by end of program	4,541 GWh
% of 2021 annual electricity consumption	28%
Estimated cost of distribution system upgrades to integrate systems	$530 million

Table 1. Estimated penetration of rooftop solar and storage a portion of federal funding funding

We further note that this proposal does not preclude community organizations or municipalities from accessing federal funds for local microgrid or distributed energy resiliency projects. The amount of FEMA funding proposed in the above table is based on the results of the March 2021 modeling studies and does not represent Puerto Rico's full allocation of FEMA funds for the electrical system. Similarly, there are also additional CDBG-DR and CDBG-MIT funds that could be available for community energy resiliency projects.

Table 2 presents a hypothetical scale-up of annual solar installations using the $9.6 billion in FEMA funds, recognizing that the average number of residential solar installations presented in the above table significantly exceeds current installation levels in Puerto Rico. Table 2 also presents an estimate

[11] In the March 2021 study, it was assumed that $9.6 billion would be used to buy down the total cost of residential systems, commercial PV systems and distribution system upgrades. While this does not cover the total capital cost of reaching 75% distributed energy resources by 2035, it was assumed that PREPA would finance the remainder through rates. In this report, we specifically propose that $9.6 billion be used for residential systems and distribution system upgrades.

[12] We assume the program would scale up, not initially start at this level, as presented in Table 2.

of direct jobs that would be involved in these installations.[13] Currently the private solar industry is installing over 1,000 systems per month, [14] implying that this proposal could create over 3,300 jobs in installation alone (and not including engineering, supervisory, administrative or maintenance positions).

Program Year	Number of residential systems installed	Average installations per month	Direct installation jobs
1	17,000	1,417	510 - 680
2	43,000	3,583	1,290 - 1,720
3	68,000	5,667	2,040 - 2,720
4	85,000	7,083	2,550 - 3,400
5	102,000	8,500	3,060 - 4,080
6	119,000	9,917	3,570 - 4,760
7	119,000	9,917	3,570 - 4,760
8	128,000	10,667	3,840 - 5,120
9	128,000	10,667	3,840 - 5,120
10	128,000	10,667	3,840 - 5,120

Table 2. Hypothetical scaling of residential renewable energy installations to reach targeted installations presented in Table 1.

For a PREPA-run residential distributed solar and storage program, we recommend the following design elements:

- An annual RFP issued by PREPA to purchase solar panels, batteries, inverters, racking systems and other ancillary equipment for standardized (2.5-3.5 kW solar, 11-15 kWh storage) residential rooftop systems. This RFP could be supplied by one or more bulk purchases, which, based on the above SMUD example and other bulk purchase models[15], should result in significant cost savings. See Appendix 1 for a sample term sheet for a RFP for equipment purchase.
- A targeted plan of installation that prioritizes low-income households and remote feeders that waited the longest for service restoration after Hurricane Maria.
- A standard offer for qualified installers, in which any installer that meets certain criteria (certifications, labor standards, etc) is able to participate in the installations. Currently solar installers in Puerto Rico are installing more than 1,000 grid-connected PV solar systems monthly, compared to the approximately 1,400 – 10,700 installations per month presented in Table 2, above. At least in the initial years of the program, PREPA will need to supplement the work of qualified installers with its own trained employees. This could provide PREPA

[13] This assumes 3- or 4-person crews that complete two installations per week (Source: Personal communication with Saúl González, Secretary, ACONER, November 26, 2021).

[14] LUMA Energy. Moción para presentar informe de progreso de interconexión, presentación a utilizarse en la vista del 16 de agosto de 2021 y plan o estrategia para atender el backlog. Puerto Rico Energy Bureau Case NEPR-MI-2019-0016. August 13, 2021. p. 15.

[15] Including a recent residential solar and battery storage bulk purchase project in the University Gardens neighborhood of San Juan.

with an opportunity to engage skilled ex-employees whose have been transferred to other Commonwealth government positions where their talents are not being utilized.[16] See Appendix 2 for a sample term sheet for contracts with qualified installers.

- An education program, in which all installers are required to educate residents so that they can better understand and manage their energy use, as well as understand how best to utilize a small-scale residential PV system to cover their critical loads and maximize household resiliency.
- Flexibility in the installation of systems, to allow for the possibility of roofs that cannot support a permanent steel-mounted structure to withstand hurricane-force winds. For such roofs, there should be other options, such as ground-mount systems, or a pivoting awning structure attached to a side of the house that could be lowered in parallel to the wall during the passage of a severe weather event, or the alternative of lighter racking systems that allow for easy dismount in the occurrence of a major storm event.
- A quality control program for participating contractors, in which PREPA checks the installation of a certain number of systems installed by each participating contractor each year. Installers that consistently fail to meet the program's design standards should be removed from the program.
- A standard offer for qualified contractors to perform maintenance on installed systems. Similar to the installations themselves, PREPA should retain qualified contractors to perform routine maintenance on installed systems, as well as respond to customer complaints regarding the functioning of their systems.
- The establishment of a dedicated trust for funding future replacements of batteries and other system components installed under this program, which may need to start being replaced within 10 to 15 years. The fund could be seeded by requiring program participants to deposit in the trust fund 0-20% of the cost of a residential installation (depending on income), which would also increase homeowner buy-in and participation in the program. The fund could also receive additional Commonwealth or federal support and could be used to help seed the development of recycling programs for batteries and solar panels.

Legal considerations

The design of a large-scale utility-run rooftop solar and storage program raises several legal questions, including: (1) What is the legal structure for PREPA to access clients' roofs for installation? And (2) How should electric rates be set for participating customers?

Regarding access to customers' roofs, a June 2021 legal study commissioned by CAMBIO explains how existing Puerto Rico law and regulations would allow PREPA to own and install rooftop systems using utility easements (as distinct from the leasing arrangements that are common in the continental

[16] Telemundo PR. Confirman que hay empleados de AEE sin funciones asignadas en nuevas agencias. August 30, 2021.

United States).[17] Such easements would be tied to the property and would not be terminated when ownership of the property changes hands.

Regarding rates, utility-run rooftop solar programs in the United States showcase several different examples of rate design for customers participating in the program. Often customers are billed for power at their normal rate and offered a financial incentive at some level for participating in the program.[18] In Puerto Rico, customers would be highly incentivized to participate in a utility-owned rooftop solar program because of the prospect of having access to a resilient power system that would continue to provide them power for essential needs during an emergency, and the prospect of overall stable and lower rates. As discussed in the March 2021 Queremos Sol study, the average rate (averaged across all customer classes) would be on the order of 20 cents/kWh even without any federal money involved, and would be as low as 15 cents/kWh with $9.6 billion in federal funds deployed. For comparison, current residential rates are above 23 cents/kWh, and likely to rise further due to increasing fossil fuel prices. Clearly one of the key benefits of the Queremos Sol scenario of 75% distributed energy by 2035 is a dramatic reduction in rate volatility due to fuel price fluctuations.

Conclusions

Puerto Rico has a historic opportunity with the influx of federal funds for the island's electrical system to reconstruct a decentralized system that would result in lower rates and higher resiliency for residents. Comprehensive grid modeling has demonstrated the technical feasibility of transitioning to 75% distributed renewable energy by 2035, based on rooftop solar and storage.

In this report, we have laid out a roadmap for implementation of this proposal by the Puerto Rico Electric Power Authority, taking advantage of federal funds by designing a program in which PREPA would manage the installation and ownership of systems on customer roofs. Such a program offers many advantages over the island's current approach, which is to leave distributed renewable energy development entirely to the private market. A PREPA-run rooftop solar and storage program would spur solar workforce development, allow the re-hiring of thousands of displaced PREPA workers, dramatically reduce costs through bulk purchase of equipment, all while ensuring that low-income households are not left out of the transition to a resilient and modern electrical system.

[17] See Annex I to IEEFA and CAMBIO's Comments in Response to June 23rd Technical Workshop, Puerto Rico Energy Bureau Case No. NEPR-MI-2020-0016, July 12, 2021.

[18] For example, in Arizona Public Service's Solar Communities program, participating customers continue to pay for their electricity at the residential rate (approximately 12 cents/kWh) but are credited $360 per year for the use of their roof for a solar system for twenty years. The Los Angeles Department of Water and Power's program is similarly structured with customers continuing to pay for their electricity at the residential rate and receiving a credit of $240 to $600 per year for the lease of their roof to LADWP, with the credit depending on the size of the system.

APPENDIX: DRAFT TERM SHEETS

Equipment procurement[19]

Parties:	Between PREPA and supplier(s) of solar panels, batteries, inverters, charge controllers and mounting and electrical equipment
Project:	PREPA seeks to contract for the bulk purchase and delivery of rooftop solar and storage equipment for FY 2022 to install 17,000 residential solar and storage systems, each sized at 2.5-3.5 kW (DC) and 11-15 kWh storage.
Quantity:	46 MW PV panels (sized to construct systems of 2.5-3.5)
	1,070 MWh (AC) of 4-hour battery storage, sized to construct 11-15 kWh battery banks
	Mounting equipment, inverters, charge controllers, remote monitoring systems, backup subpanels, wiring and ancillary equipment for 17,000 rooftop installations that complies with Puerto Rico building code 2018.[20]
Warranty:	PV modules must have at least a 25-year power warranty with at least 80% of nameplate rated power at STC by year 25;
	PV modules must have a product warranty of at least 10 years;
	Inverters must have a product warranty of at least 10 years;
	Batteries must have a product warranty of at least 10 years;
	Mounting systems must be warranted free of defects for at least 5 years
Payment:	Payment to be made upon delivery and quality control completion

Installation contract

Parties:	Contract to be entered into by PREPA, system operator and qualified installer
Project:	PREPA seeks to install 17,000[21] standardized residential rooftop solar and storage systems, each sized at 2.5-3.5 kW (DC) with 11-15 kWh battery storage.

[19] Example presented for first year of program, according to Table 2.
[20] PREPA would need to undertake a survey of a sample of residential roofs to better understand what fraction of roofs can support steel-mounted structures and which would require removable mounting systems, as referenced at p. 4 above.
[21] For the first year of the program. See Table 2 above.

Scope and size: Bids will be accepted to install between 50 and 6,000 systems in one year. The remainder of installation work that is not contracted to installers will be performed by PREPA.

Term: 1 year (with additional year of installation warranty)

PREPA responsibilities: PREPA will procure the components to be installed on customer roofs.

PREPA will own the systems installed on clients' roofs and shall be responsible for signing agreements with clients for use of their roofs. PREPA will be responsible for maintenance of these systems.

PREPA will be responsible for quality control.

System operator responsibilities:

System operator will be responsible for all interconnection studies and distribution system upgrades required to achieve the planned level of rooftop solar deployment.

System operator will be responsible for marketing the opportunity to customers and for signing up those customers who are interested in having a system installed on their roof.

System operator will be responsible for screening roofs for suitability for rooftop solar (based on shading and structural integrity) and providing a final list of customers to each participating installer.

System operator will be responsible for payments to installers within 30 days of receipt of an invoice.

Installer responsibilities:

Installer will be responsible for installation of standardized systems on the roofs of participating customers.

Installer will be responsible for education of homeowner on the functioning of their system, including routine maintenance to be performed by customer, and managing the process for soliciting interconnection and net metering. On homes where the roof condition precludes steel-mounted systems, homeowners will be trained on how to remove or lower their system during the passage of a severe storm.

Installer will provide a 1-year workmanship warranty for all installations.

Installer shall abide by the law and all applicable ethical business guidelines set forth by the Council of Better Business Bureaus (BBB), Federal Trade Commission (FTC), Consumer Financial Protection Bureau (CFPB), and Puerto Rico Energy Bureau (PREB).

Required credentials:	Installer shall be a Puerto Rico Certified Installer (according to Regulation 7796) in good standing with the Commonwealth Energy Public Policy Office and with at least 1 years' experience conducting solar installation work in Puerto Rico and with an annual volume of installations at least 50% of the level specified in its bid.
Insurance:	Installer must be insured to at least the following levels: General liability: $1,000,000 per occurrence, $2,000,000 in aggregate Worker's compensation insurance as required by Commonwealth law Automobile liability – bodily injury, death and property damage combined single limits of at least $1,000,000 per occurrence covering vehicles owned, hired or non-owned
Standards:	Installations shall be performed in accordance with all manufacturers' installation manuals, applicable laws, codes and interconnection requirements.
Quality control:	PREPA will perform quality control inspections, according to standards to be specified in the final contract, on 5%-10% of installer's jobs. Failure of installer to pass quality control inspection shall disqualify installer from participation in future rooftop solar installation RFPs. In addition, installer shall bear the cost of repairing/replacing all work found to be defective.
Payment terms:	Installer shall be paid monthly, based on the number of systems installed in that month, and no later than 30 days after system operator's receipt of invoice.
Delay:	Except in the case of a force majeure event, installer is expected to meet the installation schedule specified in its contract. In the event of delay that is not attributable to actions of PREPA or system operator or a force majeure event, liquidated damages shall be paid by installer to PREPA.
Force Majeure:	No party is liable for losses, defaults or damages that result from delays or inability to complete the obligations of the contract due to hurricanes, floods, earthquakes, terrorism, or other causes beyond the reasonable control of any party.

About CAMBIO

CAMBIO, a not-for-profit organization based in San Juan, Puerto Rico, has emerged during the past five years as a leading voice in the island's journey towards a sustainable, just and resilient future. CAMBIO develops collaborative processes in which ideas and goals are defined and translated into achievable policy, plans and actionable proposals. The organization's work fills a gap between advocacy and the design of viable and sustainable strategies. By actively participating in the implementation of the strategies and actions defined and proposed it serves as an "actionable think tank".