Expert Report of Agustín Irizarry-Rivera

PROMESA Title III - No. 17 BK 3283-LTS and

PROMESA Title III - No. 17 BK 4780-LTS

United States District Court for the District of Puerto Rico

Submitted December 11, 2023

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I. Introduction

The following organizations: Comité Diálogo Ambiental, Inc., El Puente de Williamsburg, Inc.- Enlace de Acción Climática, Comité Yabucoeño Pro-Calidad de Vida, Inc., Alianza Comunitaria Ambientalista del Sureste, Inc., Sierra Club Inc. and its Puerto Rico Chapter, Mayagüezanos por la Salud y el Ambiente, Inc., Coalición de Organizaciones Anti Incineración, Inc., and Amigos del Río Guaynabo, Inc., have asked that I review the Fifth Modified Third Amended Title III Plan of Adjustment of the Debt ("PAD") submitted by the Financial Oversight and Management Board (FOMB) for the Puerto Rico Electric Power Authority (PREPA).[1] I previously submitted testimony to this Court regarding FOMB's Second Amended Plan of Adjustment.

I have been asked to assess the effect of the proposed PAD on Puerto Rico's public policy that promotes the rapid adoption of distributed renewable energy, a resilient electricity supply for the people of Puerto Rico, and energy justice.

The proposed PAD contradicts this public policy and would hamper the achievement of Puerto Rico's energy independence, energy affordability and energy resilience goals. In Puerto Rico distributed renewables are growing while utility scale renewables are not. The proposed PAD fails to analyze the publicly available data that shows this and seems not to incorporate this data.

[1] Corrected Fifth Modified Third Amended Title III Plan of Adjustment of the Puerto Rico Electric Power Authority, dated November 16, 2023.

The fixed component of the proposed “legacy charge” is designed to tax the adoption of residential solar energy and it penalizes net metering adoption of solar photovoltaic rooftop generation.

The proposed PAD is based on flawed assumptions on the current rate of adoption of distributed renewable generation, specifically residential rooftop solar photovoltaic systems including energy storage (batteries), resulting in overestimating future energy sales and rendering the proposed PAD unable to repay the uninsured debt it seeks to pay.

My analysis shows that the current Levelized Cost of Energy (LCOE) of residential rooftop solar photovoltaic systems, including batteries, is already less than the cost of electricity from the electric grid. These distributed energy systems are currently competitive with the electric grid in cost and superior in terms of reliability and resiliency. Lack of resiliency and reliability from the electricity supplied by the electric grid further drives the adoption of rooftop solar PV systems and is not included in the LCOE calculation.

In short, the proposed PAD fails to recognize the rapid technological change and current accelerated adoption of distributed renewable energy. The proposed legacy charge will increase the cost of electricity from the electric grid, but will not increase the reliability of this service, thus accelerating the adoption of distributed renewables and probably increasing grid defection, or partial grid defection. This will result in reduced energy sales and render the proposed PAD useless since to increase revenues further increases in the legacy charge will be needed, creating a vicious cycle.

Finally, and for completeness, I include results from a case study in residential electric resiliency through rooftop solar photovoltaic generation plus batteries.

My conclusions are:

Conclusion 1 – The proposed PAD fails to analyze the current rate of adoption of distributed energy.

Conclusion 2 – Renewable energy adoption policy would be harmed by taxing the only renewable energy sector growing for the sake of paying an uninsured debt.

Conclusion 3 – Bondholders are experiencing a technological change they did not foresee. Failure to foresee technological change while investing is not cause to change the bonds guarantee whether the bondholders' claims are secured or not. Nor is it cause to tax the new technology as the proposed PAD does.

Conclusion 4 – The proposed "legacy charge" is designed to tax the adoption of residential solar energy and discourage adoption of solar photovoltaic rooftop generation.

Conclusion 5 – The LCOE of residential rooftop solar photovoltaic systems, including batteries and using equipment of good warranty and LiFePO4 batteries, will cost less than the cost of electricity from the grid after applying the proposed legacy charge.

Conclusion 6 - Contrary to what is assumed in the Legacy Charge Derivation (Supplemental Exhibit I) of the proposed PAD, significant grid defection could become a reality in Puerto Rico if the proposed legacy charge is implemented, thus rendering the proposed PAD useless.

Conclusion 7 – Rooftop solar photovoltaic systems with batteries are currently less costly than unreliable electricity from the electric grid. This lack of reliability from the electricity supplied by the electric grid will further drive the adoption of rooftop solar PV systems with storage.

Conclusion 8 - The proposed legacy charge will increase the cost of electricity from the electric grid, but will not increase the reliability of this service, thus accelerating the adoption of distributed renewables and probably increasing both full and partial grid defection.

Conclusion 9 - Residents of Puerto Rico require a cost effective and resilient alternative to generate electricity and the proposed PAD is an obstacle to achieve this much needed goal.

A description of my qualifications and compensation is available in Section XIII of this Report.

II. Energy Burden

The proposed Debt Adjustment Plan (PAD) is based on a Legacy Charge that in turn is derived, or predicated, on the existence of a “revenue envelope”. This “revenue envelope” is defined in Exhibit I Legacy Charge Derivation (page 3) “The Oversight Board derived the Legacy Charge in light of the Oversight Board’s goal of ensuring that PREPA’s rates are sustainable in the long term and affordable for PREPA’s customers. Consistent with this, any increase in PREPA’s rates, including the Legacy Charge, cannot exceed the conceptual upper bound of affordability: the total bill that PREPA customers can pay without (1) subjecting PREPA customers to undue hardship (i.e., making rates unaffordable to those customers); (2) threatening the sustainability of PREPA as a functioning utility; and/or (3) threatening the sustainability of the Puerto Rico economy. **The Oversight Board has calculated the difference between the revenues from PREPA’s rates in its current Fiscal Plan and the revenues from the notional maximum PREPA’s rates could become without undermining these goals as the “Revenue Envelope**.” (emphasis from the author of this report).

Thus, the FOMB accepts there is an upper bound on energy cost, a certain threshold above which electricity is no longer affordable. And then proposes a legacy charge that squeezes every cent within that revenue envelope and pushes most median income citizens of Puerto Rico to the boundary of energy poverty. How much is this? Exhibit I Legacy Charge Derivation states:

“The maximum charges under the Revenue Envelope calculation were therefore set so that the resulting electric bill would be affordable, in the first year of implementation, for non-exempt households with an assumed annual income of $24,429, monthly volumetric consumption of 425 kWh, and using the rates in the Fiscal Plan as the baseline. Affordability is defined as a maximum total electricity bill not to exceed 6% of total income for such customers, or a 6% “wallet share,” as calculated on the first year of implementation.

A 6% energy burden threshold has been used as an indicator of the presence of "energy poverty" (i.e., households that spend more than 6% of their household income on energy may face hardships in paying for other necessities) and as a baseline for the provision of financial support for such households to pay their energy bills in several mainland U.S. States. Further, the 6% wallet share is generally applied to low-income rather than median-income customers in other jurisdictions in the U.S., with the assumption that customers with income higher than that of low-income customers would not spend 6% of their income on home energy. Indeed, median-income households on the mainland pay 3.3% of their incomes on all home energy including electricity as well as heating and cooking fuels. Therefore, the Oversight Board considers it likely that this 6% wallet share constitutes the very upper limit of affordability."

Thus a 6% "wallet share" on energy expenditure, which in Puerto Rico includes electricity and gas (propane gas distributed in metal cylinders is used extensively in Puerto Rico for cooking) is the maximum energy burden prescribed for Puerto Rico by the FOMB. This despite accepting that, for median income households, in the US the energy burden is half of this value. A value greater than 6% is considered to create "energy poverty". But does the proposed plan considers the current energy burden in Puerto Rico? It does not. And it does not despite being readily and publicly available.

Figure 1 shows the energy burden for Puerto Rico, electricity, gas and total, as compared to the US (all 50 states and the District of Columbia) vs. the area median income. The author created the graph using the Low-Income Energy Affordability Data (LEAD) Tool from NREL.

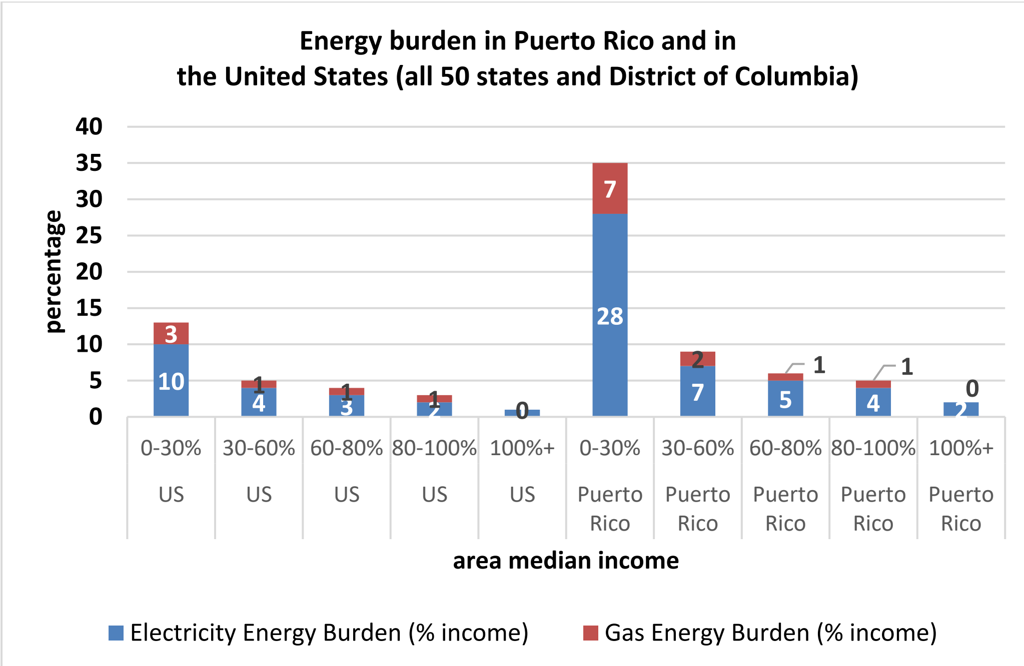

Figure 1. Energy burden for Puerto Rico, electricity, gas and total, as compared to the US (all 50 states and the District of Columbia) vs. area median income. (Source: prepared by the author of this report using the LEAD tool).

The Low-Income Energy Affordability Data (LEAD) Tool[2] is available to the general public from the National Renewable Energy Laboratory (NREL).[3]:

Figure 1 shows that every family in Puerto Rico with 0 to 80% of median income is already energy poor as their "share of wallet" expense of electricity and gas is at or above 6%. It also shows that families with 80 to 100% of median income have an energy burden of 5%,

[2] NREL https://www.energy.gov/scep/slsc/lead-tool.

[3] What is this tool? From the LEAD Factsheet: "The Low-income Energy Affordability Data (LEAD) Tool is an online, interactive platform that allows users to build their own national, state, county, city, or census tract profiles. LEAD provides estimated low-income household energy data based on income, energy expenditures, fuel type, and housing type. Users can create and save their own profile and make side-by-side comparisons with other geographies. Users can also download visuals and data associated with the following geographies, housing, and energy characteristics." https://lead.openei.org/docs/LEAD-Factsheet.pdf.

almost twice the energy burden of the same group in the United States. Perhaps families with median income up to 80% will be exempt of the fixed charge and the first block of the volumetric charge. But if they need more than 500 kWh per month their energy burden will increase. It is likely that those with median income between 80% and 100% will suffer the additional energy burden caused by the full proposed legacy charge.

Furthermore, it is important to note that the legacy charge is designed to be affordable "in the first year" of such charge:

"The maximum charges under the Revenue Envelope calculation were therefore set so that the resulting electric bill would be affordable, **in the first year of implementation**, for non-exempt households with an assumed annual income of $24,429, monthly volumetric consumption of 425 kWh, and using the rates in the Fiscal Plan as the baseline. …" (**emphasis** provided by the author of this report).

What happens in the following years? Exhibit I is silent about the energy burden consequences for the years after year 1.

Figure 2 shows energy burden, as percentage of income, per US Census track regions in Puerto Rico. The map is also available using the LEAD tool. From the data used to develop the map we determine that there are 508,629 households in Puerto Rico (42.2% of households) with energy burden of 5% and above.

Energy burden (% of income) per US Census track areas in Puerto Rico

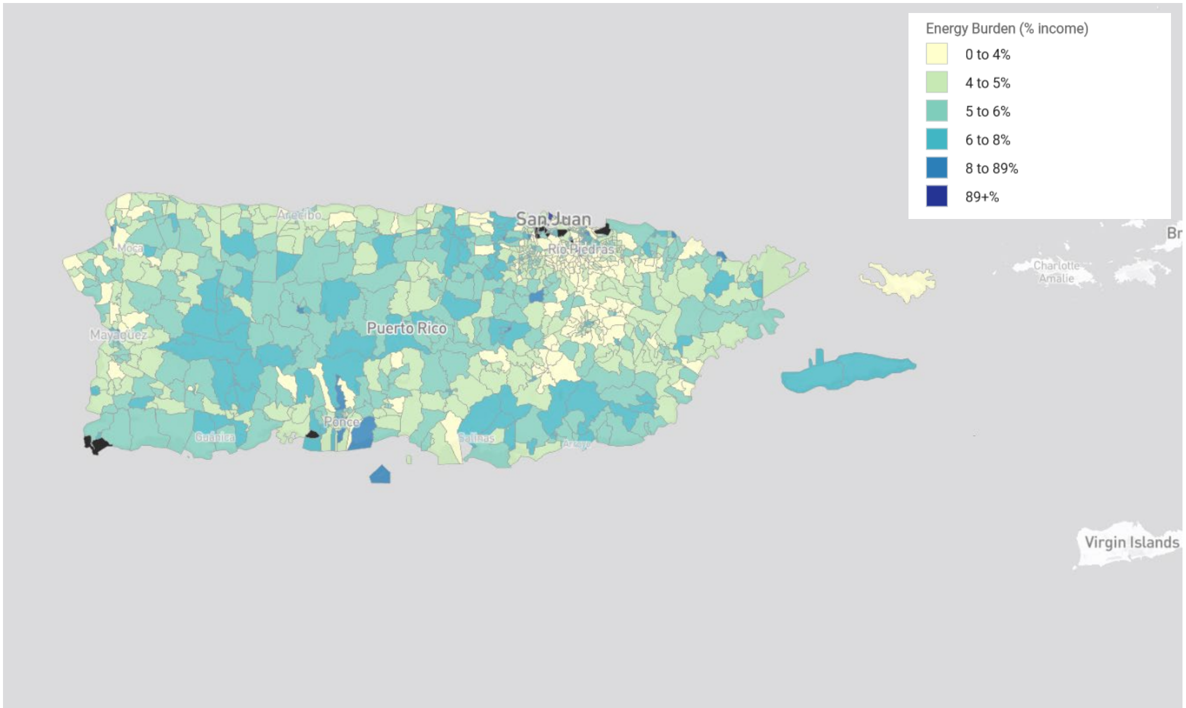

Figure 2: Energy burden (% of income) per US Census track areas in Puerto Rico. (Source: LEAD tool).

The "revenue envelope" is already zero and the proposed legacy charge will increase energy poverty in Puerto Rico.

Furthermore, the proposed legacy charge is based on clearly false assumptions as it assumes that all household energy needs are met with electricity[4]. Figure 1 clearly shows this is not the case. For residential clients with 0-30% of median income the cost of propane alone represents an energy burden of 7%.

[4] Footnote 5, on page 4 of Exhibit I Legacy Charge Derivation, reads: "This analysis assumes that all household energy needs are met with electricity. To the extent other energy sources (e.g., gas) are utilized, the 6% wallet share would apply to the total cost of all energy bills. To be clear, the Oversight Board does not think that a 6% wallet share is a sustainable place for the total electricity bills to be but it instead represents the upper boundaries before "energy poverty.""

The legacy charge is based on false assumptions and should be rejected.

It is also important to notice that the legacy charge proposed in this third PAD version is of greater impact to commercial clients than it is to residential clients. This contradicts the FOMB purpose of activating Puerto Rico's economy. It also has a secondary effect on residential clients thru the cost increase of goods and services provided by the commercial clients to residential clients since commercial clients are likely to increase their prices to pay for the legacy charge.

III. Current rate of adoption of net metering solar rooftop photovoltaic systems and batteries in Puerto Rico vs utility scale projects

The Puerto Rico Energy Bureau (PREB) has a public docket named "Performance of the Puerto Rico Electric Power Authority" (docket number NEPR-MI-2019-0007),[5] where LUMA Energy is required to report a number of metrics, including data on the incremental installed distributed generation systems capacity. This refers to the number of clients with solar photovoltaic systems (mostly rooftop systems) and wind turbines that register for net metering. If the client does not register into the net metering program the installation will not appear in this statistic.

[5] The docket is available at https://energia.pr.gov/wp-content/uploads/sites/7/2023/10/Resumen-Metricas-Master_October2023.xlsx

Figure 3 shows total number of net metering clients with solar photovoltaic generation (bars) and the total generation capacity of these systems in MW.

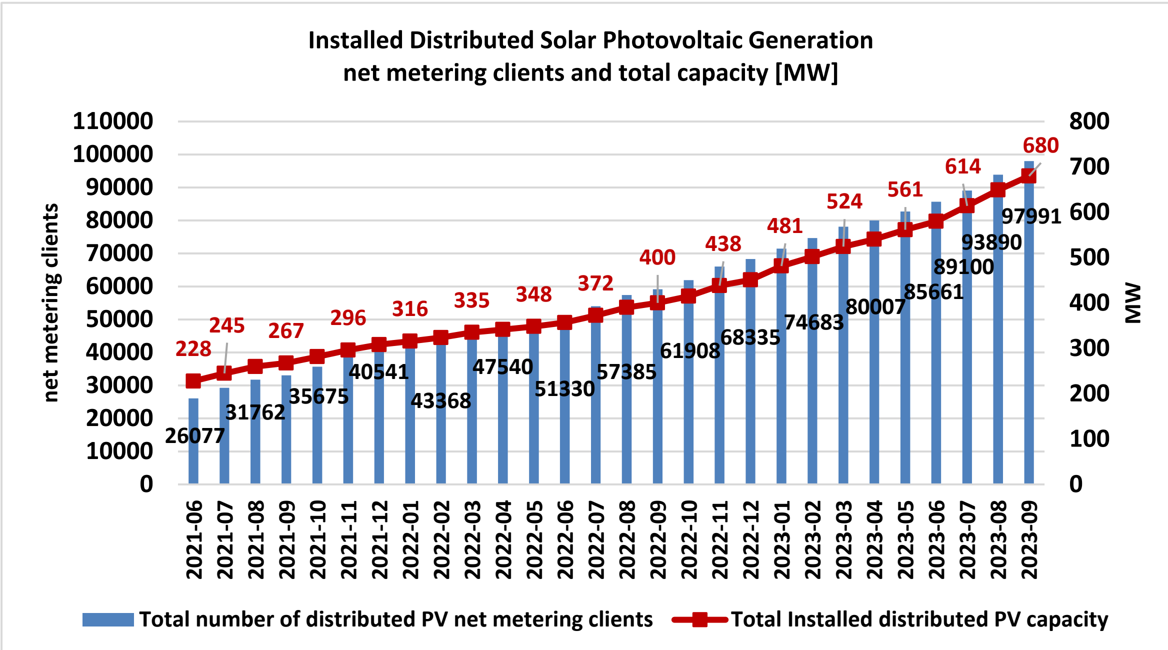

Figure 3. Incremental installed distributed solar photovoltaic generation (registered for net metering) clients and total generation capacity in MW as reported by LUMA to PREB.

Figure 1. shows the increase in solar photovoltaic generation, registered for net metering, since LUMA Energy assumed control of the operation of transmission and distribution. Note that on June 1st 2021, LUMA reported 26,077 registered net metering solar PV systems. As of October 1st 30, 2023, 28 months later, LUMA is reporting 97,991 registered net metering clients. In 28 months, the number of net metering clients has increased almost fourfold. The trend mentioned in my testimony that **the number of net metering clients is doubling every 15 months continues**. The FOMB's Legacy Charge Derivation fails to incorporate this trend.

The incremental installed capacity shows a similar trend, one that FOMB's PAD fails to acknowledge. On June 1st 2021, LUMA reported 228 MW of installed net metering solar PV capacity. As of October 1st, 2023, 28 months later, LUMA is reporting 680 MW of installed net metering solar PV capacity. In 28 months, the installed net metering solar PV capacity has nearly tripled. Further notice that the trend mentioned in the previous version of this report that **the installed capacity of net metering solar PV systems is doubling every year and a half (doubling every 18) continues**. The average fossil fuel generation capacity in use during FY 2022 was about 2000 MW.[6] Thus the 680 MW of distributed generation capacity, installed by the citizens of Puerto Rico in about two and a half years are significant.

Distributed electric energy storage since LUMA started operation is summarized in Figure 4.

[6] In FY 2022 sales of electricity were about 18,000,000 kWh.

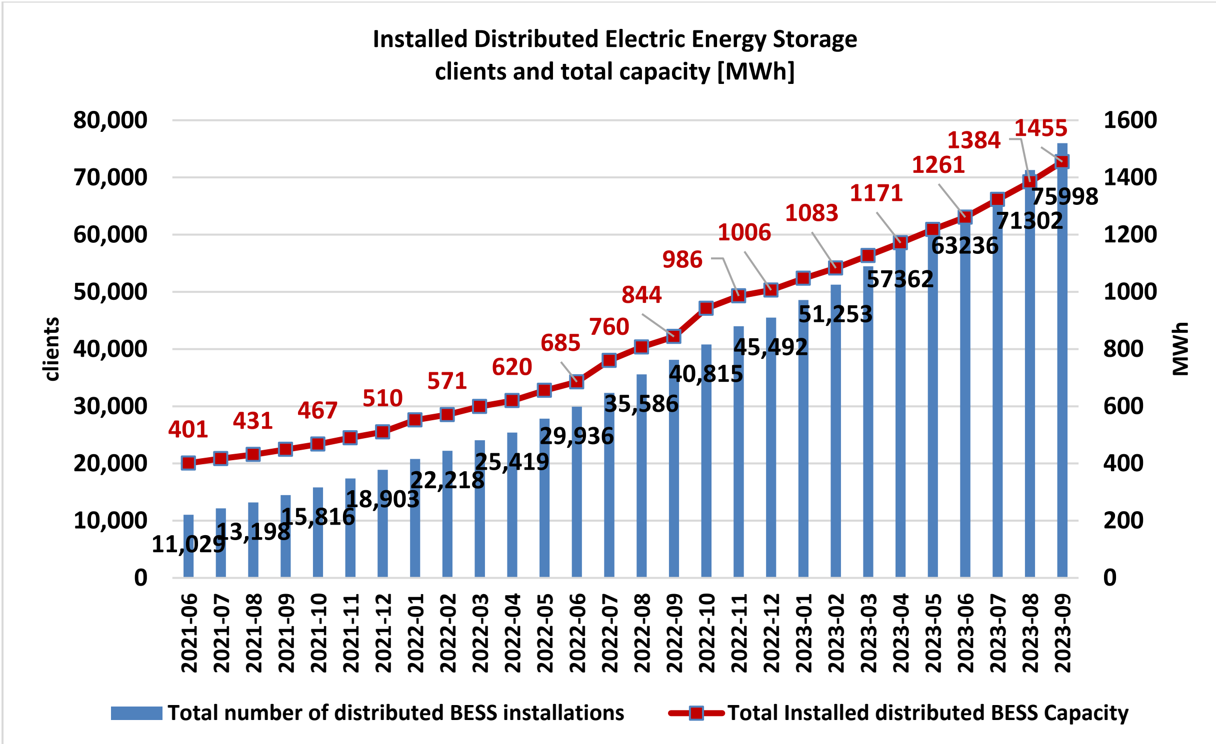

Figure 4. Incremental installed distributed energy storage, in MWh, and corresponding net metering clients as reported by LUMA to PREB.

On June 1st 2021, LUMA reported 401 MWh of installed distributed electric storage. On October 2023, 28 months later, LUMA reported 1454 MWh of installed distributed electric storage. **As seen in Figure 2 during July 2022 the amount of storage was about half 1454 MWh, thus the storage capacity is doubling every 15 months.**

Thus, the installed generation capacity of net metering solar PV systems is doubling every year and a half and the installed distributed electric storage corresponding to these net metering clients is doubling every 15 months.

It is important to note that citizens that install solar PV systems with batteries to serve a portion of their home, disconnecting that portion of the electric load from the grid, do not apply for net metering and therefore are not part of the previous statistics. These statistics undercount the total number of Puerto Ricans adopting rooftop solar and storage. Researchers at Universidad de Puerto Rico Mayagüez are studying this "partial grid defection" that results in demand reduction from the grid. Although demand reduction is attributable to a number of factors: energy efficiency, changing energy demand patterns and distributed solar photovoltaic generation among others, we have detected a demand reduction which is strongly correlated with the solar irradiance curve. Since the time frame of the demand reduction is short, our rolling window for the analysis is one year, we are exploring the following hypothesis: **we are seeing a reduction in demand due to accelerated adoption of distributed solar photovoltaic systems**. However, the net metering solar photovoltaic systems alone do not account to the magnitude of the reduction. We are currently refining our calculations, and studying newly available data, to estimate the non-net metering distributed solar photovoltaic generation. Our initial, and rough, estimate suggests there is one (1) additional PV system, not registered for net-metering PV system, per every three (3) net-metering system.

On March 30, 2023, the president of the Puerto Rico Energy Bureau, Edison Aviles, declared on a hearing of the Puerto Rico Senate Committee on Strategic Projects and Energy that all tranche 1 utility scale renewable energy projects (18 projects in total) are not under construction as planned due to "differences about the points of interconnection between LUMA and PREPA". On December 7, 2023, LUMA Energy filed a motion with the Energy Bureau, noting that the interconnections are still not resolved. LUMA explained that since project proponents would not pay the increased costs for interconnections, and therefore proposed that those costs be imposed on ratepayers – over and above the Legacy Charge costs proposed by FOMB. None of these projects can move forward until all interconnection problems are resolved.[7] Therefore, in Puerto Rico utility scale renewables are not growing while distributed renewables are growing at an accelerated pace.

Puerto Rico Act 17-2019, the Puerto Rico Energy Public Policy Act, indicates on its first paragraph that its purpose is "To create the "Puerto Rico Energy Public Policy Act" for the purposes of establishing the Puerto Rico public policy on energy in order to set the parameters for a resilient, reliable, and robust energy system with just and reasonable rates for all class of customers; make it feasible for energy system users to produce and participate in energy generation; facilitate the interconnection of distributed generation systems and microgrids, and unbundle and transform the electrical power system into an open system..." Through Law 17-2019 Section 1.6, the Puerto Rico legislature explained that Puerto Rico's energy policy required 40% renewable energy by 2025, 60% by 2040, and 100% by 2050, while keeping electricity prices below 20 cents per kWh. The Legislature also set policy goals of facilitating distributed generation "through any available mechanism", and to encourage use of energy storage. *Id*.

Is the proposed PAD aligned with Puerto Rico's renewable energy policy? No. The narrative provided in the "Legacy Charge Derivation" shows that the fixed charge of the proposed

[7] https://energia.pr.gov/wp-content/uploads/sites/7/2023/12/20231206-Informative-Motion-on-Execution-of-Tranche-1-Interconnection-Agreements-Request-for-Determination-Regarding-Interconnection-Costs-and-Request-for-Confidential-Treatment.pdf

legacy charge is meant to tax the adoption of distributed renewables, the only renewable sector growing in Puerto Rico.

The Legacy Charge Derivation explicitly states that the fixed charge component of the legacy charge is a sun tax. Quoting from Exhibit I, page 4, “A customer charge is a fixed monthly fee charged on each customer connected to the PREPA electricity grid, irrespective of the customer’s electricity consumption. Customer charges, compared to volumetric charges, are less impacted by the decreases in load as projected in the Fiscal Plan. The use of customer charges is increasingly being considered on the mainland U.S. as a response to increasing solar rooftop installations. In other words – customers can install rooftop solar to lower their energy burden from a volumetric charge – but not a fixed charge. The PAD uses a fixed charge to impose an energy burden on Puerto Ricans that they can only escape by leaving the archipelago or defecting from the grid.

Is the reality of growing distributed solar generation and distributed storage properly captured by the proposed PAD? No. The narrative provided in Exhibit I, “Legacy Charge Derivation”, is largely unchanged from the previous Exhibit P “Legacy Charge Derivation”. The proposed PAD uses PREPA’s Fiscal Plan 2023 (Exhibit C) which rely on US data to compute energy demand reduction due to adoption of solar PV systems.[8] The significant difference in rate of adoption of residential PV systems in the US and Puerto Rico has been

[8] Exhibit C PREPA’s 2023 Fiscal Plan page 126 (127/159 pdf count) “Distributed Generation (DG): The forecast was done using data collected by the Energy Information Administration (EIA) on residential rooftop systems in the US. The analysis then was made with a regression on the historical data between July 2014 and June 2021. It is important to note between the months of January 2022 to January 2023, there was an acceleration in the Distributed Generation deployment and Net Metering registration by customers all over Puerto Rico. This important deviation from historic trends had to be incorporated in the model, so it would incorporate the latest trends.”

evident since 2021, or even before, and yet this version of the proposed PAD insists that the accelerated adoption rate in Puerto Rico is a recent event. Since the method to "incorporate" data form Puerto Rico into US trends is not presented, discussed or explained in PREPA's 2023 Fiscal Plan it is difficult to assess how disconnected are the assumptions used to develop the proposed PAD from the technological reality of growing distributed solar photovoltaic plus batteries in Puerto Rico.

<u>Conclusion 1</u> – The proposed PAD fails to analyze the current rate of adoption of distributed energy.

<u>Conclusion 2</u> – Renewable energy adoption policy would be harmed by taxing the only renewable energy sector growing for the sake of paying an uninsured debt.

IV. Why the fast adoption? Current cost of solar PV and batteries in Puerto Rico and expected decline in cost

The narrative provided in Exhibit I "Legacy Charge Derivation" shows that the proposed PAD does not properly take into consideration the declining cost of solar photovoltaic plus batteries in Puerto Rico.

This despite explicitly accepting that, from page 2, "substitutes [to PREPA service] (such as photovoltaic panels and customer-premise battery storage and diesel generators) are available at economical prices."

Although Exhibit I no longer denies the possibility of grid defection (as did the previous Exhibit P) the analysis still does not include the actual costs, which are easily ascertainable. Nor it relies on public information on the current rate of interconnection of homes with solar panels and batteries, that could disconnect if prices rose too high.

In this section we use representative cost of solar PV systems with batteries in Puerto Rico and estimates of declining cost for this technology provided by the US Department of Energy to estimate the cost of disconnecting from the grid and to compare it with the estimated resulting cost of implementing the proposed PAD.

Table 1 shows representative real costs of ten (10) rooftop solar photovoltaic residential systems, with $LiFePO_4$ batteries and without batteries, installed in Puerto Rico (2021 cost).
[Table can be found in the following page].

Table 1. Representative real costs of rooftop solar photovoltaic residential systems, with LiFePO4 batteries, in Puerto Rico (2021)

	Total Cost	PV capacity kW	LiFePO4 storage kWh	$/W with storage	Total cost no storage	$/W no storage	LiFePO4 storage kW	Total cost LiFePO4 storage no PV
1	$40,529	5.60	28.8	$7.24	$26,337	$4.70	7.20	$35,319
2	$31,816	6.75	19.2	$4.71	$22,021	$3.26	4.80	$25,844
3	$28,000	6.08	15.0	$4.61	$20,129	$3.31	3.75	$22,472
4	$28,950	5.60	14.4	$5.17	$21,354	$3.81	3.60	$23,740
5	$24,900	3.96	19.2	$6.29	$15,105	$3.81	4.80	$20,777
6	$26,950	3.80	28.8	$7.09	$12,758	$3.36	7.20	$22,933
7	$27,328	6.40	19.2	$4.27	$17,533	$2.74	4.80	$21,588
8	$33,700	7.20	28.8	$4.68	$19,508	$2.71	7.20	$27,430
9	$31,076	7.20	15.0	$4.32	$23,205	$3.22	3.75	$24,806
10	$33,700	7.20	14.4	$4.68	$26,104	$3.63	3.60	$27,430
average	**$29,602**	**6.02**	**19.3**	**$4.92**	**$19,746**	**$3.28**	**4.83**	**$24,113**
minimum	$24,900	3.80	14.4	$4.27	$12,758	$2.71	3.60	$20,883
maximum	$40,529	7.20	28.8	$7.24	$26,337	$4.70	7.20	$34,259

These costs are real cost of installed systems in Puerto Rico as reported by University of Puerto Rico investigators[9] and currently being used in "The Puerto Rico 100 Study".[10]

Total cost includes: equipment (solar panels, inverter, charge controllers (if not included within the inverter), batteries), "balance of system" items (mounting racks, nuts and bolts, electrical tubing, wires, electric protection, electrical boxes) design, installation, retrofit (if needed) and profit.

PV capacity refers to the total installed generating capacity of the solar photovoltaic array, in thousands of Watts (kW).

Lithium-ion batteries (specifically LiFePO4) are used in every installation. The storage capacity is shown in Table 1 in kWh.

Total system cost for a system with no batteries, but ready to add batteries, is estimated by subtracting the actual cost of LiFePO4 batteries in Puerto Rico (2021, $458.06 per kWh) and installation cost for the batteries ($1,000).

[9] The data in the Total Cost and Total Cost - No Storage columns was obtained from reports submitted to the Puerto Rico Grid Resilience and Transitions to 100% Renewable Energy Study (PR100) by Members of the Puerto Rico Energy Recovery and Resilience Advisory Group. The figures in the rest of the columns were derived from that Total Cost data. The data submitted to the PR100 Study is attached as **Exhibit 1.**

[10] Puerto Rico Grid Resilience and Transitions to 100% Renewable Energy Study (PR100), - https://www.energy.gov/gdo/puerto-rico-grid-resilience-and-transitions-100-renewable-energy-study-pr100.

The storage package capacity, in kW, is calculated from the energy capacity, in kWh, dividing by 4 hours.[11]

Total storage package, including inverter cost, is estimated by subtracting: the actual cost of solar panels in Puerto Rico (2021, \$0.55/W), panels rack cost (\$180 per 4 panels, 400 W panels) and installation cost for the rooftop solar panels (\$1,500).

For the ten rooftop solar systems described in Table 1 above, I calculated a "dollar per installed W" (\$/W) index for both the system with batteries and the system without batteries for comparison. The average installed cost of a system without batteries is \$3.28/W. The average installed cost of a system with LiFePO4 batteries is \$4.92/W. Figure 5 summarizes this comparison graphically.

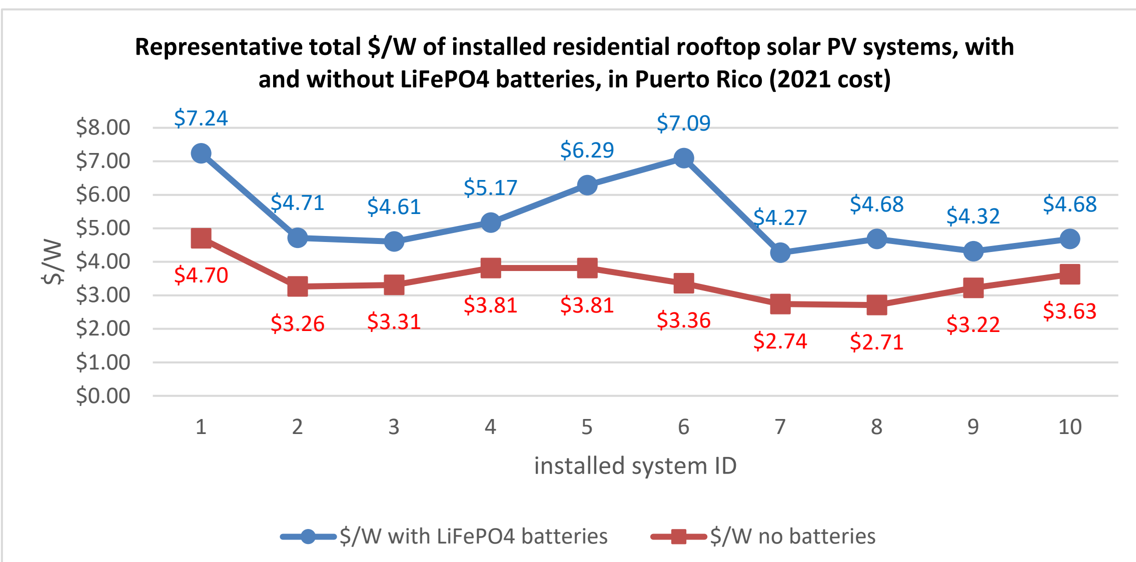

Figure 5. Representative total \$/W of installed residential rooftop solar photovoltaic systems, with and without LiFePO4 batteries, in Puerto Rico (2021 data).

[11] For the "average" system in Table 1 divide 19.3 kWh/4 h = 4.83 kW. This capacity is of the total storage package only and not to be confused with the 6 kW of installed solar panels in the same "average" system.

Contrary to the assumptions in Exhibit P "Legacy Charge Derivation" of the proposed PAD the cost of residential solar photovoltaic systems with batteries continues to decrease. How fast is the cost declining? How to estimate the expected reduced cost of these systems in the future?

The National Renewable Energy Laboratory (NREL) specializes in the research and development of renewable energy, energy efficiency, energy systems integration, and sustainable transportation. NREL is a federally funded research and development center sponsored by the Department of Energy.

NREL produces the Annual Technology Baseline (ATB) as "a consistent set of technology cost and performance data for energy analysis".[12] NREL's ATB predicts the declining cost of this, and other, technologies. Three scenarios are normally calculated: conservative, moderate and advanced.

In the conservative scenario it is assumed that historical investments come to market with continued industrial learning. Technology looks similar to today, with few changes from technology innovation. Public and private research and development (R&D) investment decreases.

In the moderate scenario it is assumed that innovations observed in today's marketplace become more widespread, and innovations that are nearly market-ready today come into the

[12] NREL (National Renewable Energy Laboratory). 2022. "2022 Annual Technology Baseline." Golden, CO. https://atb.nrel.gov/.

marketplace. Current levels of public and private R&D investment continue. This scenario may be considered the expected level of technology innovation.

In the advanced scenario it is assumed that innovations that are far from market-ready today are successful and become widespread in the marketplace. New technology architectures could look different from those observed today. Public and private R&D investment increases.

In our analysis we only consider the conservative and moderate scenarios.[13] The expected declining capital cost of residential solar photovoltaic systems, according to NREL ATB 2022 model in $/W, is shown in Figure 6.

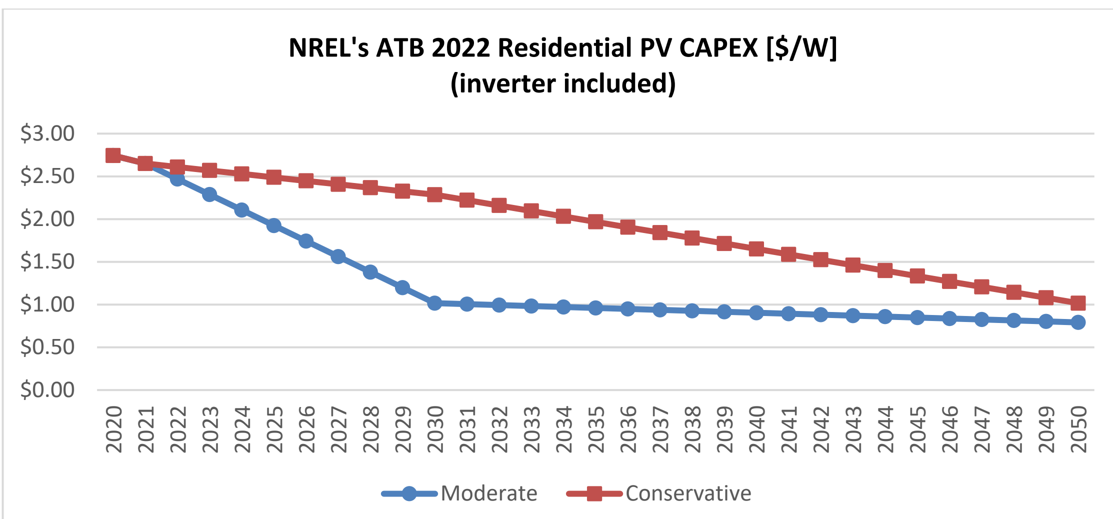

Figure 6. Declining capital cost of residential solar photovoltaic systems based on NREL ATB 2022.

[13] If the advanced scenario occurs costs for distributed solar and storage would be so low that mass grid defection is very likely.

We calculate the declining cost of rooftop solar based on the trajectories established by NREL ATB and the 2021 Puerto Rico's average cost of solar rooftop photovoltaic systems with no batteries, as shown in Figure 7.

Note that the cost in Puerto Rico, in 2021, is \$3.28/W while NREL's cost in the same year is \$2.65/W. The difference in cost is due to the type of inverter used in the representative Puerto Rico installations, a more expensive hybrid inverter, one that is ready to add batteries.

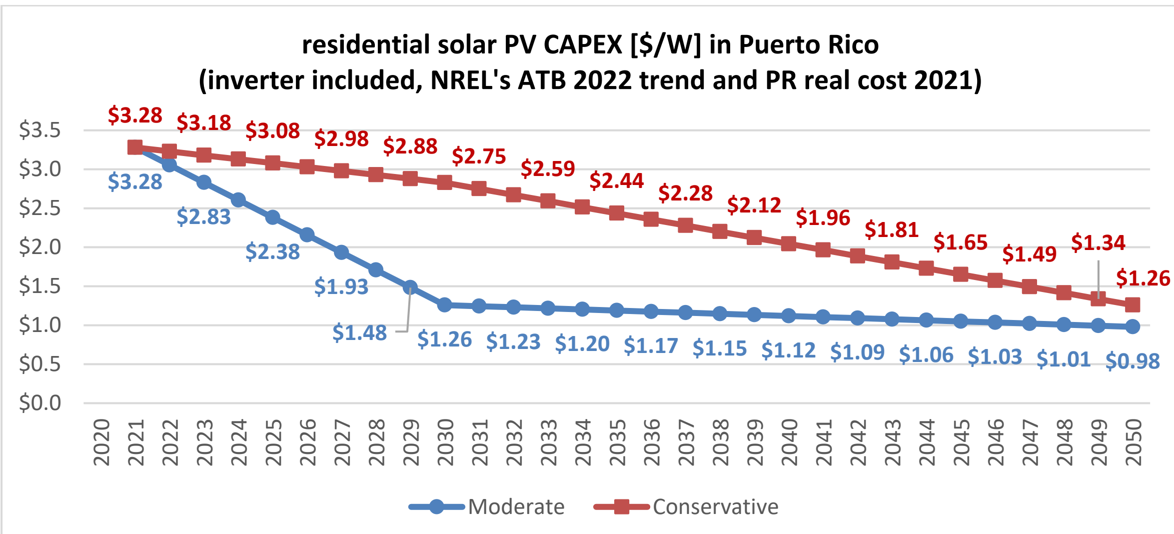

Figure 7. Declining cost of rooftop solar (trend from NREL ATB 2022) and the 2021 Puerto Rico's average cost of solar rooftop photovoltaic systems with no batteries.

The expected declining total cost of residential lithium-ion battery systems (5 kW - 20 kWh, i.e. 4 hours of storage), according to NREL ATB 2022 model, is shown in Figure 8.

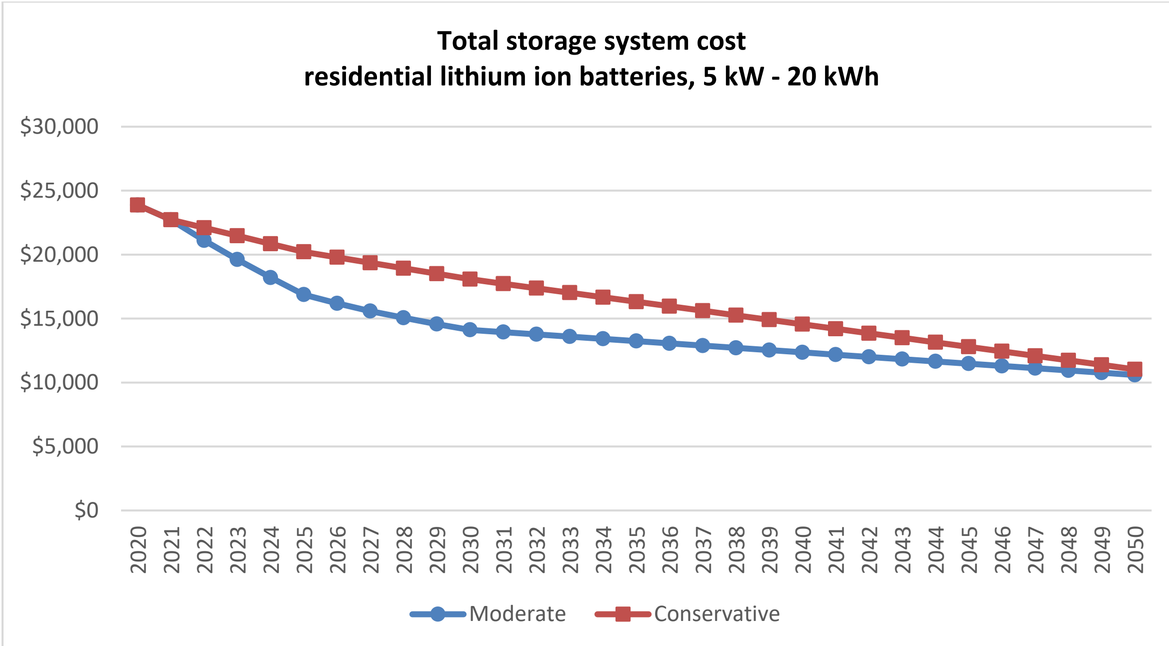

Figure 8 Total storage system cost for residential Li ion batteries in the US, ATB 2022.

From Table 1 the average cost of a storage system package in Puerto Rico, for lithium ion (LiFePO4) batteries was $24,113 in 2021. We calculate the declining total cost of residential lithium ion battery systems based on the trajectories established by NREL ATB and the 2021 Puerto Rico's average cost, as shown in Figure 9.

Note that total storage cost in Puerto Rico, in 2021, is $24,113 while NREL's cost in the same year is $22,725. Further note that the average storage system size is 4.8 kW and 19.3 kWh, very similar to NREL's values of 5 kW 20 kWh.

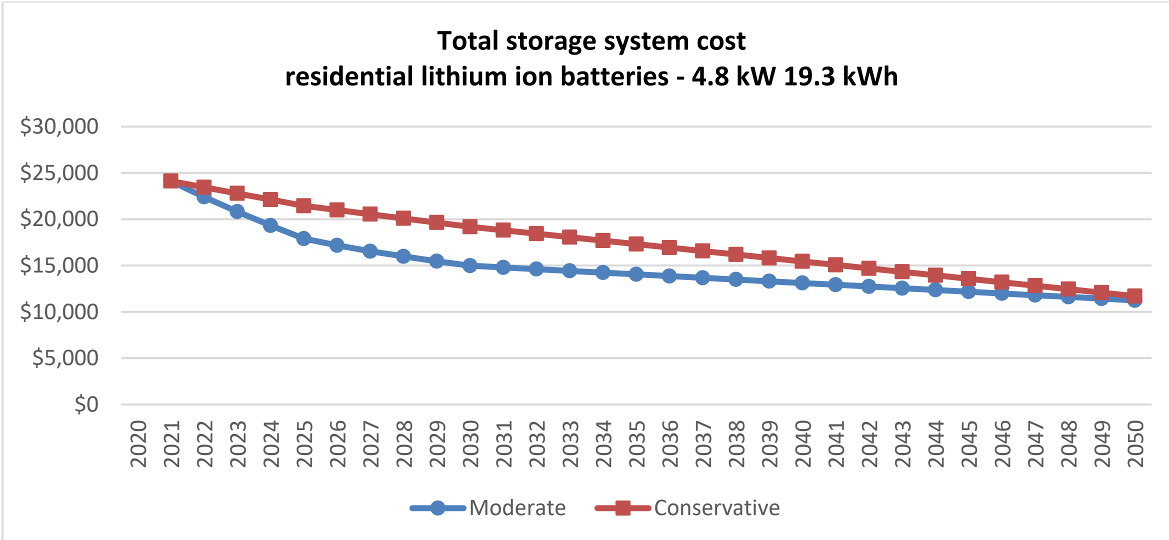

Figure 9. Estimated declining total cost of storage (trend from NREL ATB 2022) and the 2021 Puerto Rico's average cost of storage.

The proposed PAD is disconnected from the technological reality, specifically the cost of solar photovoltaic plus batteries in Puerto Rico. The rapid decline in cost of distributed solar photovoltaic generation plus energy storage is overlooked by the proposed PAD. The original Legacy Charge Derivation did not even mention energy storage. The new Legacy Charge Derivation acknowledges that both rooftop solar and distributed storage are "available at economical prices" and are an attractive substitute to paying the Legacy Charge. But neither document incorporates publicly available data on rooftop solar + storage adoption, or makes any attempt to use that data to forecast the rate of grid defection, or how that impacts the Legacy Charge or the PAD.

<u>Conclusion 3</u> – Bondholders are experiencing a technological change they did not foresee. Failure to foresee technological change while investing is not cause to change the bonds

guarantee whether the bondholders' claims are secured or not. Nor is it cause to tax the new technology as the proposed PAD does.

V. Levelized Cost of Energy (LCOE): definition, uses and limitations

The US Department of Energy (NREL) defines the levelized cost of energy (LCOE) as "LCOE is a summary metric that combines the primary technology cost and performance parameters: capital expenditures, operations expenditures, and capacity factor."[14] LCOE can be useful to assess the effect of technology advances in future projections because it accounts for primary cost (e.g., up-front capital costs, financing cost) and key performance parameters (e.g., capacity factor) when comparing different technology innovation scenarios.

But LCOE does not capture the full value to the user of reliable electric service, i.e., the electricity worth.

Furthermore, LCOE does not capture the economic value of a particular generation type to the system and therefore may not serve as an appropriate basis for comparisons between technologies. This is so because LCOE ignores attributes that can vary significantly across different technologies (both in terms of capability and cost) such as ramping, startup, and shutdown that could be relevant for more detailed evaluations of generator cost and value to the system.

[14] *Levelized Cost of Energy,* Nat'l. Renewable Energy Lab, https://atb.nrel.gov/electricity/2021/definitions.

Despite LCOE being a conservative metric in this report we use LCOE as an indicator, an index that quantifies the relative cost of electricity when comparing rooftop solar photovoltaic systems, with and without batteries and connected and disconnected from the grid, vs the current cost of electricity from the grid or the estimated cost of electricity under the proposed PAD.

Table 2 summarizes the parameters used in the calculation of LCOE for all cases. The parameters specific to each case are discussed in the corresponding section of this report.

Table 2. Parameters, and values, used in the calculation of the Levelized Cost of Energy

parameter and units	**parameter value**
rooftop solar PV system capacity (solar panels capacity) in kW	5
capacity factor, dimensionless	0.174 (17.4%)
discount rate, dimensionless	0.0435 (4.35%)
ideal annual energy yield, kWh	7621.2
annual energy yield reduction, dimensionless	0.005 (0.5%)
system lifetime, years	25
annual operation and maintenance (O&M) cost PV only, $	16
annual operation and maintenance (O&M) cost PV + storage, $	71

In the following sections we present the LCOE for three different scenarios: (1) rooftop solar PV systems with net metering and no batteries vs. the current electricity cost from the electric grid to residential end users, and (2) rooftop solar PV systems with batteries disconnected from the electric grid (grid defection) vs (3) estimated electricity cost from the electric grid to residential end users under the proposed PAD.

The first scenario is the one that the Legacy Charge Derivations consider most closely: grid-connected households lowering their use through rooftop solar, but not actually disconnecting, and therefore forced to pay the onerous fixed Customer Charge. As to Scenario 2: the first Legacy Charge Derivation summarily and incorrectly dismissed this as too expensive, even though tens of thousands of systems had been installed already. The new Legacy Charge Derivation acknowledges FOMB was wrong and these are "available at economic prices", but still imposes a fixed Customer Charge at a rate which, as I show below, would cause customers to rapidly defect from the grid in favor of rooftop solar + storage.

VI. Levelized Cost of Energy (LCOE) of rooftop solar PV systems with net metering and no batteries vs. current electricity from the grid cost

We calculate the LCOE of rooftop solar PV systems, 2021 system cost with a net metering contract and no storage, for a 5-kW solar system with capital cost of $3.28/W (average value from Table 1), fixed operation and maintenance cost of $16/year (a value equal to the average value on the moderate scenario in NREL's ATB 2022) and utility interconnection cost of $4/month, or $48/year the current interconnection cost, to be 16 ¢/kWh (0.16 $/kWh).[15]

The LCOE for the same system, and same 2021 cost, with utility interconnection cost of $5/month, or $60/year the proposed interconnection cost due to the fixed component of the legacy charge, to be 16.1 ¢/kWh (0.161 $/kWh). **The fixed component of the legacy charge becomes an immediate solar tax of 0.1 ¢/kWh.** Further note that the calculated LCOE for rooftop solar photovoltaic systems without batteries is still cheaper than electricity from the grid. Thus, we expect solar PV adoption interconnected to the grid, via net-metering contracts, to continue rising in number and causing a decrease in electric energy sales.

Note that we calculate LCOE for a system installed using 2021 costs. Since the actual cost is declining a system installed in the future, say 2025, will result in a 2025 LCOE smaller than the 2021 LCOE. For example, using $2.38/W as the capital cost (from Figure 5, ATB 2022 moderate scenario trend) the resulting LCOE is 11.8 ¢/kWh (0.118 $/kWh) with actual interconnection cost and 12 ¢/kWh (0.120 $/kWh) with the proposed additional fixed charge. Thus, the fixed component of the legacy charge is a solar tax that increases in time.

<u>Conclusion 4</u> – The proposed "legacy charge" is designed to tax the adoption of residential solar energy and discourage adoption of solar photovoltaic rooftop generation.

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[15] For comparison ATB 2022 list the LCOE for a residential solar PV system with no batteries as 8.3 ¢/kWh, about half of our calculated value. Reasons for this discrepancy are: the inverter cost assumed by NREL in the ATB are much lower than the inverter cost in Table 1 (a hybrid inverter capable of adding batteries), and NREL also incorporates in its financial components tax credits available in the continental US and not available in Puerto Rico.

VII. Levelized Cost of Energy (LCOE) of rooftop solar PV systems with batteries, system disconnected from the grid vs. electricity from the grid with proposed PAD cost

We calculate the LCOE of rooftop solar PV systems, 2021 system cost with storage, for a 5-kW, 20 kWh solar system, disconnected from the electric grid. We use total capital cost of $4.92/W (average value from Table 1), fixed operation and maintenance cost of $71/year (a value equal to the average value on the moderate scenario in NREL's ATB 2022) and no utility interconnection cost.

Since the selected lifetime of the project is 25 years, we include the cost of one battery bank replacement in year 12, $7,635. We use the battery cost in year 12 as per the decline established in the moderate scenario of the ATB 2022 for lithium-ion batteries. The LCOE is 25.8 ¢/kWh (0.258 $/kWh), approximately 26 ¢/kWh.

The Puerto Rico Electric Power Authority (PREPA) Executive Director must provide monthly reports to its Governing Board. The June 2023 version of this report[16] indicates that the average cost of residential electricity, fiscal year to date (i.e., July 2022 thru June 2023, 12 months) was 26.71 ¢/kWh.

Thus, the current electricity cost from the electric grid, prior to the proposed PAD, is already more expensive than the LCOE of rooftop solar photovoltaic generation with storage. We

[16] PREPA, *Monthly Report to the Governing Board* (June 2023), https://aeepr.com/es-pr/investors/FinancialInformation/Monthly%20Reports/2023/June%202023.pdf

acknowledge that most people do not calculate LCOE and compare it with grid electricity cost and in this case these values are close, about 26 ¢/kWh. But the combined price increase created by the proposed PAD and the declining costs of solar PV systems with batteries will induce grid defection.

The average annual solar PV electricity generation of the 5 kW/20 kWh system is 7,145 kWh, or 595.4 kWh per month. Under the proposed PAD a residential client buying this amount of electricity from the grid will pay:

$5 + 425*(0.2671 + 0.0066) + 170*(0.2671 + 0.0265) = $171.24, which results in 28.8 ¢/kWh for unreliable electric service.

The imposition of the proposed legacy charge with the subsequent electric energy price increase, a price increase associated to unreliable electric power, and the declining prices of rooftop solar photovoltaic systems plus batteries will create an incentive for customers to permanently disconnect from the electric grid. This is called "grid defection".

A 2014 study[17] shows that in places like Hawaii the conditions for grid defection are already present. The 2018 average price of residential electricity in Hawaii varies from 31 ¢/kWh to 37 ¢/kWh. As we have calculated in this report the cost of un-reliable electric energy in Puerto Rico, after the proposed legacy charge will be approximately 29 ¢/kWh.

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[17] "The Economics of Grid Defection: When and Where Distributed Solar Generation Plus Storage Competes with Traditional Utility Service", The Rocky Mountain Institute and others, 2014.

Contrary to what is assumed on the proposed PAD significant grid defection is likely to become a reality in Puerto Rico if the proposed legacy charge is implemented.

Further note that we calculate LCOE for a system installed using 2021 costs. Since the actual cost is declining a system installed in the future, say 2025, will result in a 2025 LCOE smaller than the 2021 LCOE. For example, using $3.65/W as the capital cost (using the ATB 2022 moderate scenario declining cost trend for batteries, similar to Figure 7) the resulting LCOE is 20.4 ¢/kWh (0.204 $/kWh).

<u>Conclusion 5</u> – The LCOE of residential rooftop solar photovoltaic systems, including batteries and using equipment of good warranty and LiFePO4 batteries, will cost less than the cost of electricity from the grid after applying the proposed legacy charge.

<u>Conclusion 6</u> - Contrary to what is assumed in the Legacy Charge Derivation (Supplemental Exhibit I) of the proposed PAD, significant grid defection could become a reality in Puerto Rico if the proposed legacy charge is implemented, thus rendering the proposed PAD useless.

VIII. The legacy charge will not improve electric grid reliability

The proposed PAD fails to include the investments needed in the electric grid to achieve reliable electric service. This failure will only drive further adoption of distributed solar energy and reduce sales.

One metric used to measure the reliability of U.S. electric utilities is the System Average Interruption Duration Index (SAIDI), which measures the total time an average customer experiences a non-momentary power interruption in a one-year period.[18] For utilities that report SAIDI metrics using Institute of Electrical and Electronics Engineers (IEEE) standards, LUMA follows this practice, non-momentary interruptions are those lasting longer than five minutes. SAIDI is often paired with the System Average Interruption Frequency Index (SAIFI), an index that measures the frequency of interruptions.

The Energy Information Administration (US Department of Energy) reports, for 2021, an average customer experienced 1.03 outages per year, 121.5 total outage minutes.[19] In October 2023, LUMA reported that Puerto Rican customers suffered 7.37 annual outages, for a total of 1,272 minutes. That is more than 21 hours – almost a full day each year.[20] Using data reported by LUMA to the Puerto Rico Energy Bureau (PREB) in 2022 the annual distribution system SAIDI was 1,022 minutes and the annual distribution system SAIFI was 4.7 interruptions per customer.[21]

In October 2023, LUMA reported 2,178.67 minutes of outages, per customer served, for the eighteen months between March 2022 and September 2023. This is a significant drop in

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[18] 1366-2012 - IEEE Guide for Electric Power Distribution Reliability Indices.
[19] *Table 11.1 Reliability Metrics of U.S. Distribution System*, U.S. Energy Infor. Admin. https://www.eia.gov/electricity/annual/html/epa_11_01.html
[20] https://energia.pr.gov/wp-content/uploads/sites/7/2023/10/Resumen-Metricas-Master_October2023.xlsx
[21] https://energia.pr.gov/wp-content/uploads/sites/7/2023/03/Resumen-Metricas-Master_Jan2023_Revised-1.xlsx

performance compared to the expected performance, measured by the baseline set by the Puerto Rico Energy Bureau, of 1,864.15 months for 18 months.[22]

Puerto Ricans across the archipelago reported lost food and medicine and damaged appliances from frequent outages

- "Ashlee Vega, who lives in northwestern Puerto Rico, said the power fluctuations this month were so imperceptible that it took her several hours to realize her appliances were not working right. The new refrigerator she had bought in February - to replace an old one that gave out after enduring years of volatile electrical surges - was fried."[23]
- "It has been hard to expand the business as frequent power cuts force him to close the store and also damage the fridges, which are costly to repair."[24]
- "In early August, the Independent Consumer Protection Office said it had received about twice as many monthly complaints under LUMA than it had when PREPA managed the grid; the complaints have been primarily related to service disruptions and equipment damaged by voltage fluctuations."[25]
- "The latest outage unleashed a flood of complaints on social media as anger spread among thousands of people who were forced to throw out food and refrigerated medication including insulin in recent days. Some also complained about damaged

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[22] Submission of Corrected Spreadsheets on Performance Metrics Quarterly Report for October through December 2022, and Corrected Data on Reliability Metrics for July through August 2022, PREB Docket NEPR-MI-2019-0007 (March 3, 2023)

[23] Patricia Mazzei, *Why Don't We Have Electricity?: Outages Plague Puerto Rico,* N.Y. TIMES (Oct. 19, 2021), https://www.nytimes.com/2021/10/19/us/puerto-rico-electricity-protest.html.

[24] Nina Lakhani, *We want sun: the battle for the solar power in Puerto Rico*, THE GUARDIAN (Oct. 18, 2021) https://www.theguardian.com/environment/2021/oct/18/puerto-rico-solar-power-climate-resilience.

[25] Cathy Kunkel & Tom Sanzillo, Puerto Rico Grid Privatization Flaws Highlighted in First Two Months of Operation (August 2021) http://ieefa.org/wp-content/uploads/2021/08/Puerto-Rico-Grid-Privatization-Flaws-Highlighted-in-First-Two-Months-of-Operation_August-2021.pdf.

appliances as lights flickered on and off since Thursday's outage that left 900,000 people in the dark.[26]

- "Irizarry worried for his safety ... and the growing list of appliances lost to unexpected voltage changes. .... The unreliable electricity damaged the freezer where he stored pizza ingredients. ...'We are talking about scenarios where voltage changes have been dramatic and they have destroyed medical equipment and burned down houses...'"[27]
- "Residents of the island say the power cuts have damaged appliances and can be life-threatening to those who rely on certain medical machines."[28]
- "The list of recent incidents includes massive power outages and an increase in power surges. These, along with daily complaints of citizens' damaged equipment, are some examples of the company's inability to manage a complex system."[29]

Conclusion 7 – Rooftop solar photovoltaic systems with batteries are currently less costly than unreliable electricity from the electric grid. This lack of reliability from the electricity supplied by the electric grid will further drive the adoption of rooftop solar PV systems with storage.

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[26] *Massive power outage in Puerto Rico affects hundreds of thousands amid growing outrage*, CBS NEWS (June 16, 2021), https://www.cbsnews.com/news/puerto-rico-power-outage-latest-2021-06-16/.
[27] María Luisa Paúl, *Two major power outages in a week fuel fear in Puerto Rico – and memories of Hurricane María*, THE WASHINGTON POST (June 18, 2021), https://www.washingtonpost.com/nation/2021/06/18/puerto-rico-power-outages/.
[28] *Puerto Ricans March to Protest Ongoing Power Outages After Privatization of Electric Grid*, DEMOCRACY NOW! (Oct. 18, 2021). https://www.democracynow.org/2021/10/18/headlines/puerto_ricans_march_to_protest_ongoing_power_outages_after_privatization_of_electric_grid.
[29] Johnny Irizarry Rojas, *Four years after María, Puerto Rico's power grid still in shambles | Commentary,* ORLANDO SENTINEL (Sept. 22. 2021), https://www.orlandosentinel.com/opinion/guest-commentary/os-op-puerto-rico-power-grid-in-shambles-20210922-w6cwdrrgwffzrb25ruylhigsmy-story.html.

Conclusion 8 - The proposed legacy charge will increase the cost of electricity from the electric grid, but will not increase the reliability of this service, thus accelerating the adoption of distributed renewables and probably increasing both full and partial grid defection.

IX. Is the public guaranteed continuity of electric service under the proposed PAD?

Is the public guaranteed continuity of electric service under the PAD? No.

The PAD does not mention reliability[30] of electric energy service, nor it explain how the legacy charge will provide for a resilient[31] electric power system for the public.[32] Thus, the PAD completely ignores the primary reason a utility has been granted a monopoly in exchange for cost-based regulated rates, the obligation to serve and provide an essential service.

The legacy charge's sole purpose is to collect money to pay unsecured, unaudited debt. The legacy charge collects no money to invest on the electric grid in order to make it more

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[30] NERC is the North American Electric Reliability Corporation; the entity certified by the Federal Energy Regulatory Commission (FERC) to establish and enforce reliability standards for the interconnected bulk power system in North America (www.nerc.com). NERC's definition of reliability is the degree of performance of the elements of the bulk electric system that results in electricity being delivered to customers within accepted standards and in the amount desired. Reliability may be measured by the frequency, duration, and magnitude of adverse effects on the electric supply.

[31] From the Presidential Policy Directive (PPD) 21 "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents." https://obamawhitehouse.archives.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil.

[32] "Without some numerical basis for assessing resilience, it would be impossible to monitor changes or show that community resilience has improved. At present, no consistent basis for such measurement exists. We recommend therefore that a National Resilience Scorecard be established." - National Research Council. 2012. Disaster Resilience: A National Imperative. Washington, DC: The National Academies Press. https://doi.org/10.17226/13457.

reliable and resilient. This leaves PREPA with inadequate funds to even keep the system from deteriorating further, let alone improving. In fact, section 5.1.4 Federal Funding Local Cost Share Requirements of PREPA's 2023 Fiscal Plan (Exhibit C of the proposed PAD) (page 91, pdf 92/159) indicates "For the FEMA PA 428 funding concerning permanent work related to Hurricane Maria, the cost share requirements are estimated to be at 10%, amounting to approximately $1.05 billion (or 10% of the $10.7 billion after deducting expected insurance proceeds of $193 million). PREPA plans to meet most of its non-Federal cost share obligations through the Community Development Block Grant Disaster Recovery ("CDBG-DR") program, as it becomes available. To date, $500 million has been made available under Energy Grid Rehabilitation and Reconstruction (ER1) Cost Share Program to meet the non-Federal cost shares. For the non-Federal cost share remaining, PREPA must find funding elsewhere and/or adjust rates to cover the obligation. Failure to identify the funds necessary for cost share may prevent PREPA from having access to the portion of the Global Settlement contributed by federal funding FEMA."

Thus, the proposed PAD recognizes that the cost of providing reliable electric service from the electric grid will be higher that the estimated electricity cost of 29 ¢/kWh including legacy charge. PREPA will need no less than $550 million to match FEMA funds. There are other estimates of required capital investment to increase reliability, and these are much higher as discussed in the following section.

a. Puerto Rico's electric energy delivery infrastructure is weak.

Puerto Rico's electric energy delivery infrastructure, the Transmission and Distribution (T&D) network, is weak as shown by its failed performance during a series of events prior to Hurricanes Irma and María,[33] and by its performance after Hurricane María[34] and recently Hurricane Fiona.[35] The fiscal year (2022-23) to date average residential electric energy cost in Puerto Rico is 26.71¢/kWh. **Thus, the new rate of electricity, including the legacy charge, will provide unreliable electricity at a cost of approximately 29 ¢/kWh if the current fuel prices remain as they have been in from July 2022 thru June 2023.**

How much money is necessary to invest in the T&D network to obtain a reliable electric energy supply? Different studies provide different estimates of needed investment to achieve a reliable electric system.

The following Table,[36] an estimate from 2017, summarizes the estimated rebuild cost needed to "harden and enhance the resiliency of PREPA's system".

[33] Prior to Hurricane María a fire at the switchyard of Aguirre generation station in September 2016 caused a complete blackout in Puerto Rico that lasted days. https://www.nytimes.com/2016/09/22/us/fire-at-power-plant-leaves-puerto-rico-in-the-dark.html.

[34] I. Umair, "Puerto Rico's blackout, the largest in American history, explained," Vox, 08-May-2018. [Online]. Available: https://www.vox.com/2018/2/8/16986408/puerto-rico-blackout-power-hurricane.

[35] https://www.politico.com/news/2022/09/18/hurricane-fiona-knocks-out-puerto-ricos-power-00057387.

[36] Table adapted from the Executive Summary of "Build Back Better: Reimagining and Strengthening the Power Grid of Puerto Rico", Puerto Rico Energy Resiliency Working Group members and Navigant Consulting, Inc., A Report for Governor Andrew Cuomo, New York, Governor Ricardo Rosselló, Puerto Rico and William Long, Administrator FEMA, December 2017. www.governor.ny.gov/sites/governor.ny.gov/files/atoms/files/PRERWG_Report_PR_Grid_Resiliency_Report.pdf.

Table E-1. Rebuild Cost Summary

Item	**Rebuild Recommendations**	**Total (millions, US$)**
1	Overhead Distribution (includes 38 kV)	$5,268
2	Underground Distribution	$35
3	Transmission - Overhead	$4,299
4	Transmission - Underground	$601
5	Substations – 38 kV	$856
6	Substations – 115 kV & 230 kV	$812
7	System Operations	$482
8	Distributed Energy Resources	$1,455
9	Generation	$3,115
10	Fuel Infrastructure	$683
	Total Estimated Cost	**$17,606**

Items 1 thru 6, inclusive, account for almost $12 billion needed according to this study, for electric grid "hardening".

A more recent estimate, December 2022, from the Puerto Rico Department of Housing, estimates that Puerto Rico will need a capital investment of about $6.4 billion in the electrical system beyond the federal funds available.[37]

[37] DEP'T OF HOUS. Puerto Rico Disaster Recovery Action Plan for the Use of CDBG-DR Funds for Electrical Power System Improvements at 77 (Dec. 16, 2022).

There are other estimates based on a distributed renewable energy approach. In 2018, Queremos Sol ("We Want Sun"), a multi-sectoral coalition of Puerto Rican community, environmental and labor organizations, put forward a policy proposal for the renewable energy transformation of Puerto Rico's electrical system under a reformed public ownership model.

The proposal emphasized efficiency and distributed renewable energy, particularly rooftop solar and behind-the-meter storage, as a strategy to provide resilience to households in future blackouts, to reduce the impact on agricultural and ecologically valuable lands from utility-scale renewable energy projects, and to reduce the island's dependence on imported fossil fuels and extensive transmission systems. Queremos Sol proposes a transformation that is equitable, affordable and that ensures a transition to renewables that is fair to PREPA workers.[38]

If $9.6 billion in federal funding is used to cover necessary distribution system improvements and to invest in distributed solar and battery systems as proposed by Queremos Sol and modeled, the average system cost is less than 15 cents/kWh in 2035. Therefore, a distributed energy future for the island is technically achievable, affordable and would provide real resiliency to Puerto Rico homes and businesses. None of this is even considered in the proposed PAD.

The Plan of Adjustment is proposing to emit approximately $2.28 billion in new bonds at between 6% and 7.125% interest but accepts that this is not enough. The proposed PAD

[38] https://cambiopr.org/solmastechos/.

assumes the required capital investment to achieve reliable electric service will come from FEMA funds and neglects the required matching fund that must be provided by PREPA thru an additional rate increase. The required capital investment to achieve reliable electric service from the grid is likely to be more than it is assumed in the proposed PAD.

Does this investment guarantee continuity of electric service after a strong Hurricane? No. It is virtually impossible to protect every element of the T&D system from falling trees, flying debris, landslides due to flooding, and the most severe hurricane winds.

Is there an alternative? Yes. Distributed and renewable electric energy generation plus electric storage provides a better investment in Puerto Rico and in places with high electricity costs, severe local reliability challenges or both. As presented in this report by 2025 solar photovoltaic electric energy plus storage will cost around 22 ¢/kWh while the current cost + legacy charge shall produce a cost of about 29 ¢/kWh,

Are rooftop solar photovoltaic systems impervious to hurricanes? No. But our experience during Hurricane María shows that when properly installed even a modest rooftop photovoltaic system can provide resiliency and continuity of electric service post a major hurricane.

X. Resiliency thru Distributed Renewable Energy

A case study article[39] describes how electric service resiliency is achieved thru the adaptation of a relatively small existing residential photovoltaic system, originally grid-tied under a net metering agreement with the utility, to a stand-alone system with batteries to provide continuity of service after Hurricane María destroyed Puerto Rico's electric transmission and distribution system.

A modest rooftop photovoltaic system with batteries (1 kW in solar panel capacity, 10 kWh of energy storage, total cost of $2,812) provided resiliency and continuity of electric service post hurricane María. The electric service from the grid, at the location under study, stopped 20 September 2017 and was restored 132 days later, on 30 January 2018. It took 31 days of old fashioned "walk around" to obtain the necessary equipment (charge controllers, batteries, off-grid inverter) to adapt the net metering system into a stand-alone system.[40] The rooftop solar photovoltaic system operated uninterrupted for 101 days, until the electric service from the grid was restored. The system was later re-connected to serve as a net metering system and backup in the event of grid service failure.

In the article the authors also contrast the cost of buying and operating the photovoltaic system to the cost of buying and operating a gasoline emergency generator to supply the

[39] A. Irizarry-Rivera, K.V. Montano-Martinez, S. Alzate-Drada, F. Andrade, *A Case Study of Residential Electric Service Resiliency thru Renewable Energy Following Hurricane María*, Mediterranean Conference on Power Generation, Transmission, Distribution and Energy Conversion (MEDPower), Dubrovnik (Cavtat) Croatia, Nov. 12-15 2018.

[40] There was no electricity nor communications, therefore no Internet, in Puerto Rico for close to a month after Hurricane María.

same amount of energy. The cost of using a set of gasoline generators to provide the same energy is less only if electricity from the grid is available within four months of the blackout. This cost comparison does not include labor and transportation cost of procuring fuel and oil, and the labor cost of performing oil changes and refueling the generator. Nor did we assigned a monetary value to lost sleep re-fueling the generator in the middle of the night.

This is one case study: as detailed above, more than 100,000 Puerto Rican households now have rooftop solar + storage systems. Rooftop solar + storage systems already saved lives during the most recent hurricane. When Hurricane Fiona hit the archipelago in the fall of 2022 and caused the grid to fail completely, homes and critical facilities like fire stations that had rooftop solar with storage were able to keep their lights on during and after the storm.[41] Similar stories have played out in other locations around the country, with a solar-powered community in Florida keeping the lights on during Hurricane Ian in 2022 amid widespread power outages, and renewables and batteries playing a critical role in avoiding power outages in Texas during recent extreme heat waves.[42] During the next hurricane, these systems will power phones and medical devices, and keep medicines cold – they will save lives. **The proposed PAD is designed to make ownership of a rooftop solar photovoltaic system far more expensive that it has to be and therefore to impede the ability to survive hurricanes in Puerto Rico,**

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[41] Maria Galluci, Solar is lifeline in Puerto Rico after Hurricane Fiona knocks out power, Canary Media (Sept. 19, 2022) https://www.canarymedia.com/articles/solar/solar-offers-lifeline-in-puerto-rico-after-fiona-knocks-out-power.

[42] Alejandra O'Connell-Domenech, Solar-Powered community kept the lights on during Hurricane Ian, The Hill (Oct. 12, 2022) https://thehill.com/changing-america/sustainability/infrastructure/3685296-solar-powered-community-kept-the-lights-on-during-hurricane-ian/
Arielle Samuelson, Show this to anyone who says renewables are unreliable, Heated (June 29, 2023) https://heated.world/p/show-this-to-anyone-who-says-renewables.

an island that lies squarely in the hurricane path of the Caribbean Sea as shown in Figures 10 and 11.

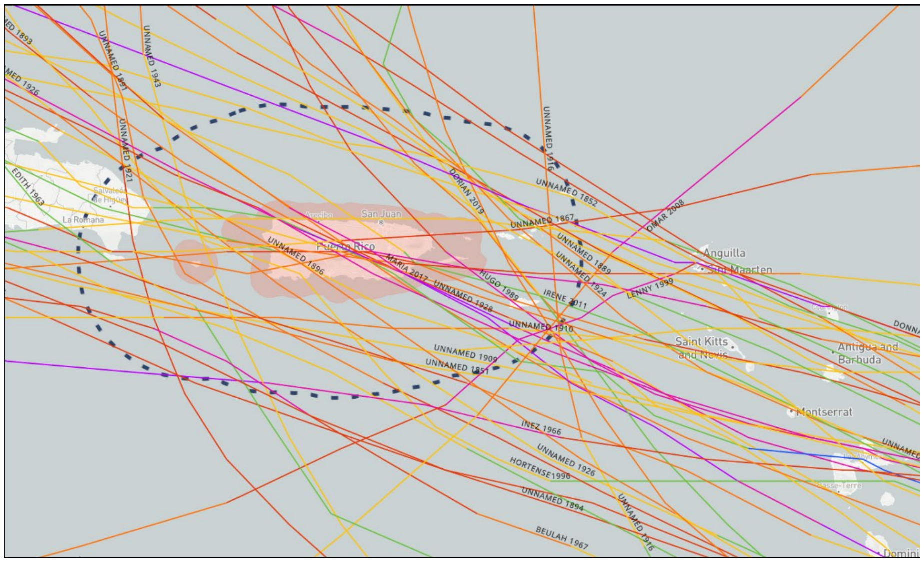

Figure 10. Forty-nine (49) hurricane tracks, from 1842-2021, crossing within 60 nautical miles of the Puerto Rico coast.[43] Note that Hurricane Fiona made landfall in Puerto Rico in 2022 raising the total to fifty (50).

Forty-nine (49) hurricanes have crossed nearby Puerto Rico, within 60 nautical miles of its coast from 1842 thru 2021. Eighteen (18) have made landfall during the same period, as shown in Figure 9. Note that Hurricane Fiona made landfall in Puerto Rico in 2022 raising the total of "cross nearby" to fifty (50) and nineteen making landfall. Of the 49 twenty-one (21) were category 3 and higher hurricanes, in the Saffir-Simpson scale, with nine (9) making landfall. Hurricanes categories 3 and higher are described as major hurricanes where near-total to total power loss is likely for weeks.[44]

[43] Nat'l Ocean Serv., NAT'L OCEANIC AND ATMOSPHERIC ADMIN. (NOAA), *Historical Hurricane Tracks*, available at www.oceanservice.noaa.gov/news/historical-hurricanes.

[44] T. Schott, C. Landsea, G. Hafele, J. Lorens, A. Taylor, H. Thurm, B. Ward, M. Willis, and W. Zaleski, "The Saffir-Simpson Hurricane Wind Scale", National Oceanic and Atmospheric Administration (NOAA), 2012.

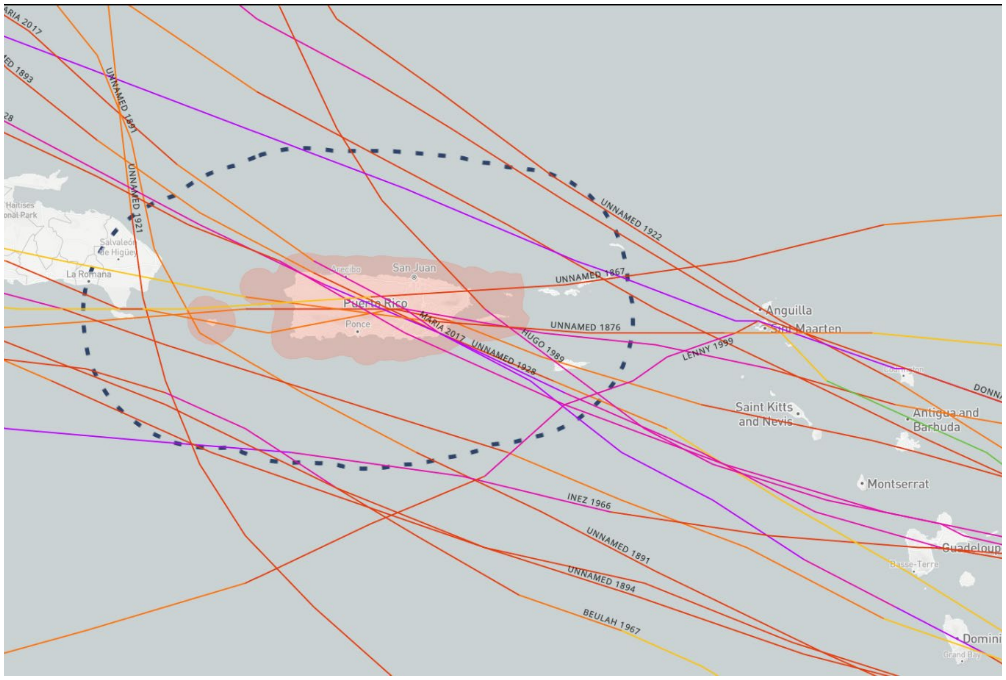

Figure 11. The path of the twenty-one (21) major hurricanes (category 3 and higher), from 1842-2021, crossing within 60 nautical miles of the Puerto Rico coast; nine (9) made landfall.

The people of Puerto Rico should not be penalized for taking advantage of a market driven technological change, the significant drop in the retail price of solar photovoltaic systems and batteries, **that allows them to use their clean indigenous resources**, their rooftop and the sun that falls on it, **to generate the totality or a portion of their electric energy needs**. Furthermore, **this technological change provides for increased resiliency of electric energy services after a major hurricane and breaks the "natural monopoly" of the traditional electric utility business**.

<u>Conclusion 9</u> - Residents of Puerto Rico require a cost effective and resilient alternative to generate electricity and the proposed PAD is an obstacle to achieve this much needed goal.

XI. Summary of Conclusions

Conclusion 1 – The proposed PAD fails to analyze the current data on adoption of distributed energy.

Conclusion 2 – Renewable energy adoption policy would be harmed by taxing the only renewable energy sector growing for the sake of paying an uninsured debt.

Conclusion 3 – Bondholders are experiencing a technological change they did not foresee. Failure to foresee technological change while investing is not cause to change the bonds guarantee whether the bondholders' claims are secured or not. Nor is it cause to tax the new technology as the proposed PAD does.

Conclusion 4 – The proposed "legacy charge" is designed to tax the adoption of residential solar energy and discourage adoption of solar photovoltaic rooftop generation.

Conclusion 5 – The LCOE of residential rooftop solar photovoltaic systems, including batteries and using equipment of good warranty and LiFePO4 batteries, will cost less than the cost of electricity from the grid after applying the proposed legacy charge.

Conclusion 6 - Contrary to what is assumed in the Legacy Charge Derivation (Supplemental Exhibit I) of the proposed PAD, significant grid defection could become a reality in Puerto Rico if the proposed legacy charge is implemented, thus rendering the proposed PAD useless.

Conclusion 7 - Rooftop solar photovoltaic systems with batteries are currently less costly than unreliable electricity from the electric grid. This lack of reliability from the electricity supplied by the electric grid will further drive the adoption of rooftop solar PV systems with storage.

Conclusion 8 - The proposed legacy charge will increase the cost of electricity from the electric grid, but will not increase the reliability of this service, thus accelerating the adoption of distributed renewables and probably increasing both full and partial grid defection.

Conclusion 9 - Residents of Puerto Rico require a cost effective and resilient alternative to generate electricity and the proposed PAD is an obstacle to achieve this much needed goal.

Signature

I declare, under penalty of perjury, under the laws of the United States of America, that the foregoing is true and correct. Signed this 11th day of December 2023, in Mayagüez, Puerto Rico,

Agustín Alexi Irizarry-Rivera, Ph.D., P.E.

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XII. Expert Witness Background

Agustín A. Irizarry-Rivera obtained his bachelor, Magna Cum Laude, at Universidad de Puerto Rico Mayagüez (UPRM) (1988), masters at University of Michigan, Ann Arbor (1990) and Ph.D. at Iowa State University, Ames (1996) all in electrical engineering. Since 1997 he has been Professor at the Electrical and Computer Engineering (ECE) Department UPRM where he teaches graduate and undergraduate courses such as: Electric Systems Analysis, Fundamentals of Electric Power Systems, Power System Analysis, Electric Machines, Electrical Systems Design, Advanced Energy Conversion, Power Systems Dynamics and Control and Transmission and Distribution Systems Design.

He has been elected member of the Electrical and Computer Engineering Department Personnel Committee and the School of Engineering Personnel Committee in three occasions and has served as President of both Committees twice. He has been elected Academic Senator to represent the School of Engineering in the Academic Senate. Dr. Irizarry-Rivera has served as Assistant Dean of Academic Affairs and Associate Director for Academic Affairs of the Electrical and Computer Engineering Department at UPR Mayagüez.

Dr. Irizarry-Rivera conducts research in the topic of renewable energy and how to adapt the existing power grid to add more of these resources in our energy portfolio. He had a research internship at Plataforma Solar de Almería, Tabernas, Spain from 2008 to 2009 to study concentrated solar thermal systems. He contributed to the development of dynamic models to simulate the interaction between these plants and the electric grid. He has served as Consultant on renewable energy and energy efficiency projects to Puerto Rico's Government agencies, municipalities, private developers and consulting firms in and outside Puerto Rico. He has also served as expert witness in civil court cases involving electric hazard, shock or electrocution.

Dr. Irizarry-Rivera conducts research in the topic of renewable energy and how to adapt the existing power grid to add more of these resources into our energy portfolio. He had a research internship at Plataforma Solar de Almería, Tabernas, Spain from 2008 to 2009 to study concentrated solar thermal systems. During this research internship he contributed to the development of dynamic models to simulate the interaction between these plants and the electric grid. A few examples of funded research and education projects are:

GEARED (Grid Engineering for Accelerated Renewable Energy Deployment) – (2013-2018) A $929,000 project (UPRM budget out of $6.9 million for the Consortium) to develop and run a Distributed Technology Training Consortium in the Eastern United States, led by the Electric Power Research Institute (EPRI) in collaboration with four U.S. universities (University of Puerto Rico Mayaguez, Georgia Institute of Technology, Clarkson University, University of North Carolina at Charlotte) and seventeen utilities and system operators. The Consortium will leverage utility industry R&D results with power engineering educational expertise to prepare power engineers in management and integration of renewable energy and distributed resources into the grid.

Streamlined and Standardized Permitting and Interconnection Processes for Rooftop Photovoltaic (PV) in Puerto Rico (2012-2013) (Investigator) A $301,911 project sponsored by the US Energy Department that seeks to improve the PV energy market of rooftop systems up to 300 kW in Puerto Rico. The project strives to create not only a standardized framework for PV deployment, but also streamlined: organized, lean permitting and interconnection processes where most residential and small commercial PV systems can be installed safely and quickly.

Design of a Renewable Energy Track within the Electrical Engineering Program at Universidad APEC, Dominican Republic (2011-2012) A $29,000 award to design a Renewable Energy Track within the existing Electrical Engineering Program of UNAPEC.

IGERT: Wind Energy Science, Engineering and Policy (WESEP) (2011-2015) A $171,600 sub-award from Iowa State University, the lead Institution, to fund master students doing research in wind technology, science, and policy as they relate to accomplishing three objectives: (a) increase the rate of wind energy growth; (b) decrease the cost of wind energy; and (c) extend penetration limits.

Achievable Renewable Energy Targets For Puerto Rico's Renewable Energy Portfolio Standard (2007-2009) A $327,197 project sponsored by the Puerto Rico Energy Affairs Administration (Administración de Asuntos de Energía), to produce an estimate, based in realistic boundaries and limitations, of renewable energy available in Puerto Rico for electricity production. The renewable energy resources studied were: biomass - including waste-to-energy, micro hydro, ocean - waves, tides, currents and ocean thermal, solar - photovoltaic and solar thermal, wind – utility as well as small wind, and fuel cells. The purpose of producing these estimates was to establish adequate targets, as a function of time, for Puerto Rico's Renewable Portfolio Standard.

Colegio San Ignacio - Ejemplo de Sostenibilidad (2007-2008) A $73,332 project to match the energy needs of Colegio San Ignacio with its available renewable energy sources. Demonstration projects with a strong educational component were designed for the School with the participation of the School Faculty and students. The philosophy of the program was of sustainable development.

Programa Panamericano de Capacitación en Ingeniería de Potencia Eléctrica (2006-2008) A $97,370 educational project to deliver a Web-broadcast master program in electric power engineering to engineers at UNAPEC University in the Dominican Republic. Courses in this program responded to the reality and necessities of the Dominican Republic electric power industry and were aimed for sustainable development.

Caguas Sustainable Energy Showcase, Phase I (2006-2007) A $90,055 project sponsored by the Municipality of Caguas, Puerto Rico to assess the current electric energy consumption profile, by sector; residential, commercial, industrial and governmental, of Caguas and to propose achievable goals (percentages of demand), by sector, to be satisfied using renewable energy sources.

Intelligent Power Routers for Distributed Coordination in Electric Energy Processing Networks (2002-2005) A $499,849 project sponsored by the National Science Foundation (NSF) and the Office for Naval Research (ONR) to develop a model for the next generation power network using a distributed concept based on scalable coordination by an *Intelligent Power Router* (IPR). Our goal was to show that by distributing network intelligence and control functions using the IPR, we will be capable of achieving improved survivability, security, reliability, and re-configurability. Our approach builds on our knowledge from power engineering, systems, control, distributed computing, and computer networks.

He has served as Consultant on renewable energy, energy efficiency and electric grid performance and operation to Puerto Rico's Government agencies, municipalities, private developers and consulting firms in and outside Puerto Rico. He has also served as expert witness in civil court cases involving electric hazard, shock or electrocution.

He is author or coauthor of over 50 refereed publications including two book chapters (see complete list in the CV section). A licensed professional engineer in Puerto Rico since 1991 and member of IEEE he has organized local and international conferences such as the Tenth International Conference on Probabilistic Methods Applied to Power Systems (PMAPS 2008) in Rincón, Puerto Rico. PMAPS Conferences provide a regular forum for engineers and scientists worldwide to interact around the common theme of power engineering decision problems under uncertainty.

Dr. Irizarry-Rivera has received several awards and honors: **Distinguished Engineer 2013** from Puerto Rico's Professional Engineers Society (CIAPR) and **Distinguished Electrical Engineer 2005** from the Electrical Engineering Institute of CIAPR in recognition of services rendered to the profession and outstanding professional achievements in electrical engineering, the **2009 Distinguished Alumni Award** from UPRM Alumni Association, the **2004 Professional Progress in Engineering Award** from Iowa State University, in recognition of outstanding professional progress and personal development in engineering as evidenced by significant contributions to the theory and practice of engineering, distinguished service rendered to the profession, appropriate community service, and/or achievement in a leadership position and the 2003-2004 ECE **Outstanding Faculty Award** from UPRM's School of Engineering.

In May 2012 he was elected, by the consumers, to the Board of Directors of the Puerto Rico Electric Power Authority, in the first election of this kind in Puerto Rico, to represent the interests of consumers. He was President of the Board's Audit Committee and an active member of the Engineering and Infrastructure, Legal and Labor Affairs and Consumer's Affairs Committees. In 2013 Board Members elected him Vice President of the Board and he served in this capacity until September 2014 when his term expired.

He is Member of the Board of Directors, in the Interest of Consumers, of PREPA Holdings, LLC, a company registered in Delaware, whose sole owner is PREPA. PREPA Holdings owns PREPANET a communications network infrastructure provider that uses an optical network platform in Puerto Rico to provide wholesale telecommunication services.

Dr. Irizarry Rivera is being paid $150 per hour for his services in this case.

XIII. Expert Witness CV

Please refer to attached CV **(Exhibit 2).**