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Policy Brief

Analysis of PR100 Summary Report

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San Juan, PR | Washington, DC | Madrid, Spain

March 2024

Introduction

On February 7, representatives of the U.S. Department of Energy ("DOE"), including Secretary Granholm, presented a summary of the findings of the PR100 Study. This was a two-year effort led by the DOE, with the collaboration of the University of Puerto Rico Mayaguez and other local stakeholders, to analyze and identify possible pathways for Puerto Rico to achieve its goal of generating 100% of its electricity from renewable energy sources by 2050.

While the PR100 Final Report will not be released until late March, in this policy brief we highlight some of the findings of the PR100 Summary due to their importance and their potential policy implications for Puerto Rico's electricity sector.

The Objective

The Puerto Rico Energy Public Policy Act of 2019 ("Act 17 of 2019") requires that Puerto Rico meet 100% of its electricity needs with renewable energy by 2050. In order to reach that objective, Act 17 set the interim goals of 40% renewable generation by 2025; 60% renewable generation by 2040; the phaseout of coal-fired generation by 2028; and a 30% increase in energy efficiency by 2040. By mid-2023, notwithstanding a significant increase in distributed solar PV generation (as opposed to utility-scale solar), only between 3% and 5% of the generation capacity available for the grid was from renewable sources. Furthermore, "achieving the 40% target by 2025 would represent an increase of at least 3 GW of additional renewable energy capacity if met with utility-scale solar" (PR100 Summary, p.1).

In plain English, this means that Puerto Rico is significantly behind schedule to meet the interim target of 40% renewable generation by 2025 and it is highly likely that Puerto Rico will miss it.

The Scenarios and their Variations

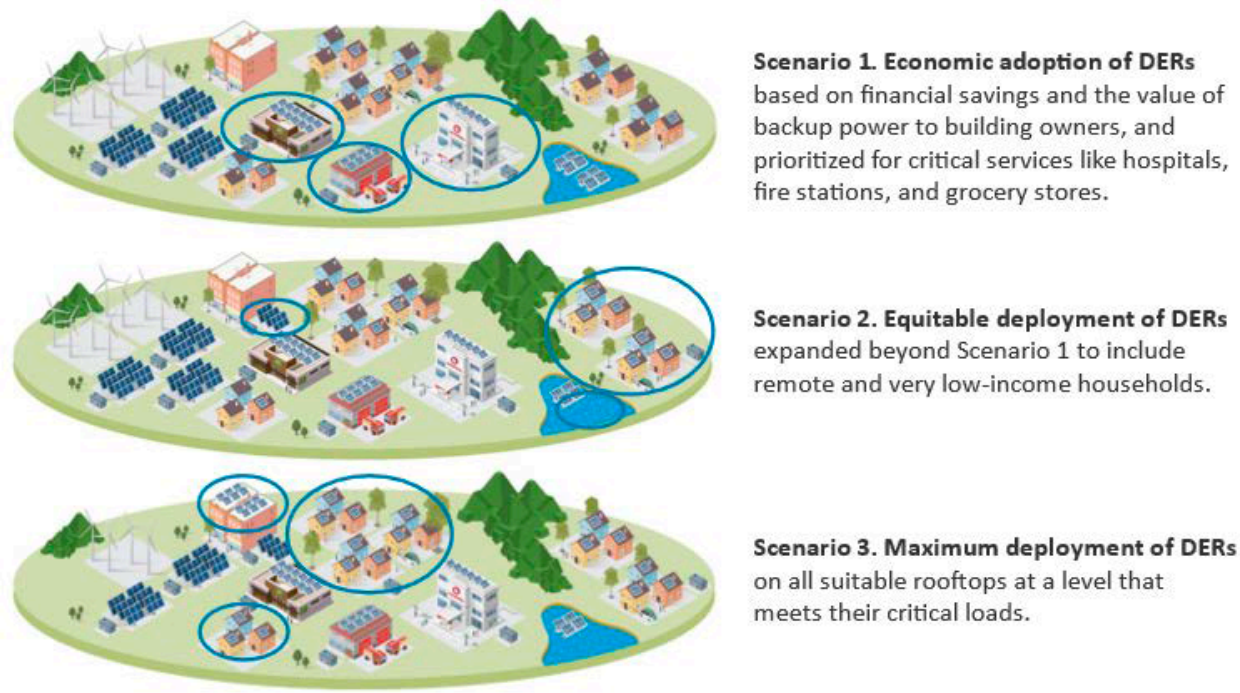
The DOE, together with several of the national labs and local stakeholders, defined three scenarios to meet the 100% target by 2050. **All three scenarios assume that "the transmission and distribution networks were repaired sufficiently to support reliable operation of the electric system, and that these repairs were completed with federal funding**" (PR100 Summary, p. 4). The scenarios are initially differentiated by varying the adoption level of distributed energy resources ("DERs").

Scenario 1 assumes the adoption of DERs is driven primarily by "economic factors and is based on financial savings and the value of backup power to building owners". It also prioritizes the deployment of DERs on "critical infrastructure such as hospitals, fire stations, and grocery stores" (PR100 Summary, p.7-8). This is called the "Economic" Scenario throughout the PR100 Study.

Scenario 2 extends the adoption of DER beyond the levels specified in Scenario 1 to include "very low-income households (0%-30% of area median income) and those in remote areas who would not have bought systems solely based on economics" (PR100 Summary, p. 8). This is called the "Equitable" Scenario.

Scenario 3 models the "maximum deployment of DERs on *all suitable rooftops* [our emphasis] at a level that meets their critical loads" (PR100 Summary, p. 8). This is called the "Maximum" Scenario.

The graphic below shows the three scenarios modeled in the PR100 Study, "distinguished by varying levels of DER adoption. Differences between scenarios are circled in blue."



Source: PR100 Summary, p. 8.

In addition, the authors also defined two variations regarding **(1) land use and (2) electric load** (demand) projections to 2050, to apply to each of the three scenarios.

The **land use variation**, in turn, has two variants: **(1) Less Land and (2) More Land**. The purpose of modeling this variation was to determine whether the 100% target by 2050 can be "met by developing utility-scale projects only on land not designated for agricultural purposes" or whether the use of agricultural lands would be required (PR100 Summary, p. 9).

In both land use variants, "development of utility-scale solar PV and wind is restricted from areas such as roadways, water bodies, protected habitats, flood risk areas, slopes greater than 10%, and agricultural reserves. **In the Less Land variant, development of utility-scale projects is also restricted from areas identified for agricultural use in the 2015 Land Use Plan"** (PR100 Summary, p. 9).

This analysis concludes that in the "More Land variant…638 km^2 [246.3 square miles] are available for solar development, with technical potential of 44.66 GW" while in the "Less Land [variant] the developable area is 203 km^2 [78.4 square miles] with technical potential of 14.22 GW" (PR100 Summary, p. 9).

The **electric load variation** also has two variants: **(1) the Mid case and (2) the Stress case**. Each case projects electric load out to 2050 taking into account (1) end-use demand variation due to changes in population, manufacturing employment, economic activity, and other variables; (2) increased demand from the adoption of electric vehicles ("EVs"); and (3) decreasing demand from the implementation of energy efficiency ("EE") measures.

The Stress case variant was expressly modeled to "help decision makers not to under plan in the event the load does in fact increase and to account for uncertainty in the inputs to the end-use load calculation" (PR100 Summary, pp. 9-10). **The development of this variant leads us to think that the DOE believes decision-makers in Puerto Rico could be underestimating the long-term demand for electricity on the island.**

The Mid case variant shows "slightly decreased end-use electricity sales over time, primarily due to forecasted long-term declines in population and real gross national product" (PR100 Summary, p. 10). On the other side of the spectrum, the Stress variant "assumes the combination of end-use loads and energy efficiency will result in flat annual electricity sales and electric loads from FY23 to FY51" (PR100 Summary, p. 10). When the adoption of EVs is added in, the electricity load increases moderately over time out to FY51.

In sum, the PR100 team modeled three scenarios with two variations and each with two variants, resulting in a total of 12 scenario variations. The scenarios are identified first by number and then by variation. For example, scenario 1LS means Scenario 1 (Economic), Less Land, Stress load. According to the PR100 Summary, there appears to be fairly small variation in the results among and between the scenarios during the next few years.

The key findings here are: (1) the DOE is assuming federal funding in the immediate to near term will be used to finance the repair of the transmission and distribution networks to support the reliable operation of the electric system before the deployment of DERs begins in earnest; (2) decisionmakers in Puerto Rico could be underestimating long-term electricity loads; and (3) "regardless of scenario or source of renewable energy, increased capacity is needed on the system immediately to achieve a robust electricity system for Puerto Rico" (PR100 Summary, p. 10).

Resource Assessment

The DOE executed assessments of the renewable energy sources in Puerto Rico to determine whether the potential of "solar, wind, hydro, and other sources is sufficient to meet Puerto Rico's goal of 100% renewable energy" (PR100 Summary p. 11). The main findings were (1) that Puerto Rico's **renewable energy potential** exceeds the projected loads out to 2050 by a factor of 10; (2) the 100% objective can be met using "mature" technologies such as utility-scale PV, distributed PV, and land-based wind; and (3) "utility-scale solar PV potential capacity on non-agricultural land is sufficient to meet total annual electric load to 2050." (PR100 Summary, p. 14).

However, the DOE also found that the costs associated with DER deployment under the Less Land variation are higher than the More Land variation, "across all modeled years and technology scenarios" (PR100 Summary, p. 12). This is due to (1) reduced economies of scale; and (2) the increased need for infrastructure (access roads, interconnections, etc.) under the Less Land variation, which would result in a greater number of smaller solar PV and land-based wind plants to be installed—more dispersed across Puerto Rico—when compared with the More Land variation.

In sum, the DOE found that the levelized cost of electricity ("LCOE") on average would be **$79/MWh under the Less Land variant** and **$75/MWh under the More Land variant**. A difference of $4/MWh, or 5.33%, which over some 25-odd years is quite significant.

From a policy perspective, the main finding here is that there appears to be a tradeoff between land use and energy affordability. That tradeoff, in turn, raises the question of which agency or entity should be in charge of deciding to choose one variant over the other.

Electric Load Forecasts

Forecasting long-term energy demand trends is one of the most complex issues in this planning exercise. The time horizon is too long, there are too many variables as well as multiple unknown unknowns (for example, the risk of a major hurricane striking the island ten years from now). Therefore, no one really knows what the demand for electricity will be in Puerto Rico twenty-five years from now. It is still necessary, however, to go through the exercise taking into account potential risks and uncertainties, in order to start the transition to achieve the 100% goal by 2050. This issue is also important in the court-led process to restructure the debt of the Puerto Rico Electric Power Authority ("PREPA") that is currently ongoing in federal court.

Given the importance of these forecasts, we will take a deeper look into the analysis and projections set forth in the PR100 Summary. As we mentioned above, the DOE executed its load analysis by analyzing three factors: (1) modeling various end-use parameters; (2) modeling the trajectory to achieve the statutorily mandated goal of a 30% increase in energy efficiency by 2040; and (3) projecting the adoption of EVs in Puerto Rico.

With respect to end-use parameters, the DOE took into account "future population size, changes to manufacturing employment, gross domestic product, and climate". Specifically, they analyzed "existing hourly end-use loads to determine if in the future these profiles would increase or decrease from year to year" (PR100 Summary, p. 15). As noted above, the DOE found that end-use loads are anticipated to decrease across Puerto Rico by 2050 in the Mid case trajectory, based primarily on population and economic forecasts.

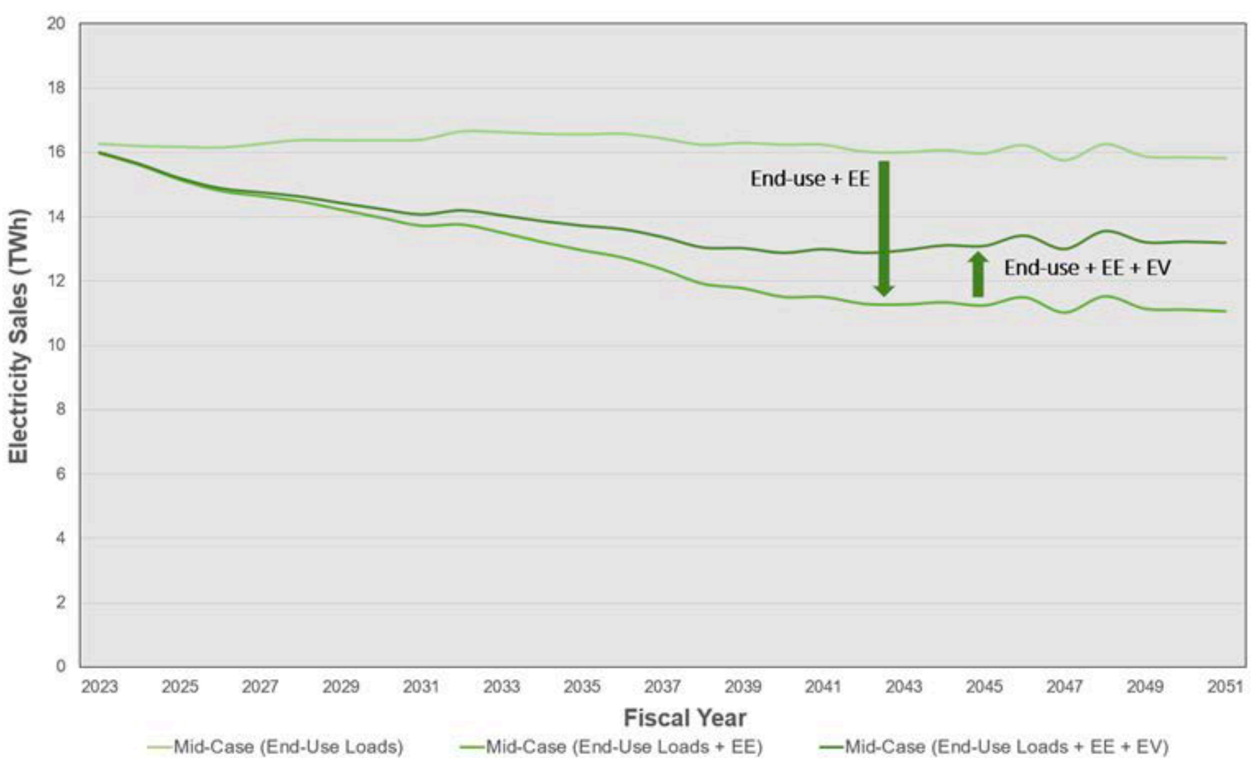
In terms of energy efficiency, the DOE carried out two modeling exercises, using different methodologies, to ascertain the feasibility of achieving a 30% increase in energy efficiency (which everything else being equal would result in a reduction in loads) by 2040. Their main finding in this area was that "achieving the 30% goal is ambitious as compared with the bottom-up analysis results which show an 18% increase [in energy efficiency] by 2050" (PR100 Summary, p. 15).

The DOE also projected the adoption of electric vehicles (light as well as medium and heavy-duty) and their contribution to electric load. The key finding here is that the DOE estimates that 25% of light-duty vehicles and 48% of medium- and heavy-duty will be electric by 2050 (PR100 Summary, p. 15).

Finally, the DOE modeled a Stress load forecast "which assumes the combination of end-use loads and energy efficiency will result in flat annual electricity sales and, due to the addition of EV loads, load trajectory increases" (PR100 Summary p. 15).

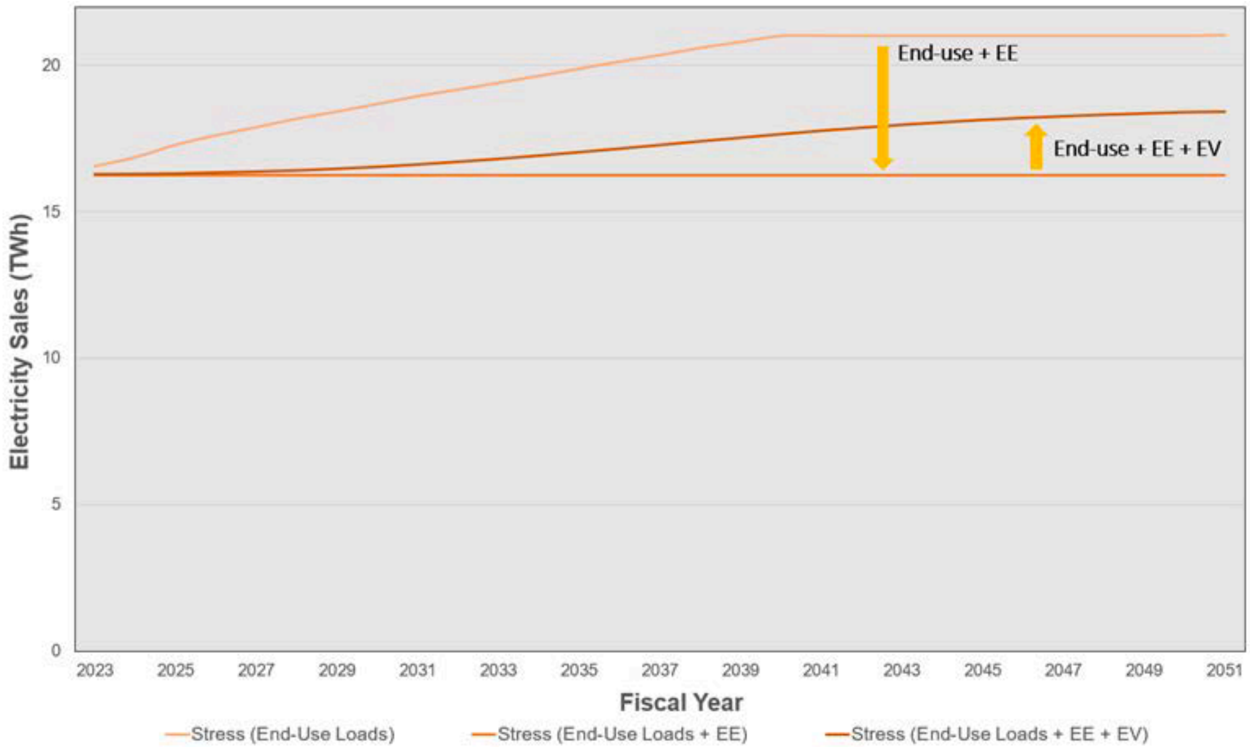
According to LUMA, **total electricity sales in Puerto Rico were 16,282 GWh in FY22**. The two variants modeled by the DOE forecast the following paths out to FY2051:

In the Mid case, sales decrease to 14,240 GWh in FY30 and to 13,192 GWh in FY51, a decrease of 1,048 GWh, or 7.4% relative to FY30, with EVs accounting for 2% of electricity sales in FY30 and 16% in FY51. The graph below shows the projected load decline in the Mid case.



Source: PR100 Summary, p. 16.

In the Stress case, **sales are projected to increase to 16,537 GWh in FY30 and to 18,422 GWh in FY51**, an increase of 1,885 GWh, or 11.4% relative to FY30, with EVs accounting for 2% of sales in FY30 and 12% in FY51. The graph below shows the projected load increase in the Stress case (PR100 Summary, p. 15).



Source: PR100 Summary, p. 16.

Notice that the difference between both trajectories is 5,230 GWh by FY2051, equivalent to 32% of actual total electricity sales in FY22. This is a huge margin of error, which unfortunately is inevitable given the nature of the exercise.

The DOE by modeling a Stress case with increasing load appears to be suggesting that decision-makers in Puerto Rico could be *underestimating* future loads and should take into account the Stress scenario in their planning. This is an interesting suggestion, given a recent op-ed published in El Nuevo Día by Dr. Ramón Cao, a former professor of econometrics at the University of Puerto Rico, suggesting that the Financial Oversight and Management Board for Puerto Rico ("FOMB") could be *overestimating* demand for electricity over the next 25 years in the forecasts it has filed with the federal court in connection with PREPA's Plan of Adjustment. Just to be clear and for the avoidance of doubt, we are not suggesting one estimate is better or more accurate than the other. We are simply pointing out the radical uncertainty surrounding these long-term forecasts.

Given this level of uncertainty, we recommend that representatives of the DOE, the FOMB, Genera, LUMA, PREPA, and the Puerto Rico Energy Bureau ("PREB") meet and seek agreement on a single set of forecasts out to 2050 and that the same projections be used for both the development of PREPA's new Integrated Resource Plan ("IRP") and in PREPA's financial Plan of Adjustment that will be eventually certified by the federal court. It would be irrational to use one set of load forecasts for operational planning purposes (the IRP) and another for financial planning purposes (the Plan of Adjustment).

At this time, though, we do need more information about the methodology used by the DOE to forecast electricity demand over the long term in order to reach any conclusion regarding the reasonableness of its estimates. Specifically, we need to know whether the DOE estimated demand functions for commercial, industrial, and residential users; the price elasticities used and how they were calculated; and additional information regarding their energy efficiency estimates. We hope this additional information will be available in the Final Report of the PR100 Study to be issued in late March.

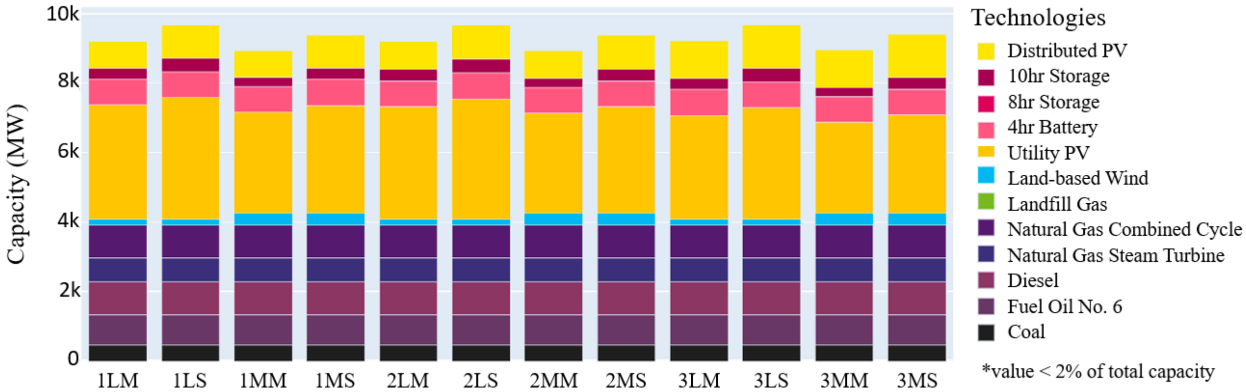
In sum, the key finding here is that there is significant uncertainty regarding future electric load in Puerto Rico. According to the DOE modeling, final demand by FY2051 could be as low as 13,192 GWh or as high as 18,422 GWh. Further information is needed to analyze the reasonableness of these results.

RENEWABLE CAPACITY EXPANSION

After forecasting loads out to 2050, the DOE then proceeded to model capacity expansion to find the lowest-cost system for each scenario while meeting load requirements. The first key finding here is that even if all six tranches of PREPA's renewable energy generation and storage plan are executed as intended (something that will NOT happen as PREPA is already at least two years behind schedule in executing this plan), **significant new investment in additional generation capacity, "on the scale of hundreds of megawatts**", is needed immediately to achieve "acceptable reliability performance" (PR100 Summary, p. 21). **It is not clear from the PR100 Summary exactly how much new capacity is needed nor how such investment would be financed in the short term.**

In order to achieve the 40% goal of renewable energy by 2025, "the optimal expansion planning results include 2,600—3,500 MW of utility-scale capacity, depending on the scenario, along with approximately 700 MW of 4-hour duration utility-scale batteries, 260—400MW of long-duration storage, and 170—340MW of land-based wind" (PR100 Summary, p. 21). During this phase, much of the existing fossil-fueled generation remains in place.

The chart below sets forth the modeling results by scenario to achieve 40% renewable energy generation by 2025:

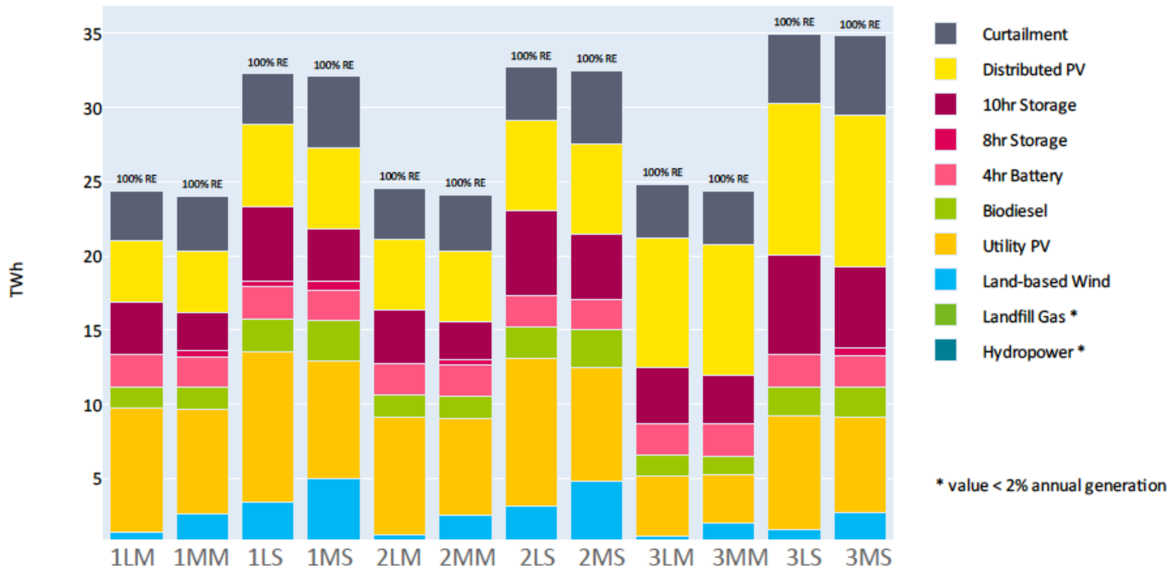


Source: PR100 Summary, p. 21.

We note that the DOE asserts that "the current pace of utility-scale deployment is **likely too slow to result in 40% renewable energy by the 2025** statutory deadline and a reliable grid in the near term" (PR100 Summary, p. 21). **Thus, there appears to be another tradeoff, in this case between meeting the 40% goal by 2025 and achieving acceptable grid reliability in the short-term.**

To achieve 100% generation from renewables by 2050, the "optimal mix of resources includes the addition of energy storage and biodiesel engines to serve system energy demands during periods of low wind and solar output" (PR100 Summary, p. 22). According to the DOE, "**once all fossil-fueled plants are retired the system requires some biodiesel engine capacity (or a similar alternative resource) that can operate for prolonged periods.**" To our knowledge, the requirement to use biodiesel engines by 2050 to meet demand during periods of low wind and solar output is new. We are not familiar with this technology and would need more information before reaching any conclusions regarding the feasibility of its future use in Puerto Rico for the generation of electric power.

The chart below sets forth the total annual electricity generation by scenario to meet 100% renewable generation by 2050:



Source: PR100 Summary, p.22.

Finally, the DOE found that curtailment (reduction) of solar generation capacity in 2050 is "notable." According to the PR100 Summary, "the expectation is that variable sources of renewable energy are curtailed somewhat regularly to balance the system; this is a common finding in 100% renewable energy studies and is still the least-cost system solution" (PR100 Summary, p. 23).

The main findings with respect to rollout of renewable generation in Puerto Rico are: (1) there is a need for hundreds of MW of new generation capacity in the immediate term to ensure grid reliability; (2) the current pace of utility-scale solar deployment is too slow to meet the 40% goal by 2025; (3) the optimal resource mix suggested by the DOE to meet the 100% objective includes generation from biodiesel engines; and (4) curtailment of significant solar capacity appears to be necessary to balance the system in the long-term.

Transmission and Distribution Issues

It is well-known that Puerto Rico's transmission and distribution system ("T&D System") has severe problems. In this section, we highlight two issues that were identified by the DOE.

On the transmission side, the DOE found that the lower-voltage (38-kV) transmission network components are insufficient to handle the projected system transitions because "the number of new generation interconnections and amount of distributed generation capacity significantly alters the flow patterns on the local transmission infrastructure that is predominantly served by 38-kV assets" (PR100 Summary p. 23). Furthermore, several mitigating actions are required to **"avoid frequent and debilitating 38-kV network overloads even at 40%-50% renewable energy"**, regardless of the scenario (PR100 Summary, p. 24). Therefore, this is an issue that will need to be addressed relatively soon if Puerto Rico is serious about meeting the 100% renewable goal by 2050.

On the distribution side, the DOE found that (1) some feeders in Puerto Rico today operate outside the standards of the American National Standards Institutes Range A voltages, even with no solar PV generation; and (2) "uncontrolled distributed PV capacity under PR100 Scenarios 1, 2, and 3 was found to exceed 65%-95% of the studied distribution feeders' hosting capacities, due to issues such as backfeeding and PV-caused voltage violations" (PR100 Summary, p. 28).

With respect to the first issue the DOE assumed that those feeders would be corrected to operate within American National Standards Institutes Range A voltages. The PR100 Summary does not include an estimate of the cost of carrying out these repairs nor of any financing sources available to pay for them. To address the second issue, the DOE identified several mitigation strategies that were found to eliminate "nearly all" of the negative impacts of high distributed PV generation.

The main finding here should not be surprising to anyone familiar with Puerto Rico's power grid. Significant work needs to be done to bring the island's T&D System up to 21st-century standards even as Puerto Rico begins the transition to achieve 100% renewable generation by 2050.

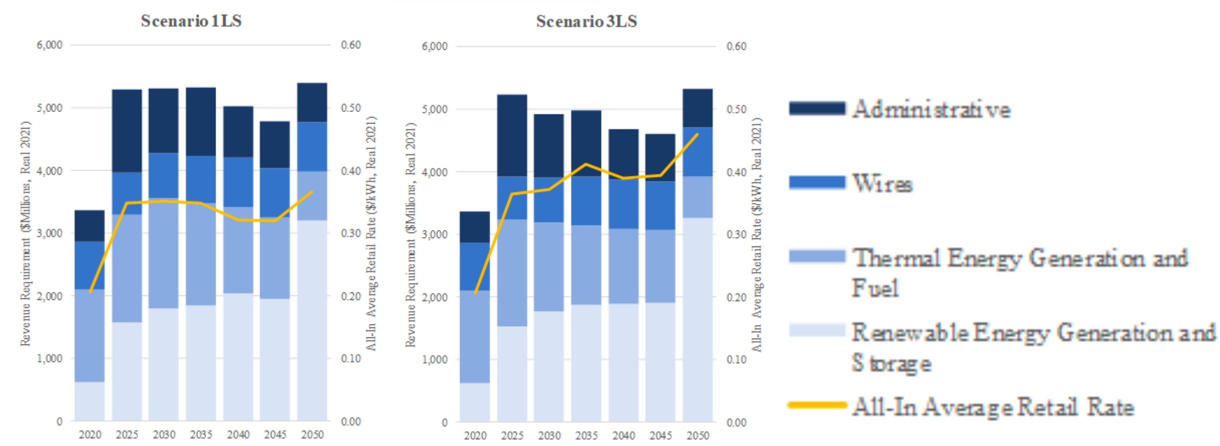
Economic Impact Analysis

The transition to 100% renewable energy is costly. New investment is needed to improve the T&D System, bring online new generation capacity, acquire and install large-scale battery storage systems, and build out the necessary infrastructure (access roads, new interconnections with the T&D System, etc.) to achieve the statutory objective by 2050. All this new investment needs to be financed in some way.

In this section, we will look at the principal findings set forth in the PR100 Summary regarding the economic impact of making the required investments to achieve full renewable generation. By definition, the findings in the PR 100 Summary are incomplete, as it is only a summary of the full study. It does not include an analysis of the reduction in the social burden and environmental costs associated with the transition to 100% renewables nor does it present the full results of its economic analysis or the methodology for executing that analysis. The PR100 Summary is also remarkably silent as to financing alternatives, a topic we will take up in the next section.

Notwithstanding those limitations in the content of the summary, the DOE is quite clear upfront about the magnitude of the costs involved. The DOE **"found that the utility-incurred costs to transform Puerto Rico's electric grid to one that is reliable will be significant regardless of the mix of generation technologies"** (PR100 Summary, p. 28). The PR 100 Summary presents the cost estimates for two scenarios (1) Scenario 1, Less Land, Stress Load ("1LS") and (2) Scenario 3, Less Land, Stress Load ("3LS").

In general, the principal finding is that **the "utility must charge substantially higher all-in average retail rates in Scenario 3LS than Scenario 1LS because the former has 20% less utility-sold electricity than the latter"** (PR100 Summary, p. 28). The charts below show the revenue required by the utility in order to cover its costs under the two scenario variations as well as an estimate of the all-in average residential rate over time in 2021 dollars.



Source: PR100 Summary, p.29

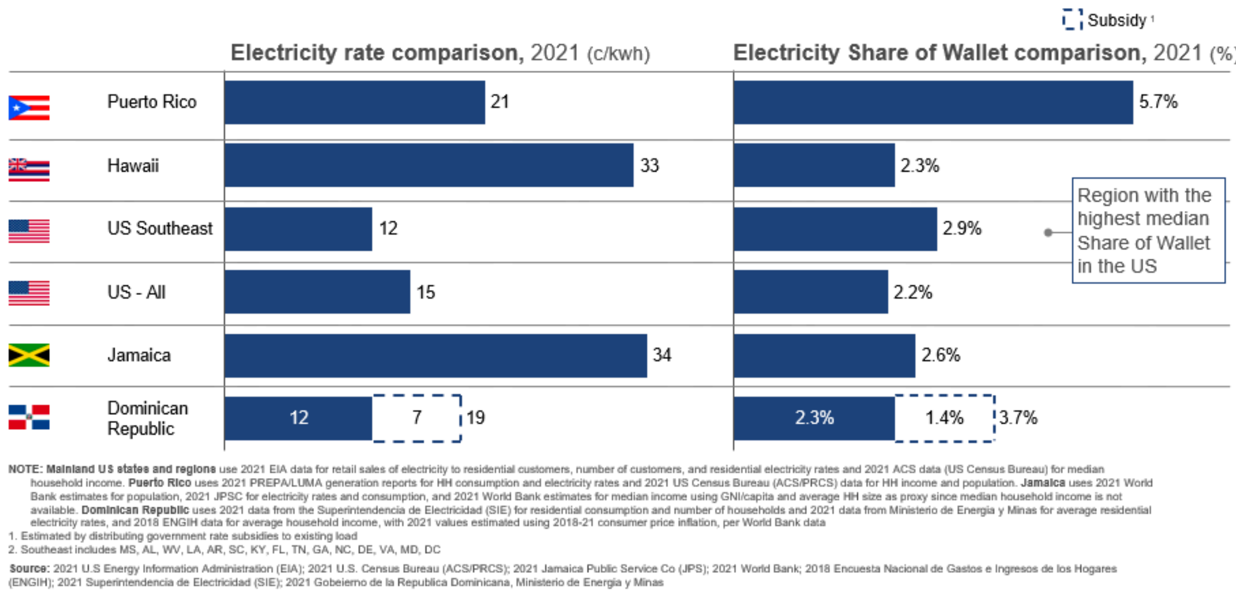
The yellow line shows how the **all-in average retail rate** evolves over time as new investments are made to achieve the 100% renewable objective. **Under both scenarios there is a sharp increase in average retail rates between 2020 and 2025, estimated to be between 66% and 83%,** driven by several factors (1) investments in the near term to achieve resource adequacy and grid stability; (2) the procurement of new renewable generation and storage systems; (3) the need to keep using fossil fuel generation while ramping up renewable generation at the same time; (4) the costs of new energy efficiency programs; and (5) the costs of paying PREPA's legacy debt and pension obligations. We note that under scenario 1LS, the average retail rate per kWh increases from approximately 21 cents in 2020 to about 34 cents by 2025; while under scenario 3LS the average retail rate per kWh increases to approximately 38 cents by 2025 in 2021 dollars.

After this initial period, costs stabilize and utility revenue requirements **decline between 9% and 24%** during the period between 2025 and 2045, as fossil-fuel generation is retired and replaced by renewable capacity, which lowers fuel and other associated costs over time.

Finally, between 2045 and 2050 "the system experiences notable cost increases that would be incurred by any system moving from already high levels of renewable energy to 100% renewable energy" (PR 100 Summary, p. 29). According to the DOE, this cost increase is due to the retirement of any remaining fossil-fuel generation units and replacing "the firming and balancing function they perform at high levels of renewable energy (i.e., supplying energy only on an as-needed basis when renewable generation is low and storage reserves are exhausted, for example during periods with several cloudy days in a row)" (PR 100 Summary p. 29). The estimated impact on the all-in average retail rate of this cost increase is estimated to be **between 11% and 17%** (PR100 Summary, p. 30).

Under both scenarios, then, there is a sharp increase in the all-in average retail rate in the short-term, followed by a period of relative rate stability during the medium to long term, and then another significant increase as the final push to 100% renewable generation is made during the 2045-2050 period.

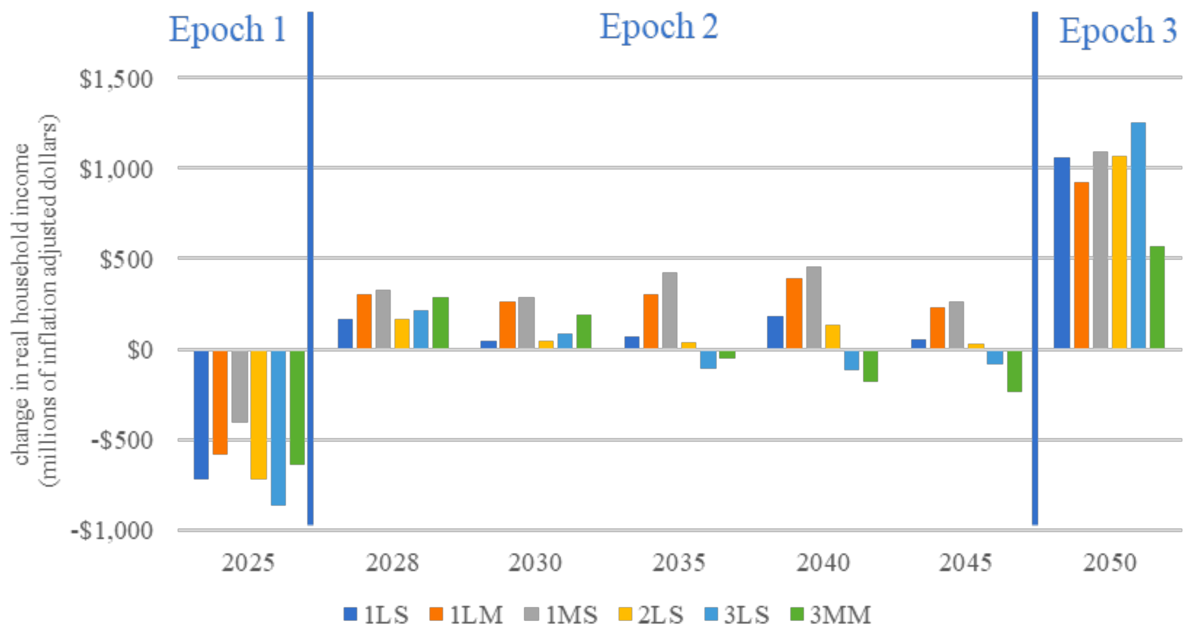
While we don't have access yet to the full economic analysis carried out by the DOE, we can assert with a high degree of confidence that an increase of 66% to 83% in the average retail rate in the short term **would have severe, materially adverse effects on the Puerto Rican economy**, in terms of GNP, GNP growth, employment, consumption, and income for several reasons. First, the Puerto Rican economy is just recently finding its legs after a prolonged period of secular stagnation. Second, the post-disaster reconstruction of the island's infrastructure has been delayed and it is still an ongoing process. Finally, if we focus specifically on residential customers, the electricity cost share of wallet (electricity expenditures as a percentage of household median income) in Puerto Rico is already the highest in the United States and among the highest in the Caribbean region as shown in the chart below:



Source: FOMB, 2023 Certified Fiscal Plan for the Puerto Rico Electric Power Authority, p. 44.

An increase in the retail rate of the magnitude estimated by the DOE is simply not economically feasible given the current state of the Puerto Rican economy. This means that it will be necessary to mitigate this impact, either through subsidies, extending the timeline for achieving the transition to 100% renewables, a different technology mix, or through other policies.

The DOE also executed an analysis of the net impact of the transition to 100% renewable generation on real household income ("HHI") in Puerto Rico. Presumably, that analysis takes into account both the costs associated with the transition to renewables as well as any positive income and employment effects associated with the new investment needed to carry it out. The chart below shows the real HHI effects (in millions of dollars) of six scenarios for all years through 2050:



note: effects in 2025 are relative to 2022 level and those in 2028-50 are relative to 2025 levels.

Source: PR100 Summary, p. 30.

As expected, the short-term impact of the transition on HHI is negative, followed by a modest positive impact between 2025 and 2045, and then a significantly positive effect by 2050. Note that if HHI decreases over the short term it is highly probable that consumption expenditures, employment, and real GNP will also decrease over the same period. However, we don't have information at this point regarding the magnitude of those additional short-term economic effects.

Finally, we note that Scenario 3LS, which maximizes roof-top solar installations, uses less land, and assumes stress load conditions, produces the largest negative impact on HHI in the short term, and has a modest positive effect on HHI between 2025 and 2035, followed by a modest negative impact between 2040 and 2050. By 2050, however, it will have the largest positive effect on HHI. **Therefore, there is a clear tradeoff in this scenario between economic costs to be incurred in the short term and economic benefits to be realized in the long term. Policymakers will have to take into account this explicit tradeoff when deciding which scenario to implement.**

Financing the Transition

The PR100 Summary provides little information regarding the potential sources for financing the transition to 100% renewables. Footnote 2 on page 1 of the PR100 Summary sets forth the following sources of federal financing ("obligated funds") for restoring and building a more reliable and resilient energy system for Puerto Rico:

- FEMA Hazard Mitigation Assistance: $7.8 billion
- FEMA Public Assistance: $9.5 billion
- HUD Community Development Block Grant ("CDBG") funds (Electric Grid): $1.9 billion
- HUD CDBG Community Energy and Water Resilience Installations Program: $800 million
- DOE Puerto Rico Energy Resilience Fund: $1 billion

Thus, a total of $21 billion in federal funds has been "obligated" to improve Puerto Rico's electric system. Most of that money, approximately $19.2 billion, or 91%, has been earmarked for improving the T&D System. The rest has been used so far to finance the installation of rooftop solar systems. The PR100 Summary, however, does not state whether these amounts are sufficient to cover all the repairs needed to upgrade the T&D System. With respect to new generation capacity, it is already known that additional resources are needed to finance rooftop solar and battery systems as well as utility-scale solar PV and wind generation systems.

We note that there is a political risk that arises from depending solely or mostly on federal funding for modernizing the grid and financing DERs for low-income households. It is possible, under certain circumstances, to rescind the obligation of federal funds (sometimes referred to as the "deobligation" of funds). The political risk would arise in the event that Donald Trump wins the next presidential election in November 2024.

The first Trump Administration imposed unduly burdensome requirements on Puerto Rico and significantly delayed the obligation of CDBG funds, as evidenced by a report issued by the Office of the Inspector General of the Department of Housing and Urban Development and other sources. A Trump victory in November could put at risk funding not only for the modernization of the grid but for the entire reconstruction process. Puerto Rico would be well advised to plan for such an eventuality by identifying and designing litigation, public advocacy, and political lobbying strategies in advance of the coming election.

Finally, it would be useful if the final PR100 Study included a breakdown, by scenario and system segment (transmission, distribution, generation, energy storage, access infrastructure, etc.), of (1) all the capital expenditures required to achieve the 100% goal by 2050 and (2) of potential financing sources for each of these expenditures. We also propose that COR3/LUMA or perhaps the DOE publicly disclose all relevant information regarding the allocation of approved federal funding.

CONCLUSION

The PR100 Summary appears to present a good preview of the findings of the PR100 Study. From the Summary it seems that the PR100 Study is a thorough and thoughtful analysis carried out by a respected group of stakeholders. It is a welcome contribution to the public debate and a valuable resource for those who analyze and study Puerto Rico's electricity system.

In our view, these are some of the most important findings:

- It is feasible to achieve the objective of 100% renewable energy generation in Puerto Rico by 2050 without using agricultural lands for developing utility-scale generation.
- The 100% objective can be met using "mature" technologies such as utility-scale PV, distributed PV, and land-based wind (but see caveat regarding biodiesel fuel below).
- Regardless of scenario, Puerto Rico needs to make significant investments in the T&D System and new generation capacity just to improve system stability and reliability in the immediate term.
- There are significant tradeoffs between resilience (Scenario 2 and 3) and energy affordability (Scenario 1); between land use and energy affordability ("less land scenarios" tend to be more expensive); between meeting the 40% goal by 2025 and achieving acceptable grid reliability in the short-term; and between incurring short-term costs to obtain long-term benefits, depending on the scenario to be implemented.
- In general, scenarios with higher deployment of DERs using less land tend to be, on average, more expensive than other scenarios, result in higher rates for the consumer, and induce greater short-term adverse effects on the Puerto Rican economy.
- The existence of these tradeoffs raises the question of which agency or entity should be in charge of making these decisions. We strongly recommend that the PREB be in charge of making these decisions.
- The levelized cost of electricity on average would be $79/MWh under the Less Land variant and $75/MWh under the More Land variant. A difference of $4/MWh, or 5.33%, which over some 25-odd years is quite significant.
- Decisionmakers could be underestimating long-term electricity loads and should take into account this risk when planning for the long term.
- The difference between the Mid case and the Stress case variants is quite significant, some 5,230 GWh by FY2051. This is a large margin of error and the uncertainty regarding this forecast should be taken into account when drafting the next IRP and PREPA's Plan of Adjustment.

- Given this level of uncertainty, we recommend that representatives of the DOE, the FOMB, Genera, LUMA, PREPA, and the PREB meet and seek agreement on a single set of forecasts out to 2050 and that the same projections be used for both the development of PREPA's new IRP and in PREPA's financial Plan of Adjustment that will be eventually certified by the federal court. It would be irrational to use one set of load forecasts for operational planning purposes (the IRP) and another for financial planning purposes (the Plan of Adjustment).

- The DOE estimates that the current pace of utility-scale solar deployment is too slow to meet the 40% renewable energy goal by 2025.

- According to the DOE, the optimal resource mix to meet the 100% objective includes generation from biodiesel engines. This appears to contradict the DOE's prior finding that it is feasible to attain the 100% renewable generation goal using only "mature" technologies. However, we need additional information about the commercial viability of this fuel source, a list of potential suppliers, and a procurement analysis, among other things, to determine whether biodiesel is a good long-term option for Puerto Rico.

- The economic cost of the transition to 100% renewable energy by 2050 is quite significant, regardless of the scenario.

- According to the DOE, the all-in average retail rate would increase between 66% and 83% between 2020 and 2025 in 2021 dollars, depending on the scenario.

- A rate increase of this magnitude would have severe, material adverse effects on the economy of Puerto Rico in the short term and is simply not economically feasible. It will be necessary to mitigate these negative effects, either through subsidies, an extension of the timeline for achieving the transition, a different technology mix, or through other policies.

- The DOE estimates that the short-term impact of the transition on household income is negative, followed by a modest positive impact between 2025 and 2045, and then a significantly positive effect by 2050. We note that if household income decreases over the short term it is also highly probable that consumption expenditures, employment, and real GNP will decrease over the same period. However, we don't have any information at this point regarding the magnitude of these additional short-term economic effects.

- The PR100 Summary provides remarkably little information regarding the sources for financing the full transition to 100% renewable energy by 2050.

- Finally, a Trump victory in November could put at risk funding not only for the modernization of the grid but for the entire reconstruction process. Puerto Rico would be well advised to plan for such an eventuality by identifying and designing litigation, public advocacy, and political lobbying strategies in advance of the 2024 election.

In addition, we find that more information is needed in the following areas:

- **Load Forecasts:** we need more information about the methodology used by the DOE to forecast electricity demand over the long term in order to reach any conclusion regarding the reasonableness of its estimates. Specifically, we need to know whether the DOE estimated demand functions for commercial, industrial, and residential users; the price elasticities used and how they were calculated; and additional information regarding their energy efficiency estimates.

- **Biodiesel Fuels:** We are not familiar with this technology and need more information before reaching any conclusions regarding the feasibility of its future use in Puerto Rico for the generation of electric power.

- **Economic Impact Analysis:** We need more information regarding the economic impact of rate increases in the short term on GNP level, GNP growth, employment, income, and consumption expenditures in order to assess the economic feasibility of the different scenarios.

- **Total Capital Expenditures and Sources of Financing:** it would be useful if the final PR100 Study included a breakdown, by scenario and system segment (transmission, distribution, generation, energy storage, access infrastructure, etc.), of (1) all the capital expenditures required to achieve the 100% goal by 2050 and (2) potential financing sources for each of these expenditures.

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