

Energy Policies in Puerto Rico and their Impact on the Likelihood of a Resilient and Sustainable Electric Power Infrastructure

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ABSTRACT

Hurricane María uncovered the vulnerabilities and frailties of Puerto Rico's electric infrastructure--in particular, the anachronism of the present fossil-based, centralized generation in a Caribbean island with an excellent, distributed solar resource. However, transitioning to a different, more resilient and sustainable infrastructure requires much more than just bringing technological gadgets to communities or implementing microgrids. Without an understanding of Puerto Rico's social contexts and its energy policy history, any transformation initiative is at risk of failure, or as has happened in the past, will mostly benefit the many outsiders anxious to make business while leaving Puerto Ricans with technological nightmares or unintended consequences. This paper strives to remind policymakers (local and federal) of recent local policies and discuss how their outcomes exemplify the challenges that need to be addressed for a transition to a more distributed, sustainable and resilient electric infrastructure while truly fostering local socio-economic development. [Keywords: Electric energy, PREPA, sustainability, energy policy, electric infrastructure, distributed energy]

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Introduction

After hurricane María hit Puerto Rico, all essential services, water, communications and electric energy collapsed. Many roads were destroyed, damaged, flooded, or obstructed due to landslides. News from some areas in Puerto Rico, especially the center of the island, were impossible to get due to an almost complete collapse of the communication infrastructure of the island. Furthermore, federal relief after the disaster arrived later and more slowly to Puerto Rico when compared to other affected areas in the continental U.S. This is due to the islanded condition and the distance from the closest continental U.S. port, as well as specific policy and institutional reasons. Had this been an earthquake, the death toll would have been enormous because the state government did not have the tools for a quick and efficient response. Hurricane María showed how vulnerable and alone Puerto Ricans are.

Why was the aftermath of María different than other post-hurricane recoveries? The winds and rain were unprecedented for modern Puerto Rican society; thus, the damage was unprecedented as well. The strongest hurricane in the last 80 years to go over Puerto Rican land (Georges) was a Category 3 hurricane. At the time (1998), Puerto Rico's economy was not as weakened as it had been previous to María; infrastructure-related agencies were still financially stable and were able to respond immediately; additionally, communications did not collapse completely after Georges.

The Federal government must ensure that the emergency relief and reconstruction funds are used effectively, not only for the immediate crisis, but to begin addressing the many aspects of emergency response that need fixing in the territory. This kind of approach will help reduce the amount of relief funds required during and after future emergencies, especially for the electric infrastructure. However, transitioning to a different, more resilient and sustainable infrastructure requires much more than just bringing technological gadgets to communities or implementing microgrids.

The first part of the paper provides relevant background on Puerto Rico and on its electric power infrastructure. Without an understanding of Puerto Rico's social contexts any transformation initiative risks failure, or as has happened in the past, will mostly benefit the many outsiders anxious to make business while leaving Puerto Ricans with technological nightmares or unintended consequences. Geri and McNabb's *Energy Policy in the U.S.: Politics, Challenges, and Prospects for Change* is used as framework to explain some of the outcomes of recent energy policies. Fur-

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thermore, how PREPA's transformation efforts fell short is discussed. Finally, despite the deep financial problems and the aftermath of María, the potential for true transformative actions is looked at, emphasizing local distributed energy resources.

This paper is a reminder, especially for policymakers (local and federal), of recent local energy policies and discuss how their outcomes exemplify the challenges that need to be addressed for a transition to a more sustainable and resilient electric infrastructure while truly fostering local socio-economic development. In this article it is argued that the introduction of new technologies and Federal funding for infrastructure are not enough for a transition toward a sustainable and resilient electric infrastructure. For a transition in this direction, PREPA's governing structures should be decentralized and participatory, infrastructure investments should aim at a sustainable energy model and reforms should be framed with participation of all local political parties. The reform initiatives undertaken between 2007 and 2014 are used as case studies to show how recent experiences can inform proposed reforms. Process tracing was used as the method for analyzing the official documents and secondary sources used for documenting this study. The importance of using process tracing in this research is that it allows us to build a comprehensive and accurate account of the policy process used as a case study (Ludwig 2015, 5).

Brief History of Puerto Rico's Electric Power Infrastructure

A key factor of Puerto Rico's "economic miracle" in the mid-20th century was the electrification of the territory. This occurred with support from the Federal government through the "Puerto Rico Emergency Relief Administration" (PRERA), established in 1933 to give special attention to Puerto Rico's dire conditions during the Great Depression. In 1935 PRERA was substituted by the Puerto Rico Reconstruction Administration (PRRA), which used a two-pronged approach: dealing with unemployment and establishing an economic reconstruction program, including the rural electrification program, that allowed the construction of hydroelectric plants and distribution lines (Látimer 1993). Puerto Rican engineer Antonio Lucchetti was in charge of the local and federal efforts related to the hydroelectric program. In 1941 the Puerto Rico Water Resources Authority (AFF, its acronym in Spanish) was created through Act 83 to plan, design, construct, operate and maintain Puerto Rico's electric infrastructure. It has been the sole provider of electricity in Puerto Rico since 1941. It used the Tennessee Valley Authority (TVA) as a model to create a public power company (owned by the state government). Before that, private companies dominated the electric sector focusing on areas where their business could prosper, while not serving rural and remote areas. As part of the plans to take many Puerto Ricans out of the dire conditions they lived in during the 1930s, Antonio Lucchetti proposed to integrate all electric power systems in Puerto Rico. It was a socio-economic development strategy in which economies of scale would make electricity cheaper, industrial activity could be promoted and electricity would be affordable for more people. The private companies did not accept this easily, and complicated

court battles ensued. In the end, war time circumstances enabled the last acquisition of private power companies and the AFF was on its way to complete its mission: the electrification of Puerto Rico (Látimer 1993). Without the AFF's leadership, Puerto Rico's electrification would not have been as fast and as inexpensive as it was. It is important to emphasize that Lucchetti placed much attention in responsibly managing municipal bond issuances to build and support AFF's key infrastructure projects.

Before María hit, Puerto Rico's electric power infrastructure had an installed generating capacity of more than 5,000 MW, transmission lines of 230 kV and 115 kV, a sub-transmission system of 38 kV and thousands of distribution lines of diverse voltages (13.2 kV, 8.32 kV, 7.2 kV, 4.16 kV). A key technical weakness was that most of the central generating capacity is in the south, while the area with the largest power demand (and economic activity) is in the north. Thus, the transmission lines going from south to north were vital for Puerto Rico's economy and daily life⁴ (Ortega 2017). The isolated nature of the electric system means that Puerto Rico does not have external support in case of major power disruptions.

PREPA's planning and operating vision was based on hierarchical control, centralized generation and top-down planning, with a condescending attitude toward non-PREPA persons, who just "could not understand the complexity of the electric grid."

The AFF successfully accomplished its founding mission in the 1970s. By then, many people began pointing out the need to make reforms to the AFF. This reform movement was fueled by the OPEC embargo of 1973, and indeed, many good initiatives took place, including the creation of a state energy office in 1977 to lead energy policy development and implementation in Puerto Rico. Unfortunately, once the '70s and early '80s oil crises went away, many of those reforms were abandoned or limited (O'Neill 2012). Even though its name changed in 1979 to the Puerto Rico Electric Power Authority (PREPA), the corporation's mission essentially remained the same as the one given in 1941.

Efforts to reform PREPA were unsuccessful through the '80s, '90s and the first decade of the 2000s. Some groups insisted on reforming PREPA, and many ideas were presented to do just that. However, PREPA's management would repeatedly oppose any proposed changes arguing that it was against their given mission of providing electricity at the least cost possible. PREPA's management lobbied periodically in the Legislature to stop attempts to amend PREPA's law and its mission, claiming possible breaches of the Trust Agreement with bondholders. In many of these cases, PREPA would be supported by the Government Development Bank (BGF, its acronym in Spanish). PREPA's planning and operating vision was based on hierarchical control, centralized generation and top-down planning, with a condescending attitude toward non-PREPA persons, who just "could not understand the complexity of the electric grid." In

a way, PREPA's management, through the last forty years, acted in the same way that the private companies did when they opposed the integration of the disconnected, private electrical systems in Puerto Rico: clinging to a way of running electrical systems that was losing touch with what Puerto Rico needed from its electric infrastructure.

Meanwhile, the social, environmental and economic costs of existing energy sources and practices continued to grow, and Puerto Ricans got used to patterns of inefficient and irresponsible energy use. Through the last quarter of the 20th century the territory remained 99 percent dependent on oil, the most expensive and polluting fossil fuel. This resulted in uncertainty in electricity prices (the cost of fuel was a pass-through charge to customers in the electric bill). The oil dependence was reduced in the early 2000s, when two independent power producers began operations in Puerto Rico. EcoEléctrica & AES use natural gas and coal, respectively, to generate electric power that they sell directly to PREPA under the federal mandate of the Public Utilities Regulatory Act (PURPA). However, Puerto Rico still depends on fossil fuels, not available locally. Furthermore, the environmental costs of coal and oil are still not properly accounted at the local or federal levels.

There were many factors that led to PREPA's financial debacle, such as the exodus of 1,000 industrial clients, excessive electric energy use patterns and the lack of public engagement. However, there were two main causes of PREPA's crisis: the multiple and constant interventions from party politics and politicians; and a narrow planning vision. Every political party that governed Puerto Rico used PREPA and other public institutions for its own purposes (Pantojas-Garcia 2016; Glanz and Robles 2018). As a public power company, it is acceptable for a Governor to provide policy direction to decisions related to electric infrastructure. In PREPA's case, however, policy directions were distorted, and sometimes supplanted by political directions, thus crushing the benefits of having an autonomous, public power company leading and managing the local electric infrastructure. For example, PREPA did not change its basic rates for 27 years (1989 to 2016), mainly due to political intervention even though by the late 1990s and early 2000s (after the departure of about 1,000 industrial clients); it was evident the basic rate structure was not enough to maintain PREPA operations. Basic rates were used to cover operating costs not including the cost of fuel. Thus, although customers would see high electricity costs, on average more than 70 percent of PREPA's income, would go to pay for fuel (billed to customers directly through an adjustment clause in the electric bill). PREPA kept issuing municipal bonds to artificially keep the same rate structures. It is important to note that PREPA might have identified and corrected inefficiencies (technical and organizational) to improve its finances and reduce its reliance on the municipal bond market.⁵

A narrow planning vision of top PREPA management degraded the public power model that Lucchetti established and that had served Puerto Rico well for many decades. The conservative, centralized planning vision became deeply engrained in management, regardless of who was Executive Director and who was in the Governing Board. The 2012 election of two consumer representatives to the Governing

Board brought some public access to PREPA, as well as a different, user-centered perspective (Cotto 2012; Irizarry 2013). Nevertheless, this was just a temporary shift. For example, the Integrated Resource Plan (IRP) presented by PREPA in 2015, insisted on the dominance of the centralized model, belittled the importance of conservation and efficiency, and refused to embrace Puerto Rico's local renewable resources. The IRP was a sad contrast to the fighting spirit of Lucchetti and his struggle to provide the island with an instrument for socio-economic development (i.e., the AFF). For Lucchetti, Puerto Rico's needs were first, not PREPA, which existed to serve the people. On the other hand, in the last forty years it seemed that PREPA's needs were first, not Puerto Rico's. It is important to point out that Puerto Rico needs PREPA's managers and planning professionals--people who know the electrical infrastructure and its limits well. The needed electric transformations require their support, knowledge and expertise in support of a new vision.

Sustainable energy policies and actions should come from a shared vision of Puerto Rico's future, and how energy strategies (electric energy as a subset) should be transformed to support that shared vision of our future. Understanding the local energy policy history is essential in crafting a shared energy vision, and in any plans to build a resilient and sustainable electric power infrastructure.

Synopsis of Energy Policies in Puerto Rico

A look back is necessary in order to learn from past mistakes and to understand the local context before committing to any energy future. This is especially true in Puerto Rico, given that technological solutions have been proposed and even built in the past without truly considering the local social contexts, resulting in unintended, negative consequences. The book by Geri and McNabb *Energy Policy in the U.S.: Politics, Challenges, and Prospects for Change* provides a suitable policy theory framework to understand some of the energy policies in Puerto Rico. Their definition of public policy describes it as a plan that guides a government or its agencies in actions dealing with issues of public concern, that shapes and is shaped by laws (Geri and McNabb 2011). But public policy is also shaped by public opinion: unless the public supports a policy, it will not succeed.

A comprehensive and coordinated energy policy is vital for a nation, not just isolated energy laws. However, a comprehensive energy policy does not happen often. Four main stakeholder energy perspectives exist based on very different values and goals: supply, demand, national security and environment. Energy policies are usually framed by some stakeholders more than others: The struggle at federal and state levels, and in public opinion, is often framing the problem (whose frame will "win" and why?). Major energy stakeholders, with political and/or economic influence, lobby to ensure that legislation unfavorable to their interests does not get passed or that favorable legislation passes (Geri and McNabb 2011). Thus, producing a comprehensive energy policy is very difficult. Another energy policy challenge is the short memory of policy-

makers. Policies do not change until elected politicians perceive a change in public opinion or new conditions force changes (Geri and McNabb 2011). Policy-makers often overlook the reasons behind existing policies when changing them, and whether existing policies are addressing an actual need or not.

In Puerto Rico there have not been consistent and enduring energy strategies and policies. The few instances that clear energy policies emerged were brief (e.g., the efforts of the late 1970s), but diverse sectors could not rally in support of a comprehensive energy policy that could withstand leadership changes in the local government. Changes in energy policy directions have been an obstacle to implement truly sustainable energy strategies and alternatives. This in turn has impeded approaching Puerto Rico's energy challenges from a holistic perspective. One notable exception was the net metering law, Act 114-2007 "Ley para establecer un programa de medición neta," which ordered PREPA to establish a net metering program for residential, commercial and industrial clients. The law was backed by a broad range of citizen and industry organizations as well as academia. A study from the Electric Power Research Institute (EPRI), commissioned by PREPA, found that there were no major obstacles for interconnection of distributed generation (key technical aspect to establish net metering). Act 248-2008 "Enmiendas al Código de Rentas Internas de Puerto Rico y a la Ley de Contribución Municipal sobre la Propiedad" provided customers with economic incentives to install renewable energy systems in their premises, which was later substituted by incentives from Act 83-2010 "Ley de Incentivos de Energía Verde de Puerto Rico." By 2017 more than 100 MW had been installed in net-metered systems at all levels, mostly photovoltaic (PV) systems in residential, commercial and industrial rooftops. Even though there have been problems with third-party ownership contracts and with permit delays from PREPA, as of December 2017 the net metering policies had been the most successful in moving the citizenry towards renewable energy (O'Neill 2016a).

Unfortunately, other recent energy policies and supporting laws have had limited success or unintended, negative consequences. For example, a wheeling mandate included in Act 73-2008 "Ley de Incentivos Económicos para el Desarrollo de Puerto Rico" ordered PREPA to establish a program through which a private generator could sell its energy to a private client via Puerto Rico's grid. As of December 2017, there was not even one wheeling transaction. This effort was perceived as a benefit for industrial clients without paying attention to the rate and service impact on other customers. The legislative process did not account for the legal, technical and social complexities of the Puerto Rican electric infrastructure. Furthermore, there was no regulatory framework to properly manage this type of operation that would ensure a safe and fair wheeling program (O'Neill 2016a). There was no technical study of the feasibility of wheeling in Puerto Rico. Nowadays, with the shift in focus to more distributed energy options due to Hurricane María, wheeling might not make much sense, considering it is still a centralized option that depends on vulnerable transmission lines to operate.

On the other hand, there have been good ideas turned into local energy policies that failed during the implementation stage. Act 82-2010 “Ley de Política Pública de Diversificación Energética por Medio de la Energía Renovable Sostenible y Alternativa en Puerto Rico” set renewable energy goals for the first time in Puerto Rico through a renewable portfolio standard (RPS): 12 percent renewable energy by 2015, 15 percent for 2020 and 20 percent by 2035. The law ordered the creation of a market for renewable energy credits (REC), through which the amount of renewable energy sold at retail would be accounted for purposes of compliance with the RPS. Unfortunately, PREPA’s Governing Board signed more than 60 contracts (power purchase agreements, PPAs) to buy more than 2,200MW from proposed large-scale renewable energy systems, at prices higher than previous PPAs PREPA had signed, and assigning value to the RECs even though the REC market had not been established yet. It is very important to remind policymakers that PREPA had signed, by 2009, PPAs for the purchase of wind energy at \$0.09 per kWh (without RECs) as part of a plan to integrate 350 MW of large-scale wind energy systems (Cordero 2009). Thus, it makes no economic sense that the PPAs signed later by PREPA up to 2012 were for \$0.125 per kWh plus 2.5 cents per kWh for wind energy (a total of \$0.15 per kWh for wind) and for \$0.15 per kWh plus 3.5 cents per kWh for solar energy (a total of \$0.185 per kWh for solar). Furthermore, there was no technical way to integrate 2,200 MW of renewable energy in a system whose peak power demand was around 3,000 MW at the time (without causing severe stability and service problems in the power grid). Had PREPA stuck with its original plan to regionally integrate wind energy, after a competitive bidding process, in the best places (environmentally, socially and technically), at the lowest possible prices, Puerto Rico would have had today much more than the 2 percent we have of renewable energy participation. Further details of the erratic, local energy policies can be found in O’Neill (2016ab).

In summary, there have been examples of good policies (e.g., net metering and the RPS) that have suffered from obstacles or implementation errors, mainly from PREPA.

Stakeholder Engagement As Part of the energy Policy Process

The short memory of policymakers in Puerto Rico, and their susceptibility to be influenced by stakeholders with economic and political power, warrants a different approach to establish policies in support of sustainable and resilient energy strategies and technologies. An approach grounded in people’s concerns and lived experience is suggested in Geri and McNabb 2011. Policy communities can be created to discuss energy visions and the policies of support that are needed. Minimum common ground can be identified through dialogue among sectors having different perspectives, and used to build the shared energy vision mentioned earlier. “Forums that encourage the formation and maintenance of cross-cutting relationships at the local level must be nurtured,” while experts can become “skilled facilitators of citizens, to help them engage in policy discourse” (Geri and McNabb 2011). A local example of such forums is the Energy Roundtable, created in 2008 as a reaction to the public debate in Puerto Rico about wheeling. This was a multi-sector group

composed of representatives from academia, community organizations, industry, the state energy office, PREPA's management and PREPA's largest labor union that was able to craft a shared vision for the future of the electric system in Puerto Rico (O'Neill 2016c).⁶

Puerto Rico's energy policy was defined as a continuous process of planning, inquiry, execution, evaluation and improvement regarding all energy issues.

Using the visions proposed by various citizen groups, including the Energy Roundtable and Town Hall meetings held in three municipalities in Puerto Rico during March 2013 (Gobernador anuncia... 2013), a new paradigm in energy policy was established, first through the governor's executive order 2013-39 "Orden Ejecutiva del Gobernador para la creación del Consejo de Autonomía Energética para Puerto Rico" (MicroJuris 2013), and later through Act 57-2014 "Ley de Transformación y Alivio Energético de Puerto Rico." Puerto Rico's energy policy was defined as a continuous process of planning, inquiry, execution, evaluation and improvement regarding all energy issues. This approach intended to expand the scope of energy policy beyond laws and regulations, for example, with a new focus on citizen participation. This was a more holistic, integrated approach to energy policy never before formalized in Puerto Rico. The process is illustrated in Figure 1, where specific activities are listed, as well as the expected time frames to complete or begin (months through one year). The objective of Figure 1 is to show the breadth of policy actions that were pursued to transform the energy regime. Executive order 2013-39 also established an Energy Autonomy Advisory Board to lead the initiatives needed to execute the new energy policy. The Board was composed of three citizen-experts in energy-related matters and one representative from each of the following: Energy Affairs Administration (state energy office), PREPA, Planning Board, Governor's office, Transportation & Public Works Department and the Natural & Environmental Resources Department.

Other Policy Initiatives between 2013 and 2014

The new energy policy approach was supported by the National Governors Association (NGA) under a DOE grant. Puerto Rico competed with proposals from state governments in the U.S. and was selected for participation along with three other jurisdictions: Arizona, Minnesota and Mississippi (States to Focus on Economic Development... 2013). NGA's "Policy Academy on Targeting Clean Energy for Economic Development" began in 2013 and ended in 2014. Puerto Rico's participation focused on promoting the local energy industry through local resources (renewables, conservation and efficiency), on supporting PREPA reform actions and on studying local biofuel opportunities. NGA coordinated workshops, seminars and consulting contacts with energy experts that allowed the Puerto Rico team to develop a framework to link energy to economic development objectives and sustainability goals. Results were presented on July 16, 2014, during an NGA Energy Summit held in Caguas that

included a panel with participation from Hawaii's regulator and DOE. Unfortunately, the event was not covered by the local media and the Governor's office did not release the final report of the NGA project (as of December 2017, the NGA project report had not been published). Nevertheless, the recommendations from that initiative were used by the state energy office in its policy development efforts, and many of the ideas obtained from that Policy Academy were used to inform the process that resulted in the approval of Act 57-2014 (discussed in the next section).

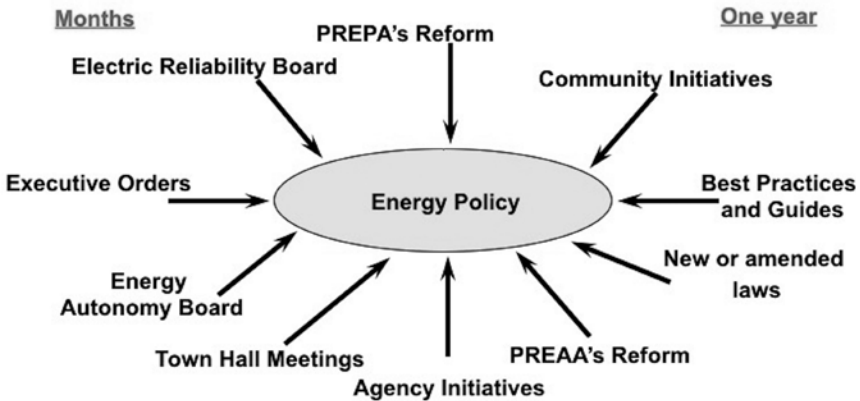
Another relevant policy initiative was the creation of an Electric Reliability Advisory Board through Executive Order 2013-40 "Orden Ejecutiva del Gobernador para la creación del Consejo de Confiabilidad Eléctrica." The Board was composed of two citizen-experts in electric power systems and one representative from each of the following: the Energy Affairs Administration (state energy office), the Planning Board and the Governor's office. The Reliability Board was tasked with estimating how much renewable energy could be safely interconnected to Puerto Rico's electric power grid. Sixty-four power purchase agreements (PPAs) were signed by PREPA between 2009 and 2012, plus 600 MW on master agreements, for a total of over 2,200 MW of large-scale renewable energy (mostly solar, some wind). No scientific study was performed to ensure that the electric grid was able to handle such large quantities of renewable energy. The reliability of Puerto Rico's electric system would have been affected since the daily peak electric demand was around 3,000 MW at the time. During October 2013, the Board stated in its report to the Governor that no more than 800 MW of renewable energy could be safely integrated to the electric grid at that time. The Board recommended to allocate a reasonable amount within those 800 MW to rooftop PV systems (Laureano 2013). The Board also mediated between PREPA and large-scale renewable energy project developers over proposed minimum technical requirements (MTR). The work by the Board informed some of the operational aspects included in Act 57-2014.

A New Mission for PREPA

A key goal in PREPA's transformation was changing its mission from "electrifying Puerto Rico" to "supporting sustainable energy in Puerto Rico" (from Executive Order 39). Besides the work described in the previous section, citizen input from formal reports, written depositions and results from Town Hall Meetings in Caguas, Adjuntas and Mayaguez were also used to create the most comprehensive reform in PREPA's history. It is important to mention that more citizen engagement meetings were planned, but pressure from influential stakeholders in the media forced the engagement process to be cut short. On October 23, 2013, the main components of PREPA's transformation were presented by the Governor in a public forum (García Padilla presenta plan de reorganización en la AEE 2013). On January 2014, bills to amend PREPA's Law (Senate Bill 881 and House Bill 1620), to create a new regulator and to modify the state energy office (Senate Bill 882 and House Bill 1618) were finally submitted to the Legislature, containing the product of a year of work, input from hundreds of stakeholders as well as input from reports from diverse groups.

Figure 1: Puerto Rico's energy policy on executive order #39.

- Formalize an energy plan with a clear vision of energy sustainability
- Coordinate inter-agency collaborations in energy matters
- Propose ways to harmonize existing laws, propose comprehensive reforms to PREPA
- Define a Citizen Forum that would allow a constant and early energy dialogue with citizens in a way that enables them to understand energy initiatives during early stages to make suggestions or present alternatives.



After a difficult negotiating process, including merging various energy bills that had been presented in the Legislature; Act 57-2014 (*Ley de Transformación y Alivio Energético de Puerto Rico*) emerged in May 2014. Although not perfect, it had the main elements to begin a transition to a sustainable electric infrastructure. For the first time in 73 years, a comprehensive reform of PREPA's law gave it a new mission: to provide reliable electric energy, contributing to the general welfare and to a sustainable future for the People of Puerto Rico, maximizing the benefits and minimizing the social, environmental and economic impacts. PREPA was ordered to focus on customer service and citizen participation. Act 57-2014 aligned PREPA's law and mission to sustainable development and emission reduction goals through explicit mandates to promote renewable and sustainable energy. PREPA was ordered to begin changing Puerto Rico's infrastructure so as to maximize renewable energy usage in a safe and reliable way. The law also mandated PREPA to reduce red tape for residential and commercial rooftop PV systems below 25 kW.

The law also created a regulator for the electric power sector (Energy Commission of Puerto Rico, CEPR in Spanish), and also a utility consumer advocate (OIPC in Spanish). The state energy office was given a new mission, a new name (OEPPE in Spanish) and became an independent identity for the first time in its history. An important task given to OEPPE was to determine the maximum level of renewable

energy that the local electric infrastructure could safely integrate, at a reasonable cost, and the most appropriate technologies and places for such integration.

Stakeholder Engagement in Act 57-2014

One of the main differences between Act 57-2014 and previous energy policy initiatives was the focus on citizen participation. The reasoning behind this emphasis was the need to identify minimum common ground over which a shared vision could be created. As mentioned earlier, citizen forums are needed to reach that shared vision. Citizen participation outlets are aligned with the main values of “public power companies” such as PREPA, which was already structured in seven operational and commercial regions (Arecibo, Bayamón, Caguas, Carolina, Mayagüez, Ponce, San Juan).⁷ Act 57-2014 allowed PREPA to establish agreements with NGOs, Academia or other citizen organizations in each of its seven regions. The main objective of the public empowerment initiatives was to engage citizens as much as possible, and as early as possible in key decisions, major projects and proposals that might impact communities.

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The task to ensure citizen participation in rate revisions fell unto the regulator (CEPR), and the utility consumer advocate (OIPC). The OIPC had ample powers to execute its mandate, including the ability to go to court in defense of consumers, even against the CEPR if necessary. Citizen participation in integrated resource planning processes was the responsibility of the state energy office (OEPPE). Figure 2 illustrates the general structure of the electric power sector in Puerto Rico as a result of Act 57-2014.

Since each PREPA region has its particularities, it was expected that citizen participation would vary from region to region. Thus, the citizen participation clauses in Act 57-2014 were designed to provide flexibility to motivate participation from NGOs and other citizen groups that had long criticized PREPA's service and lack of transparency. The main objective was to empower the public through regional participation and support from the OIPC and the OEPPE as facilitators of citizen participation. Nevertheless, the potential for broad, citizen participation never materialized. Citizen groups did not take advantage of the participation opportunities, PREPA's crisis took over most of the attention, leaving little time to demand support for the citizen participation outlets. The absence of effective citizen participation is still a problem. For example, the FOMB consistently holds public hearing in New York city, limiting Puerto Ricans' participation and access in their proceedings.

Up to this point, key policy actions and related pitfalls from 2007 to 2014 have been presented and discussed. However, the reasons behind those policy actions are

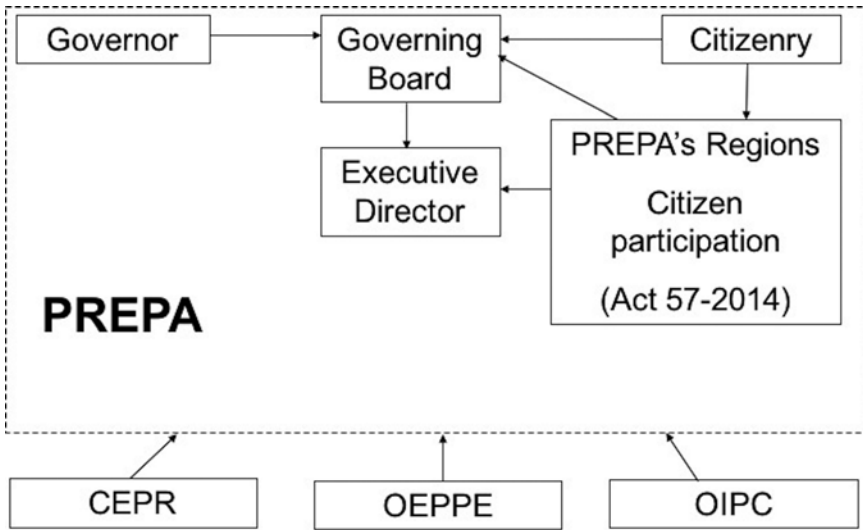
left as open questions. One possible explanation or motivation for these changes is that PREPA's problems could not be hidden anymore; and thus, the voices claiming for reform grew and sometimes joined forces. For example, the net metering law was passed with bipartisan support, and the wheeling clause passed because of strong support from the industrial sector. Since the 2008 election, both main parties had included in their government programs reforms to PREPA, including establishing a regulator. Act 82 and 83 of 2010 passed as part as reforms sought by Governor Fortuño, backed by industrial support and foreign investors who saw Puerto Rico as an opportunity for large-scale renewable projects (Cordero 2009). When Governor García Padilla took office, he ran with a program "Luz al final del camino," which presented comprehensive reforms for PREPA. The combination of those promises and strong public opinion against PREPA were some of the reasons for the reforms between 2013 and 2014. Regardless of the efforts between 2007 and 2014, a true transformation of the electric infrastructure of Puerto Rico has not really been executed yet.

Transformation Potential Despite the Financial Debacle

The energy policy actions in Puerto Rico from January 2013 to May 2014 strove to avoid the pitfalls of previous energy policies. Special attention was given to stakeholder engagement in the development of policy initiatives, as recommended by Geri and McNabb's *Energy Policy in the U.S.: Politics, Challenges, and Prospects for Change*. Act 57-2014 provided important opportunities to innovate in the electric power sector, to move forward with renewable energy, to implement a novel regulatory framework through the collaboration of CEPR, OIPC and OEPPE, and, for the first time, to integrate citizens in electric energy decisions. The effort failed in many areas.

As Act 57-2014 was being signed, PREPA's financial problems had taken center stage and dominated the focus of transformation efforts and media coverage. Most if not all other efforts were secondary matters. The CEPR, OEPPE and OIPC were never able to coordinate their work to maximize the scarce resources available for their tasks. It took too long to name the Commissioners to the CEPR; for example, the Commission's first significant order was in December 2014 (seven months after Act 57 was signed). The OIPC Director was named in 2015. Furthermore, the citizen participation opportunities provided for the first time in Act 57-2014 did not turn into real citizen engagement efforts. Positive outcomes from Act 57-2014 include the amount of information from PREPA made public for the first time through the CEPR-led proceedings (e.g., rate revision case, integrated resource planning evaluation). Also, the consultants hired by the CEPR yielded important work that provided good guidance for the first regulatory decisions. The problems related to Act 57-2014 could have been addressed, had there been the will to correct the shortcomings in the implementation of the law. A key principle that was initially followed in the policy efforts of 2013 and 2014, but was abandoned in the formulation and adoption stages, was a negotiation with other political forces in Puerto Rico. As stated in Geri and McNabb (2011) regarding the U.S., but with direct ap-

Figure 2: Main relationships in the electricity sector from Act 57-2014



plication to Puerto Rico: “Without a commitment to define a sustainable future and strong bipartisan leadership, a sustainable energy policy cannot emerge.” Because of the lack of bipartisan support for Act 57-2014, in January 2018 the new Governor announced plans to make major changes to the incipient regulatory framework and sell PREPA’s generation assets (the privatization was also part of the mandate given by the U.S. Congress to the FOMB).

Regardless of the continued tradition of governing through party politics, a process that has plagued policy decisions since the 1960s, Puerto Rico still has the potential to innovate in many areas related to electric energy. In other words, regardless of the challenge presented by political interventions, there are many actions that can be implemented to deal with the electric energy challenges. The Achievable Renewable Energy Targets (ARET) study from the University of Puerto Rico-Mayagüez Campus (UPRM) showed that the solar resource is excellent (Irizarry 2009). Figure 3 shows one of the main contributions from that study, a solar irradiation map for Puerto Rico. Some estimates of the local “rooftop resource” show the potential for PV systems: residential rooftop area, 180,814,184 m²; commercial rooftop area, 7,300,000 m²; industrial rooftop area, 2,702,545 m².

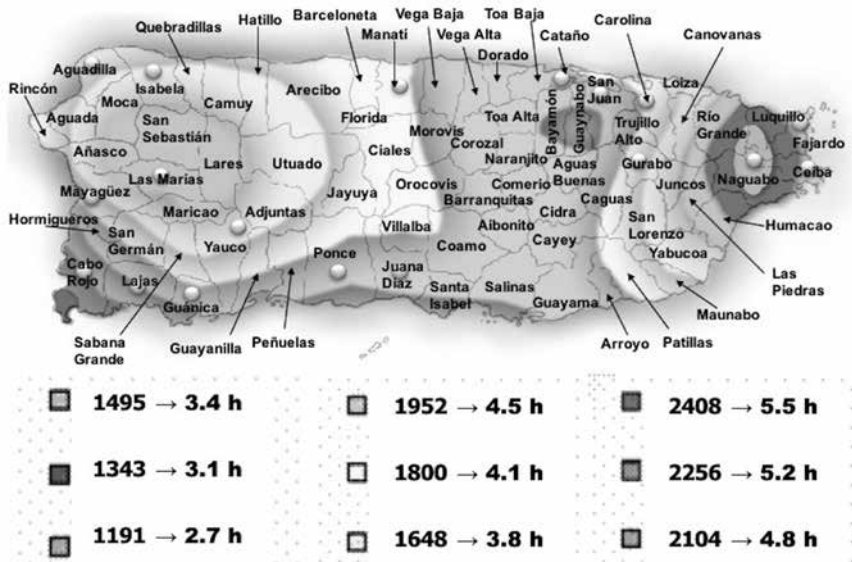
The ARET studied also showed that the wind resource is acceptable, but its potential is not as good as the solar resource. The ARET study also discussed the potential of micro-hydro and biomass, although both of these have additional environmental and social hurdles to overcome. The waves in the North of the main island are excellent, however, the technology to extract energy from the waves is

not as well developed as the PV option. Even though all resources must be explored to determine the best options, there is no doubt that the best resource, with commercially available technology, is the solar resource. Thus, a best technology practice would be to pursue aggressive deployment of rooftop photovoltaic systems (Irizarry 2009). That would also provide the best energy opportunity to spur local socio-economic development.

Puerto Rico also has great potential for socio-economic development and energy transformations through conservation and efficiency strategies and technologies. A best practice would be to support as broadly as possible, access to efficient equipment for all types of customers (industrial, commercial and residential). It is vital to begin considering conservation and efficiency as a local energy resource.

Puerto Rico needs to build the appropriate physical and social infrastructures that favor the use of local energy resources (the existing infrastructure does not). Another UPRM study concluded that Puerto Rico had already achieved grid parity in terms of costs for residential rooftop PV systems around 2010 (O'Neill 2013). Thus, we must envision and work on transitioning from the existing centralized, hierarchical, fossil-dependent electric infrastructure to a more distributed, sustainable infrastructure that favors the use of local energy resources and reduces the dependency on fossil fuels. Hawaii has a goal of 100 percent use of local energy resources by 2045, despite currently having a weaker electric infrastructure than Puerto Rico.

Figure 3: Estimated average insolation in Puerto Rico, kWh/m² per year (Irizarry 2009)



In the 1930s the local electric infrastructure was planned, designed and constructed to support the socio-economic development plans needed to overcome the critical situation of the time. In 2018, a shared vision of socio-economic development must be reached to address the existing critical period and to align accordingly the transformation of the electric infrastructure. The reforms to the local electric infrastructure require truly sustainable energy policies and actions (O'Neill 2014). Legally, that task falls under the state energy office (OEPPE), with support from the Energy Commission (with regards to electric energy). However, energy policy is not and should not be limited to laws or actions from government entities.

Distributed Energy to Transform the Electric Infrastructure

The crisis created by María calls for a new perspective regarding Puerto Rico's electric infrastructure. The reconstruction of Puerto Rico will require transparent oversight and management to ensure appropriate use of recovery funds. Whenever possible, the help or resources should not only be focused to address an immediate need, but should also be directed to supporting the longer-term recovery efforts. That is the case for the recovery of our infrastructure. Most of the infrastructure will be replaced, making this the moment to begin an electric energy revolution. Given Puerto Rico's particular context, traditional, centralized electric systems cannot continue to be the dominant model to follow. A more distributed approach should guide the reconstruction, which could not only result in a faster recovery in some areas, but would also support the much-needed transformation of Puerto Rico's electric infrastructure. Thus, a best technology practice is to give priority to the design and implementation of an infrastructure that enables the maximum possible use of distributed energy resources.

On September 15, 2017, the *Energy Advisor* (Latin America Advisor) published an opinion article that included a brief description of benefits of distributed energy in the Caribbean context (How Resilient Is the Caribbean Basin's Energy Sector? 2017). The author stated that renewable-based microgrids would increase the resiliency of the power infrastructure in islanded/isolated locations. The dominant power model (centralized and fossil-burning) could be replaced by distributed, non-centralized, local energy resources (conservation, efficiency and renewable energy). Centralized power would be minimized and focused on supporting the usage of local resources. Within each microgrid a constant energy source would provide base load or continued operation at night. During emergencies, when centralized power would likely not be available (e.g., downed power lines), microgrids could still provide basic electricity needs and help re-establish normal operation of the power infrastructure. Despite the potential of microgrids, governments and vulnerable communities should not rush to "silver bullets" or "one size fits all" promises. Technological solutions abound during critical times, as do projects that yield economic benefit but do not fully address a social need, and do not increase local capacities or increase the resiliency of the local infrastructure. Good ideas or intentions may go wrong when the technology proposed is incompatible with the context or the social goal being pursued.

For example, renewable energy and microgrids seem a logical choice for Caribbean islands (e.g., Puerto Rico) or Pacific islands (e.g., Hawaii). Nevertheless, establishing effective and consistent energy policies is challenging, even more difficult than the technological and economic challenges. Renewable-based microgrids entail turning passive users to engaged energy actors. This new energy vision requires capacity building actions, as well as new responsibilities for the government, the workforce and the citizenry. Social agreements should guide and sustain policy directions that support the economic and technological changes needed for microgrids (How Resilient Is the Caribbean Basin's Energy Sector? 2017). It is vital to ponder the social nature of electric power systems, which makes them a powerful tool for either justice or injustice (social and environmental).

Good ideas or intentions may go wrong when the technology proposed is incompatible with the context or the social goal being pursued.

Although many regular citizens cannot access energy storage due to cost, the present crisis should encourage a move toward distributed storage systems that might serve communities in common areas ("community centers"). Thus, we must envision and work to implement solar communities, with the physical and social arrangements needed. Furthermore, to increase regional emergency preparedness around the territory, "emergency response hubs" must be established in each of the 78 municipalities. In municipalities with populations greater than 10,000 persons, multiple hubs may be needed. Additionally, more than one hub might also be needed in municipalities with irregular or challenging geography (e.g., towns in the mountainous central region). These emergency response hubs should have minimal infrastructure to allow each town emergency team to work in the immediate response during and after disasters. For example, microgrids should be established to provide electricity as part of a hub. With a distributed energy approach, the electric infrastructure would be more resilient and better prepared to face the impacts of natural disasters. A key technology practice is to begin studying, designing and implementing pilot projects that use microgrids in emergency hubs, at least one in each of the seven regions of PREPA.

The transformation of Puerto Rico's electric infrastructure requires answering the following questions: How long will a transition toward renewables take? What is the right mix of resources? What is the right mix of approaches (centralized vs distributed, regional vs island, regional vs community)? What is the right mix of funding sources (private, federal, cooperative, foundations, etc.)? One key challenge is the mistrust among some of the key stakeholders who are needed to answer these questions, especially between those with economic/political power and access, and those representing communities or environmental and social justice issues (How soon can Puerto Rico restore its electric grid? 2017).

A future envisioned by many (as proven through stakeholder engagement initiatives from 2013 to 2014) is the widespread use of rooftop solar systems (O'Neill 2013; O'Neill, Irizarry, Ortiz and Pérez 2016). But Puerto Rico cannot go from almost zero renewables to 100 percent renewables straight away. Hawaii, with more effective energy policies than Puerto Rico, and much more renewable energy participation, set its 100 percent goal for 2045. But a more diverse energy mix could be achieved within a few years in Puerto Rico, where renewables are the main player and big power plants have a supporting role. That requires Puerto Rico to move beyond political bickering and focus on rebuilding a more sustainable and resilient power system (O'Neill 2017). Supporting this is the fact that the cost of residential rooftop PV in Puerto Rico, net-metered, is 11 cents/kWh (O'Neill, Figueroa and Irizarry 2013). The electrical load is nearby; thus, there are no losses in the power lines. If 2 to 3 cents are added for grid services, the cost is still at 13-14 cents/kWh. The utility scale PV contracts signed by PREPA established a cost of 15 cents/kWh, plus up to 3.5 cents/kWh as RECs, for a total of 18.5 cents/kWh. In these cases, there are power line losses since those projects are connected at the transmission level. Those contracts were challenged in court by the Congress-appointed oversight board (from the PROMESA law). Although the FOMB withdrew their case, they are still pursuing reduced rates from those contract holders, a process that might end up in court once more or take months to clear (at least with the original contract-holders). Anyone trying to push those types of projects could be shut down by the people who had original contracts.

On the other hand, the distributed option is open at the residential, commercial or industrial level. Although there are short-term limits on how much and how fast distributed resources can be deployed, the distributed option is the best bet for Puerto Rico's energy future. The effects of hurricane María is further evidence that we cannot continue to completely depend on the centralized model, which should be minimized as much as possible. A system with distributed resources, despite being costlier than large-scale renewables (in a per Watt basis), provides the opportunity for better oversight of energy issues and creates a sense of ownership among users. Although Puerto Rico has enough insolation to meet our electricity demands, we still do not have a cheap, reliable and environmentally friendly way to store all that solar energy for use at night. At 11 cents per kWh, residential rooftop PV systems are much cheaper than the 20 cents a kWh on average paid to PREPA in 2017 and 2018. However, citizens still need to come up with the money to purchase the PV systems; and the infrastructure needs to be changed to support 100 percent renewables in Puerto Rico. One way to address this challenge is to provide financing options to make PV systems accessible to more citizens.

Distributed generation, especially rooftop PV systems, presents an opportunity for local socio-economic development. Most of the companies designing, installing and maintaining rooftop PV systems are local, small and medium companies. Thus, the economic activity generated is greater, since those local companies pay taxes in Puerto Rico, employ local people and generate other indirect economic activity. Fur-

thermore, rooftop PV systems enable people to become active energy actors. The word “prosumer” has surfaced to refer to those consumers that are also energy producers. As many prosumers emerge in Puerto Rico, the possibility of creating solar community’s increases. These solar communities are a means to achieve energy democracy and local empowerment (O’Neill 2016c; Jordán and O’Neill 2016; O’Neill et al. 2017).

A balanced view of the problem should be pursued. The centralized vision has advantages, and still has value. Acknowledging other perspectives does not weaken the distributed energy vision, but rather strengthens it by allowing a civilized conversation with those with differing points of view. Puerto Rico needs civilized conversations among stakeholders, given that PR had very few of those in the last thirty years (or maybe in its whole history). A key technology practice is to evaluate which centralized energy options would make sense to support and enable an increased use of local energy resources, closer to the points of use.

The Road Ahead

Some argue that PREPA’s crisis is evidence that the public power model does not work. That is not true. If well-run, the public power model is effective and can still be useful in Puerto Rico. When comparing public power companies and investor-owned utilities in the U.S., one observes that average rates for residential and commercial clients are less in public power companies (although industrial rates are slightly better in private companies according to the American Public Power Association).

The distortions to the public power model from PREPA managers cannot continue, especially given the history of political interventions in PREPA. Act 57-2014 came too late; the legislative changes to PREPA’s Board to make it “less political” failed (e.g., Act 4-2016 “Ley para la Revitalización de la Autoridad de Energía Eléctrica de Puerto Rico”). The new regulator (Puerto Rico Energy Commission) is still in its infancy, underfunded and vulnerable to political intervention, as shown by attempts in early 2017 to merge it with other regulatory entities. And this is not just because of the present-day local government. The previous administration from the other majority party did the same in early 2013 by signing into law changes to the composition of PREPA’s board. Local politicians cannot resist the temptation to meddle in everything.

Simply privatizing generation, i.e., constructing new, privately run power plants, is not what the local electric infrastructure needs.

The PROMESA law suggests privatizing the power generation in Puerto Rico as a way to improve the local electric system. However, the aftermath of María warrants a deeper look into potential futures for Puerto Rico’s electric infrastructure. Simply privatizing generation, i.e., constructing new, privately run power plants, is not what the local electric infrastructure needs. The problems with restoring power

after María were not due to lack of generating plants, but the destruction of many of the transmission towers and lines that supply bulk power to load centers, and the destruction of most of the distribution lines that supply power to individual users. Depending 100 percent on the centralized model, and its vulnerabilities is the main cause for the delays in restoring power in Puerto Rico.

Since millions of dollars in federal money will be going to reconstructing the local electric infrastructure, those funds must be effectively used in ensuring that the new electric infrastructure is more resilient and robust to face future natural hazards. In the long-term, taking this approach now will save tax-payers money later. Of course, power had to be restored as soon as possible, but a new vision must guide the future of the electric infrastructure, and no short-term actions should be made that hinder the chances of transforming the local grid.

The recent attempts of reforming PREPA can provide useful lessons for the reconstruction of the electric system in Puerto Rico. For instance, any new policy should be framed in a multi-sector agreement among political parties, economic forces, environmental advocates and community leaders among others, with a minimum common ground over which energy vision should be pursued and how. Puerto Rican politicians and major political parties have proved incapable of reaching a consensus on socio-economic development strategies, including the proper handling of the local power infrastructure (e.g., maintenance, financial oversight and transformation of the electric grid). Recent energy policy processes shows that as soon as the opposing parties assume power, previous policies or the guiding principles of previous reforms are abandoned. To avoid this, a minimum policy agreement should be reached among stakeholders. Another important lesson that can be learned from recent attempts of reforming PREPA is the need for creating spaces for citizen participation in energy policy. Stakeholders engagement meetings must have a central role in providing better policy oversight, creating ownership among users and providing transparency to the implementation process.

Since the federal government is investing millions of dollars in the grid's reconstruction after María, it becomes necessary to establish mechanisms to ensure the problems that plagued PREPA do not resurface. Addressing the issues at hand (e.g., PREPA's debt; privatization; resiliency, renewables, conservation, efficiency; centralized vs distributed) require a non-political, objective entity, sensible and willing to adapt the diverse perspectives from local stakeholders. In this way, federal funds spent on the recovery really address the needs of the millions of Puerto Ricans through a resilient and adaptive electric system. Unfortunately, such an entity does not now exist in Puerto Rico.

An entity or mechanism should be put in place, similar to the PRERA and the PRRA, to sort out the electric energy options. Through a broad stakeholder engagement effort, it would guide the appropriate actions toward a sustainable and resilient future for the local electric infrastructure. Such an entity cannot be the FOMB, with its emphasis on repaying the debt, nor should it come about from PREPA or the local government. Al-

though PREPA has been a public power company, it has also acted similarly to the rural electric coops, electrifying rural and isolated parts of Puerto Rico. Thus, the evaluation of the local electric future is not just a private vs public debate, it deserves a wider view, and probably leads to a new hybrid model that truly addresses the needs of the millions of residents in Puerto Rico. The convener or organizer of this effort must have federal support to avoid the problems that result when local political or economic forces capture the process (problems that many energy policies have had). However, the leadership of this effort must reside within Puerto Ricans, to ensure that the initiatives are not perceived as impositions from the outside and that there is local ownership of the process.

Researchers from the University of Puerto Rico (UPR) system could be part of an appointed, overseeing entity for the electric transformation of Puerto Rico. The UPR has expertise on most areas related to the operation of the electric infrastructure. For example, the Instituto Nacional de Energía y Sostenibilidad Isleña (INESI) is a system-wide platform that connects energy and sustainability researchers on all 11 UPR campuses. INESI also convenes an Energy Stakeholders Forum, which was based on and still follows the work and principles from the Energy Roundtable mentioned earlier. Other examples of successful UPR projects relevant to the creation of a sustainable and resilient electric infrastructure include energy collaborations with communities (O'Neill 2006, 2007, 2017) and with industry (López 2017), and projects studying new structure for distribution systems (Jordán 2016; Rodríguez 2016). Another sector that could make a significant contribution to the overseeing entity is the credit unions. "Cooperatives" (as credit unions are known in Puerto Rico) follow institutional values that are aligned to the socially based creation of an electric infrastructure in support of local socio-economic development.

Under any of the possible futures, and regardless of the final policy directions given by either Congress, the FOMB and/or the local government, the incipient state regulator CEPR, or whatever entity substitutes it, needs to be supported and strengthened. It is vital to have a strong, objective, transparent regulatory framework to give regulatory certainty, to reduce investment risk and to support whatever electricity future Puerto Rico decides to have. The conditions need to be created so that the regulator is able to grow as an objective, independent, non-political entity.

Next Steps toward a True Transformation

Any action taken to build a resilient, local electric infrastructure must include Puerto Ricans in the main roles (as the role Puerto Rican engineer Antonio Lucchetti had with the PRERA and PRRA). A top-down or imposed approach will not effectively address the contextual particularities existing in the territory, which must be closely considered for the success of any policy or strategy pursued in Puerto Rico. Recent local energy policies and their outcomes exemplify the challenges that need to be addressed for a transition to a more sustainable and resilient electric infrastructure. The introduction of new technologies or the inflow of Federal funds alone will not be enough for achieving the necessary electric transformations.

Another aspect to be considered is that, in the medium term, it is important to give Puerto Rico the necessary tools to create local socio-economic development. Puerto Rico cannot continue being held hostage in a prison that does not allow the territory to enjoy the tools available to states nor the trade and financial benefits at the international level. Since the U.S. Congress and the U.S. Supreme Court have left Puerto Rico without concrete options to recover from the present crisis, Federal intervention is necessary. Thus, it is of paramount importance to link the reconstruction of the electric system to a broader socio-economic development plan. The creation of a more sustainable and resilient electric energy system can become a key driver for local socio-economic development.

Since the U.S. Congress and the U.S. Supreme Court have left Puerto Rico without concrete options to recover from the present crisis, Federal intervention is necessary.

The decisions made in 2018 and the approach taken in the coming years for the reconstruction of our electric infrastructure will either facilitate or hinder Puerto Rico's chances for a sustainable and resilient energy future. With the appropriate vision and policies, a distributed energy approach combined with aggressive demand response programs could yield a resilient and sustainable electric infrastructure in Puerto Rico. The local nature of these distributed resources, combined with the work of well-organized communities can also yield local, sustainable socio-economic development that would remain in place once the federal support is eliminated or phases out. If the federal support, e.g., monetary and human resources, is not enough, then it would require Puerto Ricans to work even harder to realize this future of increased resiliency and sustainability through local energy resources.

The main policy recommendations for the electric transformation of Puerto Rico are:

- Puerto Rico's electric transformation should part of a broader socio-economic development strategy.
- Social considerations must become an essential part of the decision-making process, as important or even more, than technological issues or technology's best practices.
- Stakeholders and citizen engagement meetings should be a central component of the electric transformation.
- The creation of an independent, non-political, overseeing entity for the electric transformation of Puerto Rico with an objective and transparent regulatory framework. The entity would have a broad, multi-sector participation of local energy stakeholders.
- Researchers from the UPR system should be included as part of any entity overseeing the electric transformation of Puerto Rico.
- Capacity building actions among citizens are needed in order to promote a transition from passive users to engaged energy actors.

- Regardless of the chosen policy direction, the policy reforms should include the participation and support of all local political parties, to ensure continuity regardless of future changes in the ruling party.
- The electric system should be as decentralized as possible, in order to facilitate a more efficient post-disaster recovery.
- For a distributed energy policy, the planning of the electric infrastructure must give priority to change the design paradigm from centralized generation to distributed energy resources, especially locally available resources such as solar energy. Appropriate funding must be allocated to support this policy direction.

NOTES

¹ “Que existe el peligro de que por no poner a uso productivo una buena parte de los fondos que importamos, crezca más rápidamente nuestra deuda exterior de lo que crece nuestra capacidad para sufragar su servicio; lo que puede acercarnos a una difícil situación en nuestra balanza de pagos internacionales” (Baquero 1963).

² The Jones Act of 1920 requires the use of U.S. Merchant Marine and U.S. built ships. Since Puerto Rico is a U.S. territory, this restriction applies, increasing shipping costs between the continental U.S. and the territory.

³ Graph by the Center for Puerto Rican Studies <<http://centrop.r.hunter.cuny/>>, data from the American Community Surveys.

⁴ Although Puerto Rico is about 35 miles wide, the transmission lines that run from south to north go through a difficult and steep central mountain range. Thus, many failures in those transmission lines are difficult to repair. The damages to that infrastructure from María included the destruction of the transmission towers; thus, there was no way to deliver the power generated in the southern plants to supply the largest local demand in the North until new transmission towers and lines were built in such difficult terrain.

⁵ These municipal bonds were issued by a public entity, and had triple tax exemption (local, state and federal).

⁶ For the Energy Roundtable’s strategic plan see <http://iteas.uprm.edu/docs/Mesa_Dialogo_Documento_Plan_Estrategico.pdf/>.

⁷ For PREPA’s regions, see <<http://www.aeepr.com/medicionneta/DOCS/Mapa%20Regiones.pdf/>>.

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