



Puerto Rico Energy Planning Resources Workshop Report

Robin Burton,¹ Elizabeth Doris,¹ and Elaine Ulrich²

1 National Renewable Energy Laboratory

2 U.S. Department of Energy

**NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
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Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-6A20-73839
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Suggested Citation

Burton, Robin, Elizabeth Doris, and Elaine Ulrich. 2019. *Puerto Rico Energy Planning Resources Workshop Report*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-73839. <https://www.nrel.gov/docs/fy19osti/73839.pdf>.

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NOTICE

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed herein do not necessarily represent the views of the DOE or the U.S. Government.

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Cover Photos by Dennis Schroeder: (clockwise, left to right) NREL 51934, NREL 45897, NREL 42160, NREL 45891, NREL 48097, NREL 46526.

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Project Overview

National Renewable Energy Laboratory (NREL), along with four other national laboratories, is working with the U.S. Department of Energy (DOE) to provide Puerto Rico stakeholders with useful tools, training, and skills which will enable them to plan, maintain and operate the electric power grid with more resilience against future disruptions.

Key objectives of this project are to:

- Deliver high-resolution solar resource data for Puerto Rico and the U.S. Virgin Islands through the National Solar Radiation Database (NSRDB)
- Deliver models of Puerto Rico using grid modeling tools FESTIV (Flexible Energy Scheduling Tool for Integrating Variable Generation) and MAFRIT (Multi-Area Frequency Response Integration Tool), and train models on real data
- Develop and execute an educational module that provides analytical support to stakeholders on best practices for interconnection of distributed energy resources (DER) and IEEE 1547 standard
- Deliver Puerto Rico-specific System Advisor Model (SAM) improvements to provide foundational solar profiles for production cost modeling and to enable stakeholders to perform detailed cost-benefit analysis of renewable energy systems, accounting for resiliency and ancillary service functionality
- Develop end-user accessible cost-benefit tools with training sessions aimed at ensuring robust, data-driven investment decisions across Puerto Rico.

Workshop Description

DOE and NREL are engaging with stakeholders in Puerto Rico to understand local energy planning needs and deliver relevant tools and training. One method of engagement is through a series of workshops to

provide an opportunity for local stakeholders to share their energy planning needs and learn about tools from DOE, NREL, and other national labs to support energy planning and transition in Puerto Rico.

During the week of March 18, 2019, DOE and NREL hosted full-day Workshops on Energy Planning Resources for Puerto Rico in two locations – San Juan on March 19 and Mayaguez on March 22. The San Juan workshop was held in the Hearing Room at the offices of the Puerto Rico Energy Bureau (PREB), and the Mayaguez workshop was co-hosted with National Institute for Energy and Island Sustainability (INESI) at University of Puerto Rico in Mayaguez (UPRM), and held in the auditorium and adjacent classrooms in the Department of Civil Engineering and Surveying.

The morning session included a welcome by DOE and NREL, followed by an opportunity for attendees to introduce themselves and share their goals for the day. DOE gave an overview of the current effort to provide support during Puerto Rico’s energy system recovery, and facilitated a panel with local stakeholders. After a break NREL and other national labs presented tools for stakeholders to use, followed by facilitated small group discussions and brainstorming on energy planning needs, a report-out, and voting to determine which needs are of highest priority.

Workshop materials can be found in the appendix, including the agenda (Appendix 1), a resource list provided to attendees by email prior to the event and as a handout (Appendix 2), and contact information for the DOE and national lab staff in attendance (Appendix 3).

Registration and Attendance

A broad range of stakeholders involved with the energy transition in Puerto Rico was invited to the workshops. A breakdown of the number of people who registered and attended each of the workshops is below, as well as a list of organizations represented by attendees of workshops in both locations.

San Juan

- Registered: 84
- Attended (local): 48
- Attended (total): 57
- DOE/NREL/Labs: 9
- Afternoon attendance (total): 37
 - SAM: 14
 - HEVI and FESTIV: 14
 - Energy efficiency: 9

Mayaguez

- Registered: 35
- Attended (local): 26
- Attended (total): 36
- DOE/NREL/Labs: 10
- Afternoon attendance (total): 17
 - SAM: 9
 - HEVI and FESTIV: 7
 - Energy efficiency: 1

Organizations represented by attendees include:

- | | |
|--|--|
| <ul style="list-style-type: none"> • Cooperativas Eléctricas de Puerto Rico Accelerator (ACE PR) • AG Group, LLC • Alternative Energy Engineering, Inc. • AZ Engineering • Blue Planet Energy • Borincana Foundation Inc. • Corvidae • Department of Economic Development and Commerce (DEDC) • Energy Management Group LLC • Energy Solutions Puerto Rico | <ul style="list-style-type: none"> • Guzman Engineering Consultants • Institute for Energy Economics and Financial Analysis (IEEFA) • JOMA Design Group • Jose O Aleman PE • National Institute for Energy and Island Sustainability (INESI) at University of Puerto Rico, Mayagüez (UPRM) • National Renewable Energy Lab (NREL) • Oak Ridge National Laboratory (ORNL) • PIRISH CORP • Power Water Energy |
|--|--|

- PRIOTTECH
- Puerto Rico Electric Power Authority (PREPA)
- Puerto Rico Energy Bureau (PREB)
- Puerto Rico Institute for Competitiveness and Sustainable Economy (ICSE-PR)
- PV Systems of PR
- Ramey School
- RAND Corporation
- Relmagina Puerto Rico
- Renewable Solutions Engineering Inc
- Sail Relief Team
- Sandia National Laboratories
- SESA-PR
- Solar Libre!
- Stantec
- Sun Power Energy LLC
- UNIMEC Inc.
- University of Massachusetts (UMASS)/INESI
- University of Puerto Rico, Mayagüez (UPRM)
- Veolia
- Watric ER
- Windmar
- Ximmena

Answers to Pre-Workshop Registration Questions

Registrants were asked to answer a number of questions during the registration process to provide workshop organizers with preliminary information on attendees' current challenges and priorities. A sample of these questions and responses is provided below. All lists are in order of frequency of comment, then alphabetical.

What energy planning challenges are you currently working on?

- Comment related to community solar and microgrids or mini-grids (x10)
- Comment related to renewables in general (x4)
- Comment related to IRP process (x3)
- Energy efficiency (x3)
- Energy storage (x3)
- Interconnection (x2)
- Access to accurate data
- Aim to monitor and influence overall PR energy policy and planning efforts
- Analyzing PREPA's IRP, looking for model to do distribution system optimization
- Building CHP in PR
- Business continuity and long-term sustainability
- Cloud prediction; modeling weather accurate data for Puerto Rico
- Collaborate on adequate PR electric system restoration and development on behalf of the people of PR
- Cost validating in support of FEMA public assistance 428
- Cost validation for transmission and distribution repair
- Creation of an electric cooperative
- Deep understanding of ESS
- DER Integration, power quality
- Designing off-grid home
- Educational and capacity-building activities
- Electrical grid recovery in Puerto Rico
- Energy system modernization for COR3
- Gathering energy consumption data from communities
- Getting on-time approvals from PREPA and Office of Permit Management (OgPE)
- Getting the word out to consumers
- Grid sensing and measurements
- High renewable penetration impacts on electricity market operation
- Model the cost of rebuilding the power grid
- Installing residential and commercial PV and storage systems
- Integration of offshore wind energy planning with desalination systems
- Learning more in depth about solar and its installations procedures
- Legal counseling on energy law
- Looking to establish an electric cooperative in my neighborhood and could use resources on project planning
- Low-pressure hydro
- Meeting RPS
- NEC implementation of rapid shutdown switch
- Need more cost effective ESS
- Orchestrating/supporting solar/storage companies' planning efforts
- Participating with various NGO in the review process of New Energy Policy for Puerto Rico

- Planning larger microgrid systems for community centers/organizations
- Policies and efforts related to the reconstruction process
- PREPA new tariffs implementation and interpretation
- PV hybrid system
- PV Penetration
- Rebuilding electrical system after hurricane
- RECs and the RPS
- Regional fault service
- Regulatory structure
- ROI on BESS
- Security and resiliency
- Smart Grid
- Solar + storage system for commercial and industrial facilities
- Stand-alone and backup systems
- Weatherization
- Wind and solar integration in transmission network and impacts on electricity market operation

What energy planning tools are you using now?

- PV Watts (x7)
- SAM (x7)
- Internal or proprietary (x6)
- HOMER (x5)
- Aurora (x4)
- PVSYST (x3)
- Excel-based models (2)
- FESTIV (x2)
- HelioScope (x2)
- Quest (x2)
- Reopt Lite (x2)
- DigSilent
- Ect
- EMMIE and Grants Manager
- Energy Demand Analysis
- Energy monitoring, SCADA, PQ Analyzers
- IAEA Energy Modelling tools
- MATLAB
- PR energy toolkit, and smart-meters
- Promod
- RSMMeans
- Sunny Design

What are your energy planning needs?

- Learning / knowledge / tools / training (x9)
- Interconnection (x2)
- Database for PR weather data
- Actual system data and planning goals
- Potential investors for the development of several microgrids
- Balance between thresholds of sustainable and resilience goals
- Better energy incentives
- Case studies
- Community service and PPA interconnection
- Cost-effective planning tool
- Cost estimation tools to compare alternatives
- Data for ResStock
- Energy efficiency analysis, load modeling
- Existing data in PV / integration to grid
- Tools for PV modeling
- Financing
- Integration of public perspective into the energy planning tools
- New energy policy for PR
- Load calculations for kwh required
- Legal advice
- Resilient infrastructure
- Political support
- Power quality and DER integration
- Technical training for community installers of PV systems
- Regulatory structure
- Restoration of PREPA's grid with allocation for high renewables penetration
- Sizing systems
- Software to estimate cost
- System analysis
- Technical assistance
- Create models for how to rebuild the grid in Puerto Rico
- Understand costs of energy infrastructure
- Understand renewable integration thresholds
- Understand capex of systems and create financial offer around it
- Evaluate critical loads of critical facilities as well as general energy requirements for developing self-sustainable microgrids based on individual building load profiles

Prioritization of Needs from Small Group Discussions

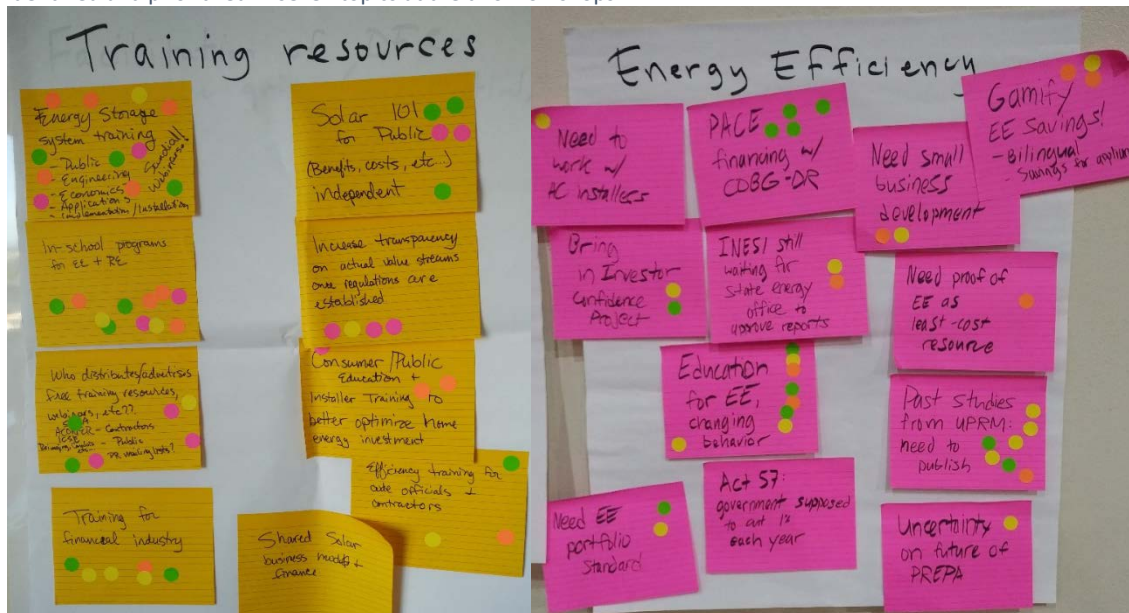
During the morning session, attendees formed small groups for facilitated discussions on energy planning needs by topic. After identifying needs within each topic and posting them on the wall, facilitators of each group reported out on the needs identified by each group. Then attendees were given sticky dots and went around the room “voting” for their highest priorities by sticking dots on them. The full list of needs identified during workshops in both locations, sorted by topic and then by number of votes, can be found in the appendices (Appendix 4). The list also includes subtotals of the number of votes cast for needs within each topic. The topics in order of number of votes received are:

- Training resources (72 votes)
- Finance (61 votes)
- Microgrids and resilience (57 votes)
- Energy efficiency (55 votes)
- Facilitation of DERs on the grid (53 votes)
- Community-based solutions (52 votes)
- Solar resource data (26 votes)

Among individual needs identified within each topic, the top vote-getters were:

Location	Topic	Need	Votes
San Juan	Finance	Making local finance more available (finance co-ops, local banks)	17
San Juan	Energy efficiency	Education; Policy; Incentives (monetary and non-monetary); Data availability	11
Mayaguez	Facilitation of DERs on the grid	Collaboration between NREL/UPRM. Power systems group. Big driver is PR need now	11
San Juan	Solar resource data	No database of distributed PV system	11
San Juan	Training resources	Energy storage system training (-public, -engineering, -economics, -applications, -implementation/installation) Sandia webinars!	11
San Juan	Training resources	In-school programs for EE and RE	11
San Juan	Microgrids and resilience	Maintenance of microgrids so as not to lose resources	9
Mayaguez	Training resources	Microgrid certification (modelling and installation) between academic, national, labs, and private sector	9
San Juan	Community-based solutions	Need for gov't / energy policymakers to incorporate bottom-up solutions	8
Mayaguez	Energy efficiency	Education for EE, changing behavior	8
Mayaguez	Finance	More availability of local finances for renewables and storage	8
San Juan	Microgrids and resilience	Modeling tools for utility side	8

Figure 1: Photos of needs identified by stakeholders, and prioritized using sticky dots. There were a total of 14 posters of needs identified and prioritized in seven topics at the two workshops.



Next Steps

The morning sessions concluded with a discussion of next steps, during which participants were asked to suggest existing resources available to support energy transition initiatives, as well as make commitments to follow-up actions.

Resources exchanged among attendees by topic include:

- Community-based solutions:
 - [Solar Libre](#)
 - [Fundación Comunitaria](#)
 - [Casa Pueblo](#)
 - University Institute for the Development of Communities ([Instituto Universitario para el Desarrollo de las Comunidades](#))
- Energy efficiency:
 - AEC
 - College of Architects
 - General Contractors Association PR chapter
 - PR Builders Association
 - [USGBC Caribbean](#)
- Finance:
 - Association of Cooperativas
 - Finance department at UPRM
 - Oriental Bank
- More technical resources:
 - College of Engineers and Surveyors of Puerto Rico ([CIAPR](#))
 - Fabio Andrade at UPRM for microgrid training
 - Puerto Rico Energy Center ([PREC](#))
 - UPRM Center for Renewable Energy and Sustainability/Centro de Energía Renovable y Sustentabilidad (CRES)

- Training resources:
 - [ACONER](#)
 - [Cambio](#)
 - Puerto Rico Institute of Competitiveness and Economic Sustainability ([ICSE-PR](#))
 - [Relmagina Puerto Rico](#)
 - Solar and Energy Storage Association of PR ([SESA-PR](#))
 - Student organizations like green campus at UPRM to educate students on energy issues

Follow-on actions :

- Raise awareness among everyone in Puerto Rico that Puerto Rico Energy Bureau (PREB) facilitates regulatory processes specifically to solicit input from the public and interested parties, and encourage participation on multiple topics including energy efficiency. This is an action that can be taken broadly.
- Identify and make more accessible some of the relevant research that has been conducted previously at UPRM. DOE is following up on this item.

Key Takeaways

- There is a need to build more local institutional capacity to enable a variety of stakeholders in Puerto Rico to participate in the modernization and transformation of the energy system. Institutional needs include: enhancing capacity within PREPA; continued support for and engagement in PREB activities; research, development and analysis facilities and capabilities; enhanced training resources through local technical colleges and trade organizations for contractors, code and enforcement officials; an energy data consortium; energy-specific small business and entrepreneurial support; and enhanced capacity within local financial institutions for energy-related investments.
- Greatest energy planning needs identified during small-group discussions are in the categories of training and finance, with additional strong interest around the topics of microgrids and resilience, energy efficiency, facilitation of DERs on the grid, and community-based solutions.
- There is a strong interest in availability of local sources of financing like financial cooperatives and local banks.
- Education and training around energy efficiency, as well as policies, incentives, and data availability to support EE was emphasized as a need.
- Microgrids are a common theme, both the need to maintain them so as not to lose resources, as well as training and certification on modelling and installation.
- The need for access to data about the power system, including a database of distributed PV systems, is a very frequently expressed need.
- There is also an interest in ongoing collaboration between UPRM and NREL.

Participants have provided positive and constructive feedback on the events both verbally and through an online evaluation survey. We appreciate the feedback and look forward to continuing this work.

Appendices

Appendix 1: Workshop Agenda Handout



U.S. Department of Energy (DOE) / National Renewable Energy Laboratory (NREL) Workshop on Energy Planning Resources for Puerto Rico

Tuesday, March 19, 2019

8:00 a.m. to 5:00 p.m. (AST)
Puerto Rico Energy Bureau, Hearing Room
World Plaza Building
268 Muñoz Rivera Ave, Suite 801
San Juan, Puerto Rico

Friday, March 22, 2019

8:00 a.m. to 5:00 p.m. (AST)
In Partnership with National Institute for Energy
and Island Sustainability (INESI)
University of Puerto Rico – Mayagüez (UPRM)
Department of Civil Engineering and Surveying
Mayagüez, Puerto Rico 00682

Purpose

This free, one-day workshop is an opportunity for exchange between energy planners and other stakeholders in Puerto Rico and DOE/NREL staff working on energy transformation in the commonwealth. Learn about a DOE project currently underway, provide input on the status of energy system recovery and needed resources, learn about NREL planning tools, and provide feedback on modifications to address local needs. Optional afternoon sessions will go in-depth on select topics.

Agenda

Morning Session

8:30-9:00 a.m. Welcome and Introductions
9:00-10:15 a.m. Overview and Panel Discussion: Local needs for energy transition capacity-building

Panelists include:

➤ San Juan

- Gabriel Perez, Regional Manager Caribbean Region, Blue Planet Energy Systems (and ACONER board member)
- Ingrid M. Vila Biaggi, President/Co-founder, Cambio
- Lillian Mateo Santos, Associate Commissioner, Puerto Rico Energy Bureau

➤ Mayaguez

- Ernesto Rivera Suárez, President, Renewable Solutions Engineering, Inc. (and ACONER former president and consultant on energy policy affairs)
- Ruth Santiago, Lawyer
- Thomas King, Founding Director, Fundación Borincana

10:15-10:30 a.m. Break
10:30-11:00 a.m. NREL Tools You Can Use: Presentation and group discussion
11:00-11:10 a.m. Oak Ridge National Laboratory – Tools presentation
11:10-11:20 a.m. Sandia National Laboratories – Tools presentation
11:20 a.m.-12:00 p.m. Facilitated discussion on data, tool, and training priorities
12:00-12:15 p.m. Report out from discussion
12:15-12:30 p.m. Next Steps
12:30 – 1:30 p.m. Lunch on your own

Concurrent Afternoon Sessions – 1:30-4:30 p.m.

- **Option 1. System Advisor Model (SAM) User Group Session.** SAM is a free computer program that calculates a renewable energy system’s hourly energy output over a single year, as well as the cost of energy for a renewable energy project over its lifetime. This three-hour, hands-on session provides an overview of SAM and related tools and solicits feedback from users on needs specific to Puerto Rico. We will also cover the National Solar Radiation Database ([NSRDB](#)), PVWatts, [Utility Rate Database](#), Jobs and Economic Development Impacts ([JEDI](#)) tool, and other relevant data and tools. Suitable for anyone interested in individual system simulations.
- **Option 2. HEVI and MAFRIT/FESTIV Tools Overview and Discussion.** Learn more about NREL’s capacity expansion modeling tool Hawaii Energy Visualization Initiative ([HEVI](#)), and the [grid modeling tools](#) Multi-Area Frequency Response Integration Tool (MAFRIT) and Flexible Energy Scheduling Tool for Integrating Variable Generation (FESTIV).
- **Option 3. Energy Efficiency Tools and Resources.** Attend this session for a more in-depth discussion on energy efficiency needs in Puerto Rico and available resources.

NREL Tools – user-driven and publicly available

Tool	Questions Answered	Training Available	URL
National Solar Radiation Database (NSRDB)	What is the level of solar irradiance at my site?	User manuals, support forum, and data download steps online	https://nsrdb.nrel.gov/ https://maps.nrel.gov/nsrdb-viewer
Building Energy Optimization Tool (Beopt)	What are cost-optimal efficiency packages for various levels of whole-house energy savings for my building design?	Training videos and publications in support menu on website	https://beopt.nrel.gov/
Community Solar Scenario Tool (CSST)	What are the costs and benefits to various audiences of a single community solar project?	Tool documentation is included as cell comments	https://www.nrel.gov/energy-solutions/csst.html
Jobs and Economic Development Impact (JEDI) models	What are job and other economic development impacts of renewable energy projects in my jurisdiction?	Instructions online and in ‘About Jedi’ tab in the spreadsheet tool	https://www.nrel.gov/analysis/jedi/about.html
PVWatts	What is the possible performance and annual value of my solar project?	Help button on website provides documentation	https://pvwatts.nrel.gov/
REopt Lite	What combination of solar PV, wind, and energy storage will help my site minimize energy costs or sustain a grid outage? (For PR, supports solar plus storage only for now, not wind)	User manual and demo video online	https://reopt.nrel.gov/tool
ResStock	Which energy efficiency measures are likely to yield the highest savings in my jurisdiction?	Documentation, publications and webinar available online	https://resstock.nrel.gov/
System Advisor Model (SAM)	What are the costs, cash flow, and performance predictions for my solar, wind, or geothermal project?	Quick start guide and extensive help menu within software; webinars online	https://sam.nrel.gov/about

NREL Tools – used for in-house analysis

Tool	Description	URL
Hawaii Energy Visualization Initiative (HEVI) tool	A custom capacity and dispatch modeling system that can quickly provide insights on cross-sectoral questions. This tool is customized in partnership with the user (typically an energy office or university) and NREL based on locally available data and information.	https://www.energy.gov/eere/energy-modeling-tool
Flexible Energy Scheduling Tool for Integrating Variable Generation (FESTIV)	A multiple-timescale, interconnected simulation tool that includes security-constrained unit commitment, security-constrained economic dispatch, and automatic generation control sub-models. FESTIV simulates the behavior of the electric power system to help researchers understand the impacts of variability and uncertainty on power system operations.	https://www.nrel.gov/grid/festiv-model.html
Multi-Area Frequency Response Integration Tool (MAFRIT)	The only software tool of its kind that integrates primary frequency response (turbine governor control) with secondary frequency response (automatic generation control). MAFRIT simulates the power system dynamic response in full time spectrum with variable time steps from milliseconds to days under both normal and event conditions. MAFRIT places emphasis on electric power systems with high penetrations of renewable generation.	https://www.nrel.gov/grid/modeling-tools.html



U.S. Department of Energy (DOE) / National Renewable Energy Laboratory (NREL)
Workshop on Energy Planning Resources for Puerto Rico

Resource List

- Clinton Global Initiative (CGI) and Direct Relief, **Puerto Rico Solar Map**. GIS-based map of “Solar Generation and Storage Projects at Critical Facilities Since Hurricane Maria.” Includes option to add additional projects to the map. <https://www.puertoricosolarmap.org/>
- Government of Puerto Rico, Central Office of Recovery, Reconstruction, and Resiliency (COR3), **Transformation and Innovation in the Wake of Devastation: An Economic and Disaster Recovery Plan for Puerto Rico** (August 2018). This 531-page economic and disaster recovery plan “lays out the Government of Puerto Rico’s strategic vision and goals and provides a detailed framework for achieving them.” <https://cor3.pr/assets/documents/pr-transformation-innovation-plan-congressional-submission-080818.pdf>
- Institute for a Competitive and Sustainable Economy (ICSE) and Rocky Mountain Institute (RMI), **Public Collaborative for Puerto Rico’s Energy Future** (2018). Report includes “recommendations created by a diverse group of participants, reflecting areas of agreement and disagreement, ... to inform new Puerto Rican energy policy.” <https://www.rmi.org/insight/public-collaborative-for-puerto-ricos-energy-future/>
- Puerto Rico Electric Power Authority (PREPA), **Puerto Rico Integrated Resource Plan (IRP) 2018-2019: Draft for the Review of the Puerto Rico Energy Bureau** (February 12, 2019). Prepared by Siemens Industry. From a docket on the Puerto Rico Energy Bureau (PREB) website that contains appendices and additional documents.
IRP: <http://energia.pr.gov/wp-content/uploads/2019/02/PREPA-Ex.-1.0-IRP-2019-PREPA-IRP-Report.pdf>
Docket: <http://energia.pr.gov/en/dockets/?docket=CEPR-ap-2018-0001>
- Puerto Rico Energy Resiliency Working Group, **Build Back Better: Reimagining and Strengthening the Power Grid of Puerto Rico** (December 2017). NREL is among contributors to this report, the purpose of which is “to provide an assessment of the electric power system storm damage, describe a new system design basis, and propose rebuild recommendations for the Puerto Rico Power and Grid Resiliency rebuild initiative.”
https://www.governor.ny.gov/sites/governor.ny.gov/files/atoms/files/PRERWG_Report_PR_Grid_Resiliency_Report.pdf
- Queremos Sol, **Energy Proposal** (October 2018). “An energy vision that responds to our objectives as a people and that is defined as a social and material, sustainable, resilient and innovative system, based on clean renewable energy, distributed generation and endogenous resources. It is an affordable system that promotes efficiency, ensures equity, fosters broad public participation and capacity building through shared governance and transparency, while producing wealth and local ownership.”
<https://www.queremosolpr.com/>
- Reimagina Puerto Rico, **Final Reports** webpage. A project of the Resilient Puerto Rico Advisory Commission, created in November 2017, Reimagina Puerto Rico, “developed recommendations to help rebuild Puerto Rico in a way that makes the island stronger – physically, economically, and socially – and more prepared to confront future challenges.” The Final Reports page includes links to the 2018 Reimagina Puerto Rico Report, and sector reports. <https://www.resilientpuertorico.org/en/reports-2/>

- **Resilient Power Puerto Rico (RPPR)** “engages community groups that provide services in historically underserved communities throughout the Islands and provides technical and financial resources in the form of direct donations for the installation of solar energy systems in communities most impacted by Hurricane Maria.” Their work includes a Renewable Energy Microgrid Program, and in partnership with Rocky Mountain Institute the creation of a Community Vulnerability Tool using GIS to map levels of vulnerability across the island. <https://resilientpowerpr.org/>
- Sandia National Laboratory, **Analysis of Microgrid Locations Benefitting Community Resilience for Puerto Rico** (September 30, 2018). An analysis by Jeffers et al. of using microgrids to increase resilience for the island of Puerto Rico. “Critical infrastructure throughout the island was mapped to the key services provided by those sectors to help inform primary and secondary service sources during a major disruption to the electrical grid.” <https://www.osti.gov/servlets/purl/1481633>
- U.S. Department of Energy (DOE), **Energy Resilience Solutions for the Puerto Rico Grid** (June 2018). “This report contains recommendations for the Government of Puerto Rico to consider for incorporation into its recovery plans... The recommendations reflect principles of resilience, and are intended to inform investments that use federal appropriations in the energy infrastructure in the Commonwealth of Puerto Rico.” <https://www.energy.gov/oe/articles/office-electricity-releases-energy-resilience-solutions-puerto-rico-grid-report>
- U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE), Federal Energy Management Program (FEMP), **Solar Photovoltaic Systems in Hurricanes and Other Severe Weather** (August 2018). Two-page fact sheet on an expansion of FEMP’s “recommended design specifications to include factors and best practices for photovoltaic system survivability identified from recent hurricanes.” https://www.energy.gov/sites/prod/files/2018/08/f55/pv_severe_weather.pdf
- U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA), **Alternative Procedures** webpage. Provides information on an amendment to the Robert T. Stafford Disaster Relief and Emergency Assistance Act, which authorizes alternative procedures for the Public Assistance program under sections 403(a)(3)(A), 406, 407 and 502(a)(5), ... and authorizes FEMA to implement the alternative procedures through a pilot program.” Includes links to pilot program guidance documents. <https://www.fema.gov/alternative-procedures>
- U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA), **Hurricanes Irma and Maria in the U.S. Virgin Islands Recovery Advisory 5: Rooftop Solar Panel Attachment: Design, Installation, and Maintenance** (April 2018, Revised August 2018). Ten-page document intended to, “provide guidance on existing code requirements as well as recommend best practices for attachment design, installation, and maintenance of rooftop solar panels ... to increase panel wind resistance in the U.S. Virgin Islands.” https://www.fema.gov/media-library-data/1535554011182-e061c2804fab7556ec848ffc091d6487/USVI-RA5RooftopSolarPanelAttachment_finalv3_508.pdf
- U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA), **Mitigation Assessment Team Report: Hurricanes Irma and Maria in Puerto Rico** (October 2018). Report on conclusions and recommendations of a FEMA Mitigation Assessment Team deployed to PR after hurricanes Irma and Maria. “Intended to provide decision makers, designers, contractors, planners, code officials, industry groups, government officials, academia, homeowners, and business owners and operators with information and technical guidance that can be used to reduce future hurricane damage.” <https://www.fema.gov/media-library/assets/documents/173789>
- U.S. Department of Housing and Urban Development (HUD), **Community Development Block Grant-Disaster Recovery Program (CDBG-DR)** webpage. Includes links to resources and training materials, as well as program news and announcements. <https://www.hudexchange.info/programs/cdbg-dr/>

Appendix 3: DOE and National Lab Participants' Contact Information

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Appendix 4: Full List of Prioritized Needs from Small Group Discussion

Location	Topic	Need	Votes
San Juan	Community-based solutions	Need for gov't / energy policymakers to incorporate bottom-up solutions	8
Mayaguez	Community-based solutions	Technical assistance to connect two mountain communities and water systems (rural aqueduct and PRASA)	7
San Juan	Community-based solutions	Involving public in design of IRP. Instruments for regulator to validate the customer experience	7
Mayaguez	Community-based solutions	Need at community level for technical assistance to follow through on ideas, and connect experts with community needs	5
San Juan	Community-based solutions	Workforce development and capacity-building (installers, electricians, maintenance, connecting with unions)	5
Mayaguez	Community-based solutions	Implementing EE first to assess energy needs and design smaller and less expensive PV systems	4
Mayaguez	Community-based solutions	Tools to help design systems for individuals and microgrids	4
San Juan	Community-based solutions	Mediator to incorporate work of institutions and organizations into future plans	4
San Juan	Community-based solutions	Defining community-based solutions and educating the public about them. - Community solar, - Electric cooperatives, -More participatory programs	4
Mayaguez	Community-based solutions	Decision-support tools for planning small systems for a group of houses (3 houses sharing a PV system)	2
San Juan	Community-based solutions	Building owners as champions of community solar/community solutions for cost savings	2
Mayaguez	Community-based solutions	Learning how to engage communities to understand their needs and be sensitive (e.g., starting a new project in Vieques)	0
Mayaguez	Community-based solutions	Hub for community-support organizations	0
	Community-based solutions Total		52
San Juan	Energy efficiency	Education; Policy; Incentives (monetary and non-monetary); Data availability. ('kids' written on one of the dots)	11
Mayaguez	Energy efficiency	Education for EE, changing behavior	8
Mayaguez	Energy efficiency	Past studies from UPRM. Need to publish	7
San Juan	Energy efficiency	Hands-on training	5
Mayaguez	Energy efficiency	PACE financing with CDBG-DR	4
Mayaguez	Energy efficiency	Gamify EE savings: - bilingual, - savings for appliances	3
Mayaguez	Energy efficiency	Need small business development	2
Mayaguez	Energy efficiency	Bring in investor confidence project	2
Mayaguez	Energy efficiency	INESI still waiting for state energy office to approve reports	2
Mayaguez	Energy efficiency	Need EE portfolio standard	2
San Juan	Energy efficiency	Higher _(%)_ water pumps and other specific technologies	2
San Juan	Energy efficiency	Policy enforcement; Technology; Assistance from DOE; Community collaboration	2
Mayaguez	Energy efficiency	Need to work with AC installers	1
Mayaguez	Energy efficiency	Need proof of EE as least-cost resource	1
Mayaguez	Energy efficiency	Uncertainty on future of PREPA	1

San Juan	Energy efficiency	Start with EE, then renewables	1
San Juan	Energy efficiency	Capacity building for communities	1
Mayaguez	Energy efficiency	Act 57 government supposed to (cut? ant?) 1% each year	0
	Energy efficiency Total		55
Mayaguez	Facilitation of DERs on the grid	Collaboration between NREL/UPRM. Power systems group. Big driver is PR need now	11
Mayaguez	Facilitation of DERs on the grid	Education: climate change and impacts. Poverty (>50% in PR). Info campaign	7
Mayaguez	Facilitation of DERs on the grid	Fear of and resistance to change/innovation, not just in energy sector (historical, political, economic). Promo, info-campaigns; social leaders, community leaders; champions (e.g. Casa Pueblo, Arturo Massol. Engage leaders first (e.g., Prof. Orama)	6
Mayaguez	Facilitation of DERs on the grid	Engage with other university departments: - social science, economics. Summer internship at NREL	5
San Juan	Facilitation of DERs on the grid	Long-term: How should system evolve (to include DER) 40% by 2025?	5
Mayaguez	Facilitation of DERs on the grid	Engagement with leaders before doing event like today (Facebook, Twitter)	3
San Juan	Facilitation of DERs on the grid	Need education for customers wanting DER	3
San Juan	Facilitation of DERs on the grid	DER market structure. -Local co-op market vs. PREPA market (offsite high prices)	3
Mayaguez	Facilitation of DERs on the grid	"Main Street" building owners getting together to form microgrids - alliance or consortium. Rooftop solar, battery storage	2
San Juan	Facilitation of DERs on the grid	What can be accommodated (with existing system)?	2
San Juan	Facilitation of DERs on the grid	Impact of large customer loads self-generating (but still tied to grid)	2
San Juan	Facilitation of DERs on the grid	How to configure 8 microgrids throughout system in terms of system architecture (incorporating DER)?	2
San Juan	Facilitation of DERs on the grid	Need data. Not open system model	1
San Juan	Facilitation of DERs on the grid	What physical reinforcements for DER? Value added? (Who pays)	1
	Facilitation of DERs on the grid Total		53
San Juan	Finance	Making local finance more available (finance co-ops, local banks)	17
Mayaguez	Finance	More availability of local finances for renewables and storage	8
San Juan	Finance	USDA REAP access for these funds for rural projects (grants and finance). Infrastructure and EE	7
San Juan	Finance	Local incentives for storage, etc.	6
Mayaguez	Finance	Training for local banks on existing DER products	5
Mayaguez	Finance	Training on available federal grants and finance programs (DOE, USDA, etc.) and how to apply	5
Mayaguez	Finance	Microgrid co-op business models and structures (co-op charters, etc.)	3
Mayaguez	Finance	Transparency on funds for RE projects	3
San Juan	Finance	PACE info (Property-assessed clean energy)	3

San Juan	Finance	Connecting communities to CDBG-DR funds and programs. - Vivienda, - community organizations to access and develop projects	2
San Juan	Finance	Energy efficiency programs for small commercial and residential projects. - Finance (PAYS, or bill, rebate, etc.)	1
San Juan	Finance	More info on power-purchase agreements and contracts. -consumer protections, -standard contracts and guidelines	1
Mayaguez	Finance	Connect installers with more finance options	0
	Finance Total		61
San Juan	Microgrids and resilience	Maintenance of microgrids so as not to lose resources	9
San Juan	Microgrids and resilience	Modeling tools for utility side	8
Mayaguez	Microgrids and resilience	Protection within a microgrid and the critical point where to implement them. Delay settings for microgrids	7
San Juan	Microgrids and resilience	Main grid health for sustaining microgrid integration	6
San Juan	Microgrids and resilience	Energy storage systems integration	5
San Juan	Microgrids and resilience	Peer-to-peer energy sharing technologies. Need effective economic model (e.g., financed community-owned solar)	4
San Juan	Microgrids and resilience	Strategic planning. Incremental growth	3
San Juan	Microgrids and resilience	Strategic development of pilot projects, real life scenario	3
San Juan	Microgrids and resilience	How to deal with clients that do not want to be part of the microgrid or that are part and later they want to drop off	3
Mayaguez	Microgrids and resilience	How do we build resilience into the grid?	2
Mayaguez	Microgrids and resilience	How can we study the data consumption accurately in order to build a sustainable grid?	2
San Juan	Microgrids and resilience	Base load microgrid	2
San Juan	Microgrids and resilience	Resource/asset placement vs. transmission cost	2
Mayaguez	Microgrids and resilience	Local technical knowledge	1
San Juan	Microgrids and resilience	Cost of microgrids	0
	Microgrids and resilience Total		57
San Juan	Solar resource data	No database of distributed PV system	11
Mayaguez	Solar resource data	Good GIS high-level maps of resource data for decision-makers	6
San Juan	Solar resource data	Microclimates. Sunny <-- 10 miles -->mostly rainy	3
San Juan	Solar resource data	Spikes in load. A/C aligned with solar	3
Mayaguez	Solar resource data	Good sharing and outreach of new data being developed	2
Mayaguez	Solar resource data	Spanish language version of PVWatts	1
	Solar resource data Total		26

San Juan	Training resources	Energy storage system training (-public, -engineering, -economics, -applications, -implementation/installation. Sandia webinars!	11
San Juan	Training resources	In-school programs for EE and RE	11
Mayaguez	Training resources	Microgrid certification (modelling and installation) between academic, national, labs, and private sector	9
San Juan	Training resources	Who distributes/advertises free training resources, webinars, etc.? - Contractors, -Public, -PR mailing lists	6
San Juan	Training resources	Training for financial industry	6
San Juan	Training resources	Solar 101 for public (benefits, costs, etc...). Independent	5
Mayaguez	Training resources	Efficiency training for contractors and code enforcement	4
Mayaguez	Training resources	Cost-benefit info for public and communities. How to run processes to establish value framework	4
San Juan	Training resources	Increase transparency on actual value streams once regulations are established	4
San Juan	Training resources	Consumer/public education and installer training to better optimize home energy investment	3
San Juan	Training resources	Efficiency training for code officials and contractors	3
Mayaguez	Training resources	Parliamentary laws (?) for microgrids	2
Mayaguez	Training resources	Better market online and in-person trainings to PR via social media (LinkedIn) and Instagram	2
Mayaguez	Training resources	PV Watts phone app	1
Mayaguez	Training resources	Energy storage 101 webinars (Sandia)	1
Mayaguez	Training resources	Translating SAM into Spanish	0
San Juan	Training resources	Shared solar business model and finance	
Training resources			72
Total			

Appendix 5: Workshop Photos



Figure 2: Panel discussion during morning session in San Juan, March 18, 2019 (top and bottom)



Figure 3: Afternoon session on System Advisor Model (SAM) and other tools with Nate Blair of NREL in San Juan on March 18



Figure 4: Afternoon session on FESTIV with Xin Fang of NREL in San Juan on March 18, 2019



Figure 5: Afternoon session on energy efficiency with Adam Hasz of DOE in San Juan on March 18, 2019



Figure 6: Panel discussion during morning session in Mayaguez on March 22, 2019



Figure 7: Afternoon session on HEVI with Rob Spencer and Tom Harris of NREL in Mayaguez on March 22, 2019



Figure 8: Afternoon session on MAFRIT with Himanshu Jain of NREL in Mayaguez on March 22, 2019



Figure 9: Department of Civil Engineering and Surveying at UPRM Mayaguez where workshop was held on March 22, 2019 (above), and directional signage (at right)

