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Puerto Rico—Status of Electric Power Recovery

(name redacted)
Specialist in Energy Policy

July 10, 2018

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SUMMARY

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Puerto Rico—Status of Electric Power Recovery

On September 20, 2017, Hurricane Maria made landfall in Puerto Rico as a Category 4 storm with sustained wind speeds of over 155 miles per hour. At that time, the Commonwealth of Puerto Rico was already in recovery mode following the glancing blow struck by Hurricane Irma on September 6, 2017, which left 70% of electricity customers without power. Puerto Rico's office of emergency management reported that Hurricane Maria had incapacitated the central electric power system, leaving the entire island without power as the island's grid was essentially destroyed. Even before the 2017 hurricane season, Puerto Rico's electric power infrastructure was known to be in poor condition, due largely to underinvestment and the perceived poor maintenance practices of the Puerto Rico Electric Power Authority (PREPA).

The primary focus of territorial and federal efforts thus far has largely been on restoring electric power in Puerto Rico. The new hurricane season in the Atlantic Basin (comprised of the Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico) began on June 1, 2018, and will last until November 30.

A large part of the Federal Emergency Management Agency's (FEMA's) role in Puerto Rico was centered on coordinating the restoration of electric power. For this task, FEMA made available about 900 portable generators (including several generation units providing over 50 Megawatts of capacity at the partially operating Palo Seco station in San Juan), and contracted with the U.S. Army Corps of Engineers (USACE) to oversee restoration of the electric transmission system, which was damaged extensively. PREPA itself has largely been focused on the restoration of the electric distribution system, and service connections to its customers. In Puerto Rico, USACE is not only restoring emergency power but also leading initial grid repair. With the end of the grid repair part of USACE's mission assignment on May 18, 2018, almost 99% of PREPA's customers have seen their electric service restored.

Section 21101 of the Bipartisan Budget Act of 2018 (P.L. 115-123) provided $28 billion in supplemental appropriations to the U.S. Department of Housing and Urban Development (HUD), under the Community Development Block Grant (CDBG) fund. Of this amount, up to $2 billion was made available (until expended) for "enhanced or improved electrical power systems."

Approximately $2 billion in CDBG funds were made available to "enhance or improve" any electric power systems damaged by Hurricane Maria. To help guide the process of rebuilding Puerto Rico's grid, the U.S. Department of Energy (DOE) reports that five national laboratories have collaboratively built a model of Puerto Rico's electricity system to test how to place microgrids, determine where to place power lines underground, and test siting of renewable energy projects where they can be sheltered from damage by extreme weather events. DOE believes its modeling efforts can therefore help guide HUD and FEMA CDBG investments to improve the power grid in Puerto Rico. DOE says that it plans to complete a "resilient grid model" to prioritize investments for "transmission, distribution, new generation, energy storage, microgrids, and strategic power reserves." This would allow potential impacts on other critical infrastructure such as the petroleum, natural gas, and telecommunications sectors to be estimated.

With the power restoration effort almost finished, the next focus for authorities will likely be on rebuilding Puerto Rico's electricity transmission and distribution systems, as a modern system built to U.S. industry standards is more likely to survive extreme weather events. Once the backbone of the infrastructure is in place, then the major effort of making the electricity system of Puerto Rico more resilient can follow in earnest. Building resilience would likely require improvements that go beyond even modernization and rebuilding. Resilience may require additional improvements to the system aimed at better withstanding the effects of extreme weather events.

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Background

On September 20, 2017, Hurricane Maria made landfall in Puerto Rico as a Category 4 storm with sustained wind speeds of over 155 miles per hour. At that time, the Commonwealth of Puerto Rico (the Commonwealth) was already in recovery mode following the glancing blow struck by Hurricane Irma on September 6, 2017, which left 70% of electricity customers without power. Puerto Rico's office of emergency management reported that Hurricane Maria had incapacitated the central electric power system, leaving the entire island without power as the island's grid was essentially destroyed. After Maria, officials were estimating that many of Puerto Rico's 3.5 million people could be without electricity for up to six months.

Even before the 2017 hurricane season, Puerto Rico's electric power infrastructure was known to be in poor condition, due largely to underinvestment and the perceived deficient maintenance practices of the Puerto Rico Electric Power Authority (PREPA). With the poor state of the electricity system (physically, organizationally, and financially),[1] and a perceived lack of transparency with regard to decisions (both before and since Hurricane Maria),[2] discussions have already started about how the electricity system in Puerto Rico would be rebuilt, and under what regulatory regime it will operate.

The primary focus thus far has largely been on restoring electric power in Puerto Rico, while the task of rebuilding the grid in Puerto Rico to modern standards is expected to follow. The new hurricane season in the Atlantic Basin (comprised of the Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico) began June 1, 2018, and will last until November 30.

Congress continues to follow the recovery of Puerto Rico from the 2017 hurricanes, and the restoration of power. The electric power infrastructure for transmission and delivery of power was largely destroyed by the hurricanes, and PREPA's aging power generation facilities have been struggling to provide electricity. Whether, and how, Puerto Rico rebuilds its system into a reliable, efficient, and resilient electricity system will be of key interest to Congress.

Status of Electric Power Restoration

A large part of the Federal Emergency Management Agency's (FEMA's) role in Puerto Rico was centered on coordinating the restoration of electric power. For this task, FEMA brought about 900 portable generators (including several generation units providing over 50 Megawatts (MW) of capacity at the partially operating Palo Seco electric power generation station in San Juan), and

[1] In his written statement, Governor Ricardo Rosselló, governor of Puerto Rico, stated "On the eve of Hurricane Maria, Puerto Rico was literally bankrupt—having sought Title III protection for the Commonwealth and certain of its instrumentalities, including the Puerto Rico Electric Power Authority (PREPA), due to a mountain of over $80 billion of debt that it could no longer service with available revenues." Also, from the written statement of Ricardo Ramos, Executive Director of PREPA, "When I became Executive Director of the Puerto Rico Electric Power Authority in March 2017, I knew that PREPA faced significant challenges including a declining revenue base, a shrinking workforce, a backlog of unmet or deferred maintenance, key major equipment beyond its useful life, and of course, the many challenges associated with Puerto Rico's and PREPA's financial condition." U.S. Congress, Senate Committee on Energy and Natural Resources, *Written Statement of Hon. Ricardo Rosselló, Governor of Puerto Rico*, Hearing on Hurricane Recovery Efforts in Puerto Rico and the U.S. Virgin Islands, 115th Cong., 1st sess., November 14, 2017, p. 2. U.S. Congress, Senate Committee on Energy and Natural Resources, *Written Statement of Ricardo Ramos, Executive Director of PREPA*, Hearing on Hurricane Recovery Efforts in Puerto Rico and the U.S. Virgin Islands, 115th Cong., 1st sess., November 14, 2017, p. 1.

[2] Ross Marchand, "To Get the Lights Back On, Puerto Rico Must Boost Transparency," *The Hill*, October 26, 2017, http://thehill.com/opinion/finance/357326-to-get-lights-back-on-puerto-rico-must-boost-transparency.

tasked the U.S. Army Corps of Engineers (USACE) to oversee restoration of the electric transmission system, which was damaged extensively. PREPA itself has largely been focused on the restoration of the electric distribution system, and service connections to its customers.[3] Both USACE and PREPA have used contractors to do much of the transmission and distribution system repairs.[4] With the end of the grid repair part of USACE's mission assignment on May 18, 2018, almost 99% of PREPA's customers have seen their electric service restored. However, over 16,000 customers (in mostly rural parts of the island) were still without electricity after eight months.

The power restoration mission has been described as incomplete by the USACE, with much of the work to date essentially to patch up the electric system to bring power back to the people of Puerto Rico.[5] FEMA has agreed to leave over 700 portable generators on Puerto Rico past the end of the USACE's grid repair mission.[6]

FEMA and Grid Restoration Assistance[7]

PREPA is a public power utility[8] owned by the Commonwealth of Puerto Rico, and is the largest supplier of electricity in the Commonwealth. As a public utility, PREPA is an eligible applicant that can receive federal assistance through the Federal Emergency Management Agency (FEMA). In particular, FEMA provides grant assistance through the Public Assistance Grant Program (PA Program) for the repair, restoration, and replacement of public facilities, as defined by law, in states and communities that have received major or emergency disaster declarations through the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act, P.L. 93-288, as amended).[9]

Role of the Army Corps of Engineers

USACE supports the Department of Homeland Security in carrying out the National Response Framework. If requested by the President and the affected governors under the Stafford Act, USACE's primary role under the framework is to provide emergency support in areas of public

[3] PREPA's power transmission system consists of 1,100 miles of 115 kilovolt (kV) and 230 kV transmission lines. In addition, there are approximately 1,375 miles of 38kV subtransmission level lines including 55 miles of undersea lines that connect the main island with the islands of Vieques and Culebra. The hurricanes knocked out of service over 2,400 miles of transmission lines (including 1,375 miles of subtransmission lines operating at 38 kV), and 30,000 miles of distribution lines, representing almost the entire transmission and distribution infrastructure of the island. See CRS Report R45023, *Repair or Rebuild: Options for Electric Power in Puerto Rico*, by (name redacted), (name reda cted), and (name redacted) .

[4] Andrew Scurria, "Puerto Rico Contract Spending Accelerates with Army Corps Exit," *Wall Street Journal*, March 2, 2018, https://www.wsj.com/articles/puerto-rico-contract-spending-accelerates-with-army-corps-exit-1519948452.

[5] Voice of America, *Army Corps Quits Puerto Rico Saying Job is Incomplete*, May 18, 2018, https://www.voanews.com/a/army-corps-leaving-puerto-ricans-without-power/4399485.html.

[6] Carlos Giusti and Michael Weissenstein, "Corps Leaving Puerto Rico with Hurricane Recovery Unfinished," Associated Press, May 18, 2018, https://apnews.com/cba884b0d5664368a18dfe7ea1b18e75/Corps-leaving-Puerto-Rico-with-hurricane-recovery-unfinished.

[7] See CRS Report R45023, *Repair or Rebuild: Options for Electric Power in Puerto Rico*, by (name redacted), (name redacted), and (name redacted) .

[8] "Public power utilities are operated by local governments to provide communities with reliable, responsive, not-for-profit electric service. Public power utilities are directly accountable to the people they serve through local elected or appointed officials." American Public Power Association, *About Public Power*, 2017, http://publicpower.org/.

[9] For an overview of the PA Program, see CRS Report R43990, *FEMA's Public Assistance Grant Program: Background and Considerations for Congress*, by (name redacted) and(name redacted) .

works and engineering.[10] These USACE activities are funded through the Disaster Relief Fund and not through direct appropriations to the agency. In Puerto Rico, USACE not only restored emergency power but also led initial grid repair. USACE leadership in grid repair as part of domestic disaster recovery is a novel development.[11]

On September 30, 2017, the FEMA Administrator also tasked USACE to work with PREPA, Department of Energy (DOE), and FEMA to provide a unified effort to repair Puerto Rico's power grid. USACE was tasked with leading the planning, coordination, and integration of the electric power grid repair. The Unified Command Group (comprised of the Corps, FEMA, PREPA, and Puerto Rico's Restoration Coordinator) was organized to evaluate and coordinate efforts for the work of restoring power to prestorm electricity customers (i.e., not new customers, poststorm).[12]

PREPA's electric power generation plant at Palo Seco in San Juan is not operating at full power due to the condition of the facility.[13] FEMA installed two "mega" 30 MW mobile diesel-fueled generators to stabilize power generation in the heavily populated region around San Juan.[14] FEMA also installed several smaller mobile generators at Palo Seco to provide additional power at times of peak electric demand. Another large mobile 30 MW generator is installed at the Yabucoa Power Plant to help stabilize power generation in the southeastern region of Puerto Rico. USACE personnel are assisting with the operation and maintenance of the mobile generators.

FEMA Funding for 2017 Disasters[15]

Supplemental Appropriations Bills

In light of the hurricanes and other disasters in 2017, Congress passed three supplemental appropriations bills in response to Administration requests made in September, October, and November 2017. Amounts for electric grid restoration in Puerto Rico were not specified, even though the third supplemental does allow for $2 billion in funding for "enhanced or improved electrical power systems" for all areas affected by Hurricane Maria.

First Supplemental, September 2017 (P.L. 115-56, Division B)

On September 1, 2017, the Trump Administration requested $7.85 billion in supplemental funding. On September 6, the House passed the relief package requested by the Administration as

[10] Other tasks typical for USACE include technical assistance; engineering; construction management; emergency contracting; and repair of power systems, public water and wastewater systems, and solid waste facilities.

[11] Each disaster often results in FEMA adjusting assignments to meet the needs and demands of the specific situation. Furthermore, USACE is the entity designated with emergency contracting under the National Response Framework (NRF). USACE was also active in assisting PREPA with emergency dam-safety measures at its Guajataca dam. USACE actions to reopen navigation through channel assessments and clearing has allowed for improved delivery of materials, equipment, and personnel to the island for grid repair and other recovery activities.

[12] U.S. Congress, Senate Committee on Energy and Natural Resources, *Statement of Charles Alexander. Jr., Army Corps of Engineers, Update on the Restoration of Puerto Rico's Electric Infrastructure*, 115th Cong., 2nd sess., May 8, 2018, pp. 3-4.

[13] Javier Colón Dávila, "Engineers to Assess Whether Palo Seco Can Operate," *ElNuevodia*, October 20, 2017, https://www.elnuevodia.com/english/english/nota/engineerstoassesswhetherpalosecocanoperate-2367636/.

[14] Approximately 70% of Puerto Rico's power generation is in the southern region of Puerto Rico, while approximately 70% of power demand is in the northern regions.

[15] See CRS Report R45084, *2017 Disaster Supplemental Appropriations: Overview*, by (name redacted) .

an amendment to H.R. 601. On September 7, the Senate passed the bill further amended to include an additional $7.4 billion for disaster relief through the Department of Housing and Urban Development's (HUD's) Community Development Fund. The House subsequently passed the Senate-amended version of the bill on September 8, 2017, and it was signed into law by President Trump the same day (P.L. 115-56), authorizing $15.3 billion in funding.[16]

Second Supplemental, October 2017 (P.L. 115-72, Division A)

On October 4, 2017, the Trump Administration requested an additional $12.7 billion for the Disaster Relief Fund (DRF). On October 12, the House passed H.R. 2266 with a further House amendment including $18.67 billion for the DRF (to the DHS Office of Inspector General for disaster audits), and also allowed some of that funding to be transferred to two other programs: $4.9 billion would go to FEMA's Disaster Assistance Direct Loan Program account, and $10 million to the Department of Homeland Security (DHS) Office of Inspector General for oversight of disaster-related activities. The bill subsequently was signed into law as P.L. 115-72 on October 26, 2017, authorizing $36.5 billion in funding. Of the $4.9 billion, up to $150 million is available for the cost of providing loans through the Advance of Non-Federal Share Program for the cost shares for Puerto Rico and the U.S. Virgin Islands related to Hurricanes Irma and Maria, and $1 million is for administrative expenses for the program.

Third Supplemental, February 2018 (P.L. 115-123, Division B)

The Trump Administration made a third supplemental appropriations request for disaster relief and recovery funding on November 17, 2017, seeking roughly $44.0 billion in additional funding. On February 7, 2018, the Senate took up H.R. 1892, with the Senate leadership adding S.Amdt. 1930. This became the Bipartisan Budget Act of 2018 (P.L. 115-123). Subdivision I of Division B of the amendment was titled "Further Additional Supplemental Appropriations for Disaster Relief Requirements Act, 2018" and included more than $84 billion in additional disaster assistance funding. The amended bill passed the House and was signed into law by President Trump as P.L. 115-123, authorizing $84.3 billion in funding.[17] Out of that amount, FEMA received an additional $23.5 billion in funding authority for the DRF.

P.L. 115-123 transferred up to $150 million of the $23.5 billion for DRF to the Disaster Assistance Direct Loan Program for costs related to Hurricanes Irma and Maria, of which $1 million may be used for administrative expenses for the program.

Funding for Power Restoration in Puerto Rico

In the Appendix, **Table A-1** shows FEMA's estimate of the allocations for the approximately $3.2 billion in funding for various electric power restoration activities in Puerto Rico under federal disaster supplemental appropriations.

According to FEMA, disaster charges related to Hurricanes Irma and Maria are being charged to P.L. 115-56 and P.L. 115-72. Thus, Disaster Declaration 4339 is being charged to P.L. 115-56 and P.L. 115-72. Once those funds are exhausted, funds from P.L. 115-123 will be used.[18] However, FEMA has also stated that there has been discussion about which supplemental will be eventually

[16] Ibid., p. 3.

[17] Ibid., p.4.

[18] Email communication from Jerry Johnson, FEMA Congressional Affairs, June 19, 2018.

charged with the various activities, and it is possible that the allocation of funds could change in the future.

Preparation for the 2018 Hurricane Season

In recognition of the current fragility of the electric system in Puerto Rico, FEMA has left behind three large mobile power generation units, and charged the cost of the units to Disaster Declaration 4339.[19] FEMA has also left behind a number of peaking generation units to support power demands on the grid, and these are also charged to the same disaster declaration account.[20]

End of USACE Mission Assignment

The USACE's power restoration mission in Puerto Rico essentially ended on May 18, 2018, with approximately 99% of electric power customers having their power restored. Some USACE personnel remain to maintain the temporary generators still providing power on the island.

Rebuilding Puerto Rico's Grid

The grid emergency in Puerto Rico led to triage-type decisions, resulting in electric distribution poles and transmission towers that were marginally structurally sound being left in place in some instances. These poles and towers will almost certainly have to be replaced,[21] as the focus of the Commonwealth and the federal government turns from power restoration to rebuilding what has been described in the media as a "teetering" grid.[22]

While USACE's initial power restoration efforts were focused on repairing Puerto Rico's grid to "pre-storm" conditions, the poor state of the electrical system soon led to FEMA realizing that improvements would have to involve mobilizing the USACE to "rebuild the grid to U.S. code standards."[23]

When asked to what extent were improvements made to Puerto Rico's grid under authority granted by the Restoration of Damaged Facilities, 44 C.F.R. §206.226(d), FEMA responded as follows:

> To date, power restoration has been completed as "Emergency work." The materials used for emergency power restoration were designed to current codes and standards. Many areas received materials that will ultimately strengthen the system. For example, some towers

[19] See **Table A-1** in the Appendix, "MEPA 142." Consists of three "Mega" 30 Megawatt mobile diesel-fueled generators.

[20] See **Table A-1** in the Appendix, "MEPA 113." Consists of 20 diesel-fueled combustion turbine generators (of varying sizes) at eight locations in the PREPA system to support peak load operation during the hours of highest daily, weekly, or seasonal system electricity demands.

[21] "Electricity transmission towers installed specifically for temporary emergency restoration should be considered for replacement, potentially by monopoles; many of the round monopole structures survived the 2017 storms." U.S. Congress, Senate Committee on Energy and Natural Resources, *Full Committee hearing to Examine Puerto Rico's Electric Grid*, Written Testimony of Assistant Secretary Bruce J. Walker, 115th Cong., 2nd sess., May 8, 2018, p. 4. (hereinafter, Walker Testimony.)

[22] Michael Weissenstein, *Puerto Rico grid 'teetering' despite $3.8 billion repair job*, Associated Press, May 31, 2018, https://www.apnews.com/fa210cd1434c4d909e6030c7da884bce/Puerto-Rico-grid-'teetering'-despite-.

[23] U.S. Congress, Senate Committee on Homeland Security and Governmental Affairs, 2017 Hurricane Season: Oversight of the Federal Response, 115th Cong., 1st sess., October 31, 2017, pp. https://www.hsgac.senate.gov/hearings/2017-hurricane-season-oversight-of-the-federal-response.

> that toppled over (that were rusted and not maintained) were replaced with new towers. While some infrastructure was replaced and even upgraded to code, Puerto Rico Electric Power Authority (PREPA) was not able to use the optimal materials or design to maximize resilience, because it was focused on emergency work. That will be done in the permanent work phase.[24]

Modernizing Puerto Rico's Grid

Approximately $2 billion in CDBG funds were made available to "enhance or improve" any electric power systems damaged by Hurricane Maria. To help guide the process of rebuilding Puerto Rico's grid, DOE reports that five national laboratories have collaboratively built a model of Puerto Rico's electricity system to test how to place microgrids, determine where to place power lines underground, and test siting of renewable energy projects where they can be sheltered from damage by extreme weather events.[25] DOE believes its modeling efforts can therefore help guide HUD and FEMA CDBG investments to improve the power grid in Puerto Rico.[26]

In June 2018, DOE issued a report focused on enhancing the resilience of Puerto Rico's electric grid with recommendations that it believes may help prioritize investments for transmission, distribution, new generation, energy storage, microgrids, and strategic power reserves.[27] This would allow potential impacts on other critical infrastructure such as the petroleum, natural gas, and telecommunications sectors to be estimated.

An enhanced and improved electricity system in Puerto Rico would likely include Smart Grid technologies to allow incorporation of more varied energy choices, both at consumer and electric utility levels.[28] DOE describes the Smart Grid as "an intelligent electricity grid—one that uses digital communications technology, information systems, and automation to detect and react to local changes in usage, improve system operating efficiency, and, in turn, reduce operating costs while maintaining high system reliability."[29]

However, the extent to which a Smart Grid would be fully deployed in Puerto Rico would likely depend on an evaluation of the potential benefits and costs of projected applications.[30] Cyber- and physical security would have to be a consideration in the design, construction, and operations of a modern grid incorporating Smart Grid technologies.[31]

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[24] Email communication from Jerry Johnson, FEMA Congressional Affairs, July 10, 2018.

[25] Walker Testimony, Near Term Modeling Support at p. 3.

[26] "DOE seeks to facilitate collaboration with PREPA as they plan future investments and determine where financial resources will be most beneficial in strengthening Puerto Rico's grid and increasing its resilience." Ibid.

[27] U.S. Department of Energy, *Energy Resilience Solutions for the Puerto Rico Grid*, June 2018, https://www.energy.gov/sites/prod/files/2018/06/f53/DOE%20Report_Energy%20Resilience%20Solutions%20for%20the%20PR%20Grid%20Final%20June%202018.pdf. (Hereinafter, DOERecs.)

[28] CRS Report R43742, *Customer Choice and the Power Industry of the Future*, by (name redacted) .

[29] DOE, *Transforming the Nation's Electricity System: The Second Installment of the Quadrennial Energy Review*, January 2017, p. S-4, https://www.energy.gov/sites/prod/files/2017/02/f34/Quadrennial%20Energy%20Review--Second%20Installment%20%28Full%20Report%29.pdf.

[30] See CRS Report R45156, *The Smart Grid: Status and Outlook*, by (name redacted) .

[31] CRS Report R43989, *Cybersecurity Issues for the Bulk Power System*, by (name redacted) .

Prospective Funding for Electric Power Systems

Section 21101 of the Bipartisan Budget Act of 2018 (P.L. 115-123) provided $28 billion in supplemental appropriations to HUD, under the Community Development Fund. Under the appropriation, $16 billion of the appropriation was to be available for declared disasters in 2017, with $11 billion for state and local governments affected by Hurricane Maria. Of this amount, up to $2 billion was made available (until expended) for "enhanced or improved electrical power systems."[32] Puerto Rico and the U.S. Virgin Islands are not specifically named as the intended recipients, and other states or local governments are also likely eligible for the grants.

Section 21210 of the act also places a requirement for FEMA (with assistance from DOE and the Governor of Puerto Rico, among others) to report on a 12- and 24-month economic and disaster recovery plan for electric power systems and grid restoration.

Reorganization of the Electric Power System

Puerto Rico's Governor Rosselló initially proposed privatizing and selling PREPA's assets in January 2018. This was followed in March 2018 with a plan submitted to Puerto Rico's Legislative Assembly with details of how the privatization of the utility would proceed.[33] One of the goals of the plan was to use public-private partnerships to stabilize the electric system and lessen prices for electricity customers.[34] Details of how the privatization effort could accomplish these goals are unclear at this time.

There have been two previous efforts at privatization of a public utility in Puerto Rico. Efforts were made in the 1990s and early 2000s to privatize the Puerto Rico Aqueduct and Sewer Authority (PRASA), but "service quality deteriorated and prices for consumers increased, as did the agency's operational deficit."[35]

Improving Reliability in Puerto Rico

Power recovery efforts in Puerto Rico have focused primarily on restoring power to electricity customers. However, according to reports in the media, the speed of emergency restoration has taken precedent over "basic quality standards" for the work.[36] Puerto Rico is taking steps to adopt

[32] The funds "shall be awarded directly to the State, unit of general local government" pursuant to the Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 U.S.C. 5121 et seq.).

[33] "In January, Governor Rosselló announced a transformation of Puerto Rico's energy sector that is expected to take at least 12–18 months. The transformation envisions possibly engaging a private operator for the Island's transmission and distribution system through an effective mechanism (e.g., long term concession agreement) which is compliant with federal funding requirements and complimentary to the anticipated and planned reconstruction and hardening of that system following last year's storms. This transformation also contemplates a private ownership or operation of existing PREPA assets as well as development of greenfield generation projects." U.S. Congress, Senate Committee on Energy and Natural Resources, *Full Committee Hearing to Examine Puerto Rico's Electric Grid*, Written Statement of Walter M. Higgins, Chief Executive Officer of the Puerto Rico Electric Power Authority, 115th Cong., 2nd sess., May 8, 2018, p. 3. (Hereinafter, Higgins Testimony.)

[34] Danica Coto, "Puerto Rico Gov Signs Bill to Privatize Power Company Assets," Associated Press, June 20, 2016, http://www.newsobserver.com/news/business/article213520879.html.

[35] Lara Merling, *Privatization Won't Fix Puerto Rico's Broken Power Utility*, North American Congress on Latin America, February 1, 2018, https://nacla.org/news/2018/02/01/privatization-won%E2%80%99t-fix-puerto-rico%E2%80%99s-broken-power-utility.

[36] Michael Weissenstein, *Puerto Rico Power Grid Fragile Despite $3.8 billion in Repairs*, May 31, 2018, https://www.elp.com/articles/2018/05/puerto-rico-power-grid-fragile-despite-3-8-billion-in-repairs.html?cmpid=

guidelines for electric systems maintenance used on the mainland.[37] DOE has recommended that Puerto Rico follow guidelines for electric industry standards suggested by the Rural Utilities Service of the U.S. Department of Agriculture.[38] However, the extent to which the restored infrastructure in Puerto Rico is rebuilt to current electrical standards will be important to the modernization efforts that would follow, and much of this work may have to be redone.

Among the recommendations by DOE for improving electric reliability in Puerto Rico was the recommendation for an effective mutual assistance agreement to be in place.[39] Mutual aid agreements help utilities recover from power outage situations often caused by severe weather events, and are typically negotiated in anticipation of a future need. Under mutual assistance agreements for electric utilities, the utility receiving aid generally pays for the costs incurred by the utility providing aid in accordance with the assistance agreement.[40]

Congress gave the Federal Energy Regulatory Commission (FERC) authority to oversee the reliability of the bulk-power system under the Energy Policy Act of 2005 (P.L. 109-58). Reliability standards were added as Section 215 of the Federal Power Act[41] to help ensure the reliable operation of the bulk power system so that "instability, uncontrolled separation, or cascading failures" will not occur as a result of a sudden disturbance. FERC-approved reliability standards address programs ranging from vegetation clearances in electric transmission line rights-of-way, to policies and procedures for critical infrastructure protection of power plants and supporting facilities. However, FERC-approved reliability standards are only applicable to the continental United States, and not to U.S. territories such as Puerto Rico.[42] To date, no legislation has been proposed to change this.

Building Electric System Resilience

With the power restoration effort almost finished, the next focus for authorities will likely be on rebuilding Puerto Rico's electricity transmission and distribution systems, as a modern system built to U.S. industry standards is more likely to survive extreme weather events. According to DOE, vegetation trimming and clearance requirements for utilities on the U.S. mainland for reliability purposes should be enforced on Puerto Rico, and are likely to reduce power outages caused by weather-related events.[43]

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6dcc0f78e37d799dcf22bd9576140&eid=288971764&bid=2125048.

[37] "PREPA, with the support and guidance of FEMA and the United States Department of Energy, is working to harden the power grid and deploy the proper equipment and processes to meet power grid compliance standards. This initiative will continue to be deployed over the coming years and is expected to improve the reliability and efficiency of the system." Higgins Testimony, p. 3.

[38] "USDA Rural Utilities Service (RUS) standards should be adopted where feasible and appropriate to standardize equipment and design, which will aid with replacement in both regular and emergency situations. USDA RUS standards govern the engineering and component specification of all voltage ranges of electrical transmission and distribution networks used by every rural electric utility in North America that borrows from RUS." DOERecs, p. 18.

[39] "The Governor and PREPA should immediately ensure that updated, effective mutual aid agreements are primed to quickly provide support during the next event." Walker Testimony, p. 4.

[40] David Ferris and Peter Behr, "Cash Crunch Slowed Puerto Rico's Appeal for Grid Help, CEO says," *E&E News*, October 9, 2017, https://www.eenews.net/stories/1060063083/print.

[41] 16 USC 12, Sections 824 to 824w.

[42] 150 FERC ¶ 61,095.

[43] DOERecs, p. 20.

While electric system reliability and system resiliency are related, they differ both in scope and regulatory requirement. Reliability, according to the U.S. Department of Energy (DOE), is the ability of the system or its components to withstand instability, uncontrolled events, cascading failures, or unanticipated loss of system components.[44] Resilience, as defined by DOE, is the ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions.[45]

Authorities in Puerto Rico were encouraged by DOE to define what system resilience entails for the island's power system.[46] This may combine elements of power generation modernization, incorporating microgrids with hardening of infrastructure for the island's grid and communications systems.[47]

Electric System Resilience Must Be Planned

Once the backbone of Puerto Rico's electric system infrastructure is in place, then the major effort of making the system more resilient can follow. Enhancing resilience would likely require improvements that go beyond even rebuilding the electric power system according to standards in effect for U.S. mainland power utilities. Resilience may require additional improvements to the system aimed at better withstanding the effects of extreme weather events.

According to the DOE, there are no commonly used metrics for measuring grid resilience. Electric system resilience is not mandated by federal law, but the ability of the system to adapt to changing conditions and recover rapidly from disruptions is a key attribute of electric system reliability. A 2016 report from several of DOE's national laboratories focused on the potential for a changing environment, and the need to maintain a resilient power system.[48] The report identified risks ranging from weather events that disrupt transmission or distribution, to high impact, low frequency (HILF) risks such as catastrophic hurricanes. The report also built upon previous developments identified by DOE in the energy sector including growing potential threats from climate change, energy security, transitions from coal to natural gas generation, increased deployment of distributed and renewable generation, and rising investments to modernize the energy grid.[49] While the report acknowledged that electric power systems "are currently well-equipped to effectively manage a broad range of threats," it recognized that some risks remain challenging and that "resilience efforts should shift toward these more complex risk management challenges." Some of the key risks to resilience identified in the study include the following:

[44] U.S. Department of Energy, *Transforming the Nation's Electricity Sector: The Second Installment of the QER*, January 2017, https://www.energy.gov/sites/prod/files/2017/01/f34/Chapter%20IV%20Ensuring%20Electricity%20System%20Reliability%2C%20Security%2C%20and%20Resilience.pdf.

[45] Ibid.

[46] "The report also notes where additional analysis is needed to more precisely articulate resilience-related, investment-grade suggestions regarding the design and specification of the electricity system in Puerto Rico." DOERecs, p. 7.

[47] Executive Office of the President, *Economic Benefits of Increasing Electric Grid Resilience to Weather Outages*, August 2013, https://www.energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf.

[48] Benjamin L. Preston, Scott N. Backhaus, and Mary Ewers, et al., *Resilience of the U.S. Electricity System: A Multi-Hazard Perspective*, DOE National Laboratories, August 2016, https://www.energy.gov/sites/prod/files/2017/01/f34/Resilience%20of%20the%20U.S.%20Electricity%20System%20A%20Multi-Hazard%20Perspective.pdf. (Hereinafter, GR.)

[49] DOE, *The Quadrennial Energy Review*, January 2017, https://www.energy.gov/policy/initiatives/quadrennial-energy-review-qer.

- HILF threats associated with natural hazards (particularly weather or space weather) of historic intensity or large-scale physical, cyber, or electromagnetic attacks.
- Combined or blended threats associated with simultaneous exposure of the electric grid to one or more natural threats in combination with a physical or cyberattack.
- Threats that affect vulnerable components of the electricity system or that exceed critical thresholds. For example, distribution networks are often a weak link in the electric grid, but disruptions and outages associated with distribution are often localized.

The report provided a number of recommendations "to guide future decision-making to enhance resilience of the U.S. electricity system."[50] These recommendations included the following:

- Build a greater understanding of HILF events and capability to incorporate HILF threats into risk assessment. Scenario-based planning to explore multiple contingencies can be used to stress test the system and identify gaps in resilience.
- Develop a robust and scalable system of resilience metrics for the electricity system.
- Increase capacity to assess and manage risks and their uncertainties which may change over time and geographic areas. Future changes in not only the climate, but also population, technology, and societal preferences have important implications for resilience.
- Institute policies and practices that can help to streamline assessment and decisionmaking while enhancing coordination and communication can be just as important to resilience as the development of robust infrastructure and assets.

How electric power systems incorporate resiliency into reliability planning will depend on their evaluation of risk to the system, and the financial and other resources available to system planners. Given the potential consequences of long-term electric power failures in Puerto Rico, Congress may consider further how various electric power systems incorporate resilience into reliability planning.

Other Issues Going Forward

Puerto Rico's reliance on fossil fuels for power generation raises cost, reliability, and potential health issues going forward.

Before the 2017 hurricane season, coal and diesel fuel represented approximately 64% of fuel used for power generation. And the mega- and peaking electric combustion turbine generators left behind on Puerto Rico by FEMA are currently powered by burning diesel fuel. Coal and diesel fuel are expensive to import to Puerto Rico, and the reliance on diesel fuel for almost 50% of electricity on the islands has resulted in high prices, about 24 cents per Kilowatt-hour (kWh) for residential customers for power when compared to an average price of 13 cents per KWh on the U.S. mainland.[51] On the financial side, PREPA's inability to pay for fuel for power generation

[50] GR, p. 43.

[51] U.S. Energy Information Administration, *Why Puerto Rico's Electric Grid Stood No Chance Against Maria*, June 21, 2018, https://www.eia.gov/state/print.php?sid=RQ.

was a major complicating factor following Hurricane Maria. On the health side, among other factors (such as an increase in mold spores), emissions from diesel- and gasoline-fueled power generators of all sizes have been reported in the media as being linked to rising asthma rates in Puerto Rico since the 2017 storm season.[52]

Puerto Rico adopted a Renewable Portfolio Standard (RPS) in July 2010 (Act 82 of 2010) which mandated that PREPA supply increasing amounts of retail electricity sales from eligible "green energy" resources, peaking at 20% of retail sales by 2035. In 2014, concerns about PREPA's ability to follow through with this goal led to new legislation (Act 57 of 2014) that established a Puerto Rico Energy Commission and an office of consumer advocacy.[53] The Puerto Rico Energy Commission must have an independent regulatory role if RPS goals are to be met.[54]

Increasing renewable electric generation and requiring more energy storage may potentially reduce electricity costs, since most renewable electric technologies do not directly require a fossil fuel to produce power. However, the variability and intermittency of renewable generation means that energy storage, and traditional power generation capable of flexible, efficient operation (to increase or decrease power generation to support renewables) to provide reliable electricity would likely be needed. Increasing natural gas generation has been discussed by some as an option for Puerto Rico, since it is generally considered a cleaner-burning option to diesel fuel. But given Jones Act restrictions on importing liquefied natural gas to Puerto Rico, whether and how authorities may follow through with this option is unclear.[55]

Recent Legislation

In the 115th Congress, S. 1894 was introduced in September 2017, as a bill to exempt Puerto Rico from the coastwise laws of the United States. The bill would revise the coastwise laws, commonly known as the Jones Act, that govern domestic transportation of merchandise or passengers by vessels. The Jones Act requires that vessels transporting merchandise or passengers between Puerto Rico and other U.S. ports be built in the United States, at least 75% owned by U.S. citizens, and mostly crewed by U.S. citizens. Jones Act requirements are currently waived with respect to vessels transporting passengers between Puerto Rico and U.S. ports. This bill would permanently exempt vessels transporting merchandise between Puerto Rico and other U.S. ports from those requirements.

In the 115th Congress, the "Puerto Rico and Virgin Islands Equitable Rebuild Act of 2017" (S. 2165), introduced in November 2017, would provide for additional disaster-recovery assistance and other assistance to Puerto Rico and the U.S. Virgin Islands with respect to infrastructure, health care, agriculture, education, economic development, and environmental remediation, among other sectors. Specifically, regarding energy use in both territories, the bill would provide for the use of certain emergency assistance to rebuild electric grids, and would establish grant programs to promote energy efficiency and renewable energy.

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[52] Ayana Bird, *Asthma Rates Rise in Puerto Rico Following Hurricane Maria*, June 18, 2018, https://www.colorlines.com/articles/asthma-rates-rise-puerto-rico-following-hurricane-maria.

[53] CRS Report R45023, *Repair or Rebuild: Options for Electric Power in Puerto Rico*, by (name redacted), (name r edacted), and (name redacted) .

[54] Doreen Hemlock, *Can Puerto Rico Really Depend on Microgrids and Renewables for Power?*, Renewable Energy World, December 15, 2018, https://www.renewableenergyworld.com/articles/2017/12/can-puerto-rico-really-depend-on-microgrids-and-renewables-for-power.html.

[55] CRS Report R45006, *U.S. Liquefied Natural Gas (LNG) Exports: Prospects for the Caribbean*, by (name redacted) et al.

In the 115th Congress, the "Puerto Rico and Virgin Islands Equitable Rebuild Act of 2018" (H.R. 4782), introduced in January 2018, would provide additional disaster-recovery assistance and other assistance to Puerto Rico and the U.S. Virgin Islands with respect to infrastructure, health care, agriculture, education, economic development, and environmental remediation, among other sectors. Specifically, regarding energy use in both territories, the bill would provide for the use of certain emergency assistance to rebuild electric grids, and would establish grant programs to promote energy efficiency and renewable energy.

Appendix. FEMA—Puerto Rico Temporary Power Restoration Obligations

Table A-1. FEMA Estimated Funding for Electric Power Restoration in Puerto Rico

As of June 18, 2018

Date	Disaster Declaration Number	Applicant Name	Application Title	Amount Obligated[d] $	Mission Assignment $	Project Worksheet $
9/29/17	4339[a]	US Army Corps of Engineers (USACE) SAD16	Activation-Contracts/labor to execute mission	87,500,000	87,500,000	
10/08/17	4339	USACE SAD16	Contracts/labor to execute mission	489,500,000	489,500,000	
10/10/17	3384[b]	PREPA[c]	Emergency Protective Measures (EMP)	7,200,255		7,200,255
10/11/17	4339	PREPA	AEE001B EMP	45,000,000		45,000,000
10/14/17	4339	PREPA	PREPA—Emergency Power Plant Fuel[e]	42,800,000		42,800,000
10/15/17	4339	PREPA	PREPA—Emergency Power Plant Fuel[e]	128,400,000		128,400,000
10/28/17	4339	USACE	Contracts/labor to execute mission	450,000,000	450,000,000	
11/30/17	4339	USACE SAD16	Contracts/labor to execute mission	802,600,000	802,600,000	
12/30/17	4339	PREPA	251E2—AEE002 EMP COBRA CONTRACT	200,000,000		200,000,000
	4339	PREPA	PREPA Emergency Power Plant Fuel de-obligation[e]	(171,200,000)		(171,200,000)
1/5/18	4339	USACE SAD16	Contracts/labor to execute mission	80,000,000	80,000,000	
3/6/18	4339	PREPA	314E1- EMP	200,000		200,000
3/9/18	4339	PREPA	251E2 – AEE002 EMP COBRA CONTRACT	745,429,800		745,429,800

Date	Disaster Declaration Number	Applicant Name	Application Title	Amount Obligated[d] $	Mission Assignment $	Project Worksheet $
3/16/18	4339	USACE SAD16	Contracts/labor to execute mission	44,000,000	44,000,000	
3/23/18	4339	USACE SAD16	Contracts/labor to execute mission	200,000,000	200,000,000	
5/1/18	3384	PREPA	EEPA004—EMP	10,625		10,625
5/17/18	4339	USACE	Net de-obligation (-$250,000,000 + $115,000,000)	(135,000,000)	(135,000,000)	
5/17/18	4339	USACE SAD33	Contracts/labor to execute mission	45,000,000	45,000,000	
5/20/18	4336[b]	PREPA	IEPA001—EMP	95,507		95,507
5/25/18	4339	PREPA	MEPA037—EMP	62,373		62,373
5/31/18	4339	PREPA	MEPA113—EPM-Peaking Generator Units	130,897,179		130,897,179
	4339	PREPA	MEPA142—Mega Generator Purchases	58,500,000		58,500,000
6/1/18	3384	PREPA	EEPA005 EMP Distribution	49,962		49,962
6/2/18	4339	PREPA	MEPA063—EMP Canovanas	65,923		65,923
6/11/18	4339	USACE SAD16	De-obligate contract funds	(60,000,000)	(60,000,000)	
			Total	3,191,111,623	2,003,600,000	1,187,511,623

Source: Email communication from Jerry Johnson, FEMA Congressional Affairs, June 18, 2018.

Notes: Columns may not add due to rounding.

a. Declaration number 4339 is for Hurricane Maria.

b. Emergency declaration number 3384 and Disaster declaration number 4336 are for Hurricane Irma.

c. PREPA is the Puerto Rico Electric Power Authority (*Autoridad de Energía Eléctrica*, in Spanish).

d. Funds made available to the State via electronic transfer following FEMA's final review and approval of Public Assistance projects (see https://www.fema.gov/disaster-page-definitions).

e. The emergency fuel funds were returned to FEMA, and the funds de-obligated.

Funds listed under "Project Worksheet" in **Table A-1** are amounts associated with FEMA's Public Assistance program.[56] Funds listed under Mission Assignment refer to the work orders issued by FEMA to another federal agency directing the completion of a specific task.[57]

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[56] As a public utility, PREPA is an eligible applicant that can receive federal assistance through the Federal Emergency Management Agency (FEMA). In particular, FEMA provides grant assistance through the Public Assistance Grant Program (PA Program) for the repair, restoration, and replacement of public facilities, as defined by law, in states and communities that have received a major or emergency disaster declaration through the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act, P.L. 93-288, as amended). For an overview of the PA Program, see CRS Report R43990, *FEMA's Public Assistance Grant Program: Background and Considerations for Congress*, by (name redacted) and (name redacted) , *FEMA's Public Assistance Grant Program: Background and Considerations for Congress*,.

[57] FEMA, *Federal Agencies Providing Disaster Assistance*, 2018, https://www.fema.gov/federal-agencies-providing-disaster-assistance.