PREPA Ex. 6.0

GOVERNMENT OF PUERTO RICO
PUERTO RICO ENERGY BUREAU

IN RE: REVIEW OF THE PUERTO RICO ELECTRIC POWER AUTHORITY INTEGRATED RESOURCE PLAN	**No.** CEPR-AP-2018-0001 **SUBJECT:** Direct Testimony of Nelson Bacalao, Ph.D.

Direct Testimony of

NELSON BACALAO, PH. D.

Senior Consulting Manager
Siemens Power Technologies International

June 14, 2019

TABLE OF CONTENTS

I. INTRODUCTION

A. Witness Identification

Q. **Please state your name, title, employer, and business address.**

A. My name is Dr. Nelson Bacalao. I am a Senior Consulting Manager at Siemens Industry Inc., Power Technologies International ("Siemens – PTI" or "Siemens"). My business address is 4615 Southwest Freeway Suite 900, Houston TX 77027.

Q. **On whose behalf are you testifying before the Puerto Rico Energy Bureau (the "Energy Bureau") (formerly known as the Puerto Rico Energy Commission)[1] in this proceeding?**

A. I am testifying on behalf of the Puerto Rico Electric Power Authority ("PREPA").

Q. **Have you previously testified or made presentations before the Energy Bureau?**

A. I made presentations and answered questions at technical conferences before the Energy Bureau's in PREPA's first Integrated Resource Plan ("IRP") proceeding, Case No. CEPR-AP-2015-0002, and in this current IRP proceeding.

I also prepared testimony as part of PREPA's February 13, 2019, IRP filing in this current docket, but that testimony is no longer applicable because of later developments in this case. On March 14, 2019, the Energy Bureau issued a Resolution and Order that found the February 13th IRP filing to be not in compliance with the Energy Bureau's IRP regulation (Reg. No. 8021) and prior Energy Bureau orders. The March 14th order, among other things, directed PREPA to submit a "refiled IRP", also referred to as a "revised IRP",

[1] References in my testimony to the Energy Bureau include the former Puerto Rico Energy Commission when applicable.

that would replace the February 13th IRP. PREPA filed the new IRP on June 7, 2019. Accordingly, the new testimony that I am submitting today replaces my February 13, 2019, testimony. In my testimony, I will refer to the June 7th IRP simply as the IRP, because that is the IRP that PREPA is presenting and proposing. I will refer to the February 13th IRP as the February 13th IRP.

B. Summary of Direct Testimony

Q. **What are the purposes and subjects of your Direct Testimony?**

A. My Direct Testimony addresses the following purposes and subjects:

1) I discuss and support the development (including stakeholder processes) and contents of PREPA's new IRP, consisting of a main Report, an Attachment, and Appendices, PREPA Exhibits ("Ex.") 1.0 through 1.04 (see also PREPA Ex. 2.0, IRP supporting documents), including compliance with the Energy Bureau's March 14th order;

2) I identify and describe, at a high level, the scenarios, strategies, and sensitivities evaluated and presented in the IRP;

3) I describe the planning and modeling process that was performed in support of the IRP; and

4) I present the results of the IRP and PREPA's proposed Action Plan found in Part 10 of the IRP main Report.

Please note that the IRP main Report is designed to "speak for itself". So, my Direct Testimony generally is presented at a high level without repeating at a more detailed level material that is stated and presented in the IRP.

Q. **In brief, what are your conclusions and recommendations?**

A. The IRP was developed in accordance with the applicable requirements of PREPA and the Energy Bureau, including the Energy Bureau's March 14, 2019, order and later orders, subject to a Motion that PREPA filed on June 7, 2019, for very limited waivers of the Energy Bureau's Regulation ("Reg.") No. 9021.

The IRP's development included a robust stakeholder process in which plans for the IRP were shared and stakeholders gave feedback, input, and proposals, on strategies, scenarios, sensitivities, and other aspects of the plans. The IRP's development also included a robust process of discussions with the Energy Bureau and its staff through filings, technical conferences, and Energy Bureau orders. The IRP reflects months of effort to understand and comply with the Energy Bureau's March 14, 2019, order and later orders.

The IRP reflects a very extensive and careful planning and modeling process that used appropriate data, software, and techniques.

The IRP's results are reasonable and provide what is, in my professional opinion, a practical plan to develop an economic and resilient power system for Puerto Rico and it has built in enough flexibility to manage the substantial uncertainties that exist at this moment. The Energy Bureau should accept PREPA's IRP and Action Plan.

Q. **Are there any exhibits attached to your testimony?**

A. Yes. My testimony includes the following attached exhibit:

- PREPA Exhibit ("Ex.") 6.01: My *curriculum vitae.*

C. Qualifications and Professional Background

Q. **What is your educational background?**

A. I received a Ph. D. in Electrical Engineering from the University of British Columbia, Vancouver, BC, Canada, in 1987. I received a Master Engineering (Electrical) degree from Rensselaer Polytechnic Institute in Troy, NY, in 1980. I received an Electrical Engineer degree from Universidad Simón Bolívar in Caracas, Venezuela, in 1979.

Q. **What is your professional experience?**

A. I have over 39 years of professional experience providing technical and strategic consulting services to utilities, governments, regulators, independent project developers, and the financial community, in domestic as well as international assignments in the energy industry. My experience is and has been centered on power system planning, including generation additions, transmission and distribution. I have provided services to various institutions including the World Bank, the Overseas Private Investment Corporation ("OPIC") and the Inter-American Development Bank. I am currently the senior manager of the Siemens PTI Houston Office. More detail is found in PREPA Ex. 6.01, which is my *curriculum vitae*, as noted above.

Q. **How long have you been employed by Siemens?**

A. I have worked at Siemens since January 2006.

Q. **Please describe your work experience prior to joining Siemens in 2006.**

A. Please see PREPA Ex. 6.01.

Q. **Do you hold any professional licenses?**

A. I am a registered engineer in Venezuela.

II. PREPA'S IRP

A. General Description

Q. What is an integrated resource plan or IRP in the context of an electric utility?

A. In brief, at a very high level, an IRP is an analysis of options for achieving an electric utility's resource needs in order to meet expected demand over a long-term planning horizon, subject to applicable policy objectives and constraints such as the applicable legal framework.

Q. Can you please broadly describe the development of PREPA's IRP?

A. PREPA's IRP (PREPA Ex. 1.0; *see also* PREPA Ex. 2.0, IRP supporting documents) was prepared by Siemens in cooperation with PREPA at PREPA's direction and considers a planning period of 20 years. PREPA's direction included the requirement that the IRP comply with the Energy Bureau's Regulation No. 9021 and the Energy Bureau's applicable orders. The IRP took into account the Energy Bureau's March 14, 2019, order and later orders. The IRP also took into account that renewable portfolio standard ("RPS") of Puerto Rico Act 82-2010 as amended by Puerto Rico Act 17-2019. Act 17-2019 was signed into law on April 11, 2019, during the course of our work on the IRP. The development of the IRP also took into account robust stakeholder processes that I discuss later in my testimony.

The IRP considered six Scenarios reflecting different materializations of key uncertainties, such as ability to develop liquefied natural gas ("LNG") terminals, cost of renewable generation, and resource options. These Scenarios, combined with three Strategies (centralized generation development, decentralized development and a combination of both), resulted in different Long-Term Capacity Expansion plans

("LTCE") for three levels of load forecast, High, Base and Low. In addition, nine sensitivities were run on selected cases including high fuel costs, lower and higher cost of renewables, no LNG terminals in San Juan, etc. During the IRP's development, the process produced a great number of LTCE computer model runs that were developed using industry-accepted modeling software, AURORAxmp. The IRP also includes analysis of eight large "islands of resiliency" called "MiniGrids". The IRP also includes and reflects professional analysis performed by experts in the fields of engineering, economics, statistics, and regulatory process, among others.

Q. **What do you mean when you say that the IRP took into account the Energy Bureau's March 14, 2019, order and later orders?**

A. The Energy Bureau's March 14th order is extremely detailed. The body of the order is nearly 20 pages long and very specific for the most part. The order has 17 more pages of highly detailed requirements.

The March 14th order also provided for a formal process to clarify the order. PREPA, with our input, presented written clarification questions to the Energy Bureau on March 25, 2019. On April 1, 2019, the Energy Bureau conducted a Technical Conference in which the clarification questions and related topics were discussed at length. On April 5, 2019, the Energy Bureau issued a Resolution and Order following up on the Technical Conference and clarification questions. The compliance process also included additional filings and orders after April 5th.

We take the Energy Bureau's directives very seriously. We spent an enormous amount of effort to develop an IRP that complied with those directives. For example, we

expended a significant amount of time in designing the LTCE runs that were responsive to the Energy Bureau mandates of March 14th and thereafter. We ended up modeling 35 LTCEs as part of the development of the IRP. The IRP also includes the assessment of eight large "islands of resiliency" called MiniGrids. We expanded significantly the analysis of the MiniGrids to provide answers to the Energy Bureau's questions on the impact in the form of cost of energy not served of not making the investments for resiliency for the MiniGrids. We also provided detailed answers on the limitations of the distribution system to integrate distributed generation ("DG"), effect on losses, and the main challenges of this electric system to provide reliable service to PREPA's customers. With respect of the transmission system, we identified investments that would be necessary for the interconnection of the new combined cycle plants (plants that use both a gas and a steam turbine together) at Yabucoa and Mayagüez, in the absence of the resiliency investments recommended. With respect of the selection of the Action Plan, we made clear what were the aspects that were part of the Optimization Process (least cost alternative) and what elements of the Plan were due to other professional and policy considerations.

Q. **Is this IRP tailored to meet PREPA's customers' needs?**

A. Yes. The IRP is not a classical IRP designed to identify the least cost approach to address an expected gap between future load growth and resources while maintaining a desired Planning Reserve Margin. Rather, this plan must satisfy the five pillars identified by PREPA's Governing Board in its Vision for the Future of Power in Puerto Rico, described below, for a system with declining load. The five key pillars, in brief, are: customer-centric, financial viability, reliable and resilient, model of sustainability, and

151 economic growth engine. Instead of focusing on new resources to meet load growth, this
152 IRP focuses on addressing PREPA's needs in order to serve its customers, including
153 addressing the impacts of an aging generation fleet, achieving a reduction of cost of supply
154 by incorporating renewables at the new market prices, achieving compliance with the
155 Renewable Portfolio Standard, and shifting from centralized generation to more
156 decentralized generation resources distributed across the island. The IRP places a great
157 deal of emphasis on the creation of eight islands of resiliency called MiniGrids into which
158 the system could be segregated following a major storm to facilitate timely recovery from
159 the impacts of the storm.

160 Q. **How is the write-up of the IRP organized?**

161 A. The write-up of the IRP is comprised of a standalone document (the main Report), the
162 accompanying Attachment A, and the technical Appendices directed by the Energy
163 Bureau's Regulation No. 9021. The main body of the document (the main Report) is
164 divided into ten Parts:

165 1) Part One - Introduction and Summary of Conclusions
166 2) Part Two - Planning Environment
167 3) Part Three - Load Forecast
168 4) Part Four - Existing Resources
169 5) Part Five - Resource Needs Assessment
170 6) Part Six - New Resource Options
171 7) Part Seven - Assumptions and Forecasts
172 8) Part Eight - Resource Plan Development

9) Part Nine - Caveats and Limitations

10) Part Ten - Action Plan

The IRP also includes an Attachment A about the Gas Pipeline Competition Model ("GPCM") used in the IRP.

The main Report plus Attachment A are PREPA Ex. 1.0.

Please note that confidential information was moved out of the main Report and into Appendix 1, described below, so that the full main Report would be a public document while protecting the confidential information. The confidential information consists of Critical Energy Infrastructure Information ("CEII").

The IRP also was going to include an Attachment B providing the detailed list of Priority 1 and Priority 2 transmission line and substation investment projects, but as the IRP was finalized we concluded that Attachment B would be redundant with information in Appendix 1.[2]

PREPA and Siemens also prepared a document called "Answers to Order of March 14th Questions Appendix A, B &C" that either provides direct answers to the question or in the majority of the case refers to a section in the Main Report, the Appendices and /or a workpaper. This document is being filed on June 14, 2019.

Finally, the IRP also contains four technical Appendices:

1) Appendix 1 - Transmission and Distribution Planning (in Confidential, public redacted, and public MiniGrids versions, so PREPA Exs. 1.01A Conf., 1.01B, and 1.01C)

[2] IRP Section 10.2.1 contains an incorrect reference to Attachment B instead of Appendix 1.

2) Appendix 3 - Renewable Energy Project Status (split up into four documents) (broken into four documents, so PREPA Exs. 1.02A through 1.02D)

3) Appendix 4 - Demand-Side Resources (PREPA Ex. 1.03)

4) Appendix 5 - New and Existing Supply-Side Resources Supplemental Data[3] (PREPA Ex. 1.04)[4]

Q. **What modeling software was used to perform the IRP?**

A. In brief, the IRP was performed principally using AURORAxmp capacity expansion modeling software and the AURORAxmp- Nodal model for detailed production cost modeling to confirm the absence of congestion. The software to be originally used for production cost modeling, PROMOD, was unable at the time to handle correctly the massive amounts of battery storage that needed to be analyzed, forcing the use of the equivalent AURORAxmp-Nodal models. Also, there were simulations and runs made with PSS®E for power flow and system stability analysis, GPCM for natural gas market modeling, GT-Pro for assessing thermal generation performance, Siemens' proprietary MATLAB load forecasting model, and PREPA's distributed generation forecast models.

B. Stakeholder Processes

Q. **Please describe the stakeholder processes that PREPA and Siemens conducted as part of the development of the IRP.**

[3] Please note, however, that the subject matter of Appendix 5 is covered by the IRP main Report, Parts 4 and 6. Accordingly, Appendix 5 simply points to those two Parts rather than redundantly repeating the same information.

[4] There is no Appendix 2. Appendix 2 essentially was inapplicable due to the 2017 Hurricanes and it was waived by the Energy Bureau's March 14, 2019, order.

A. To begin with, I should note that the Smart Electric Power Alliance ("SEPA") played a major role in assisting PREPA and Siemens in arranging and conducting the stakeholder processes, which occurred prior to the development of the February 13th IRP. PREPA and Siemens engaged in a robust interactive stakeholder process through which, during in person and call-in conferences, the interested parties provided valuable input to assist in the design and preparation of the IRP. We shared plans for the IRP, and stakeholders gave feedback, input, and proposals, on strategies, scenarios, sensitivities, and other aspects of the plans. The IRP's development also included a robust process of discussions with the Energy Bureau and its staff through filings, technical conferences, and Energy Bureau orders. There were technical conferences on August 14, 2018, September 13, 2018, and November 2, 2018. Interested parties filed questions and comments in advance of the conferences, and, to the extent directed by the Energy Bureau, PREPA and Siemens responded. The technical conferences included extensive discussions between Siemens and the Energy Bureau's retained staff or consultants from Synapse Consulting. Since February, PREPA and Siemens have maintained contact with stakeholders and carried out two stakeholders meetings open to the public in Puerto Rico on March 12, 2019, and has maintained contact with other stakeholders including the Financial Oversight and Management Board and other interested parties.

Q. **Did PREPA and Siemens take stakeholder input into account in preparing the IRP?**

A. Yes, PREPA and Siemens took stakeholder input into account in preparing the February 13th IRP and this carried over to the June 7th IRP. For example, PREPA and Siemens considered inputs on the merits of the Strategies and accordingly modified the

IRP design in certain respects. Because of most stakeholders' input, PREPA did not originally include Strategy 1, the centralized generation approach, into the model runs as the majority of the stakeholders preferred the distributed generation approach of Strategy 2. Based on stakeholder inputs we made sure that demand side resources such as rooftop solar and combined heat and power ("CHP") and demand response were properly accounted for in the IRP process. Another example is the formulation of MiniGrids and microgrids in order to enhance the resiliency of the electric system after major events, as well as the recognition of recent new developments in the manufacturing of batteries for bulk storage applications.

Q. **Did PREPA and Siemens provide information to and receive directions and input from the Energy Bureau and its staff / consultants throughout the process of designing the IRP?**

A. Yes, PREPA and Siemens provided input and received input and directions through Regulation No. 9021, the Energy Bureau's orders, and the interactions I have referenced above. In addition, feedback continued even after we began performing LTCE model runs. For example, at the third technical conference, on November 2, 2018, we presented certain preliminary results of certain Long-Term Capacity Expansion Plan runs, which then were discussed. In addition, later on, there were extensive additional communications and cooperation as part of the process of clarifying and complying with the Energy Bureau's March 14, 2019, order and later orders.

C. IRP Scenarios, Strategies, and Sensitivities

Q. **What Scenarios were considered in the IRP?**

A. The Scenarios evolved in certain respects during the process of creating and refining the IRP. There were five original Scenarios, but, ultimately, Scenario 2 was not included in the final 35 LTCEs because Scenario 4, Strategy 2, and Scenario 4, Strategy 3, resulted in the same resources that would be built under the constraints of Scenario 2. It should be noted that in the February 13 IRP filing, Scenario 4, Strategy 2, did build a combined cycle gas turbine ("CCGT") by 2027 in Mayagüez, making it not fully aligned with Scenario 2. Thus, the Energy Bureau's March 14th order found, however, that, given this result, PREPA should have continued to model Scenario 2. However, in this new IRP filing, Scenario 4, Strategy 2, is not building terminals in Mayagüez or Yabucoa and is aligned with Scenario 2.

In addition, the final IRP also includes a sixth Scenario for PREPA's Energy System Modernization Plan ("ESM").

The IRP, Part 5, Section 5.4, describes the six Scenarios as follows.

> The PREB IRP Regulation defines Scenarios as a combination of system requirements needed to serve load, commodity prices, capital costs, and risks that influence the choice of resources serving PREPA's future load. Each scenario constitutes a possible resource plan. Traditional uncertainties (e.g., load forecasts, fuel forecasts, and renewables capital costs) are assessed via cases (High, Base and Low) and sensitivities. They could also be assessed via stochastic analysis. Based on extensive stakeholder engagement and consolidation of the September scenarios orders by PREB, PREPA considered a total of six Scenarios as part of the 2018-2019 IRP.
>
> With respect of fuel infrastructure and renewables, the following Scenarios are considered as outlined in Exhibit 5-2 and further described below.
>
> **Scenario 1:** No new gas-fired generation is installed. The scenario uses the base case assumptions of solar and storage costs and availability. The only new gas generation considered in this scenario is the conversion of the combined cycle at San Juan 5 & 6.

Scenario 2: Gas to North: The land-based LNG at San Juan in the North is assumed to acquire the required permitting approval. The Scenario uses the base case assumption of solar and storage costs and availability. This scenario was eventually dropped as Scenario 4 collapsed to the same conditions in this scenario; only gas was developed in the north and the south.

Scenario 3: Gas to Yabucoa (east) and to Mayagüez (west) through ship-based LNG and gas to the north is supplied through land-based LNG at San Juan. The land-based LNG at San Juan is assumed to acquire the required permitting approval. The Scenario assumes the deeper drop (NREL Low Case) of solar and storage costs coupled with high availability of renewables (early ramp up).

Scenario 4: Gas to Yabucoa (east) and to Mayagüez (west) through ship-based LNG and gas to the north is supplied through land-based LNG at San Juan. The land-based LNG at San Juan is assumed to acquire the required permitting approval. The Scenario uses the base case assumption of solar and storage costs and availability.

Scenario 5: Aguirre Offshore Gas Port (AOGP), gas to Yabucoa (east) and to Mayagüez (west) is supplied through ship-based LNG. Gas to the north is supplied through land-based LNG at San Juan which is assumed to achieve required permitting approval. The Scenario uses the base case assumption of solar and storage costs and availability. The Scenario also places no restriction on the size of the combined cycle units (CCGT) and up to H-Class (449 MW) could be added. All previous Scenarios had a maximum size of 302 MW F-Class CCGT. The scenario eventually did not select the AOGP, thus confirming that other options modeled were superior.

ESM: Energy System Modernization (ESM); this is a variation of Scenario 4 advanced by PREPA and that includes a set of pre-defined investments decisions that considers procurement options presented by the Public Private Partnership Authority, pricing structures necessary to retain existing natural-gas fired generation in the south, and locational alternatives for new large scale CCGTs. The ESM is benchmarked against the formulated least cost plans. See further details below.

Exhibit II-1. PREPA IRP Scenario Definition

Scenario	New Gas				Renewable & Storage	
	AOGP	Land-based LNG at San Juan	Ship-based LNG at Yabucoa	Ship-based LNG at Mayagüez	Costs	Availability
1	No	No	No	No	Reference	Reference
2	No	Yes	No	No	Reference	Reference
3	No	Yes	Yes	Yes	Low	High
4	No	Yes	Yes	Yes	Reference	Reference
5	Yes	Yes	Yes	Yes	Reference	Reference
ESM	No	Yes	Yes	Yes	Reference	Reference

Additionally, as detailed in Part 5, fundamental uncertainties, such as the load forecast, were addressed through analysis of High, Base and Low Cases and other important uncertainties, like fuel prices and renewable costs, were addressed via sensitivities.

Q. **Why were those Scenarios selected?**

A. In brief, as the above discussion indicates, the Scenarios reflect work with PREPA, interactions with the Energy Bureau and stakeholders, Energy Bureau orders, PREPA's initiative regarding the ESM, and our informed professional judgment. More information may be found in the IRP.[5]

Q. **Do the Scenarios used represent a reasonable range of Scenarios?**

[5] When I refer to more information being available in the IRP, I generally mean the main Report, although the Appendices provide further information, as do the other supporting documents.

A. Yes, the Scenarios, combined with the cases (High, Base and Low load forecast) and the sensitivities, provide a reasonable range of future materializations that could impact the IRP's decisions. More information may be found in the IRP, Part 5.

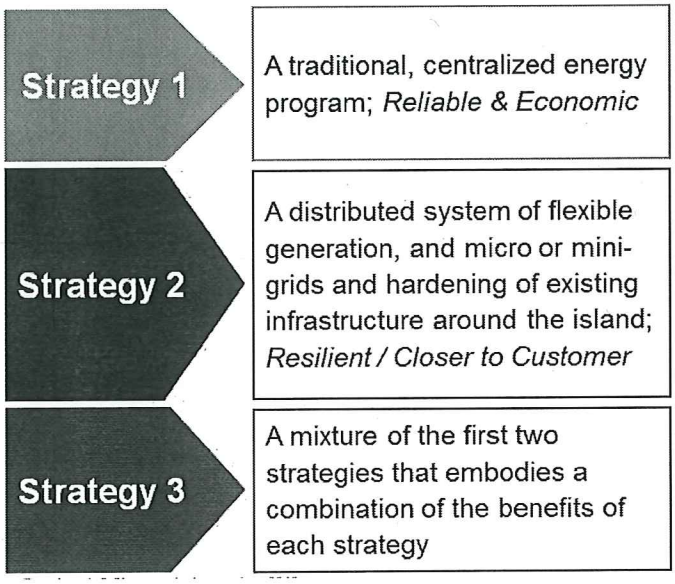
Q. **Was the ESM evaluated and considered in the IRP in the same manner as the other Scenarios?**

A. Yes. The ESM was studied in the IRP in the same manner as the other Scenarios, as reflected in for example, the discussion in the IRP, Part 5. For example, Section 5.3 states in part: "As was the case of all other scenarios, the ESM plan was assessed using a capacity expansion model, to determine, in addition to the 'fixed' decisions above, the timing of and amounts of other resources including Photovoltaic ("PV") generation, wind turbine generation, additional thermal generation (e.g. the possibility of installing a CCGT at Mayagüez) and the economic retirements of the existing generating fleet. The workpaper 'Considerations on the ESM Plan' provides further details on the reasons behind the fixed decisions of the plan." More information also may be found in the IRP, Part 8, Section 8.3.

Q. **What are the overall Strategies considered by the IRP?**

A. Each of the Scenarios described above was combined with one or more resource Strategies. The chart below from the IRP, Part 5, Section 5.2, depicts, at a high level, the three overall Strategies considered by the IRP. More information may be found in the IRP.

298 **Exhibit 5-1. PREPA IRP Strategies**



299

300 Strategy 1 reflects a traditional and centralized energy program that emphasizes
301 reliability and economic metrics. Strategy 2 reflects a distributed system of flexible
302 generation, and micro or MiniGrids and hardening of existing infrastructure around Puerto
303 Rico, which emphasizes resiliency and closeness to the customer. In Strategy 2, at least
304 80% of the load (see IRP, Section 5.2) could be supplied from local supply resources that
305 can be isolated from the remainder of the island during a major event but still supply all or
306 a portion of the nearby load.

307 Strategy 3 reflects a hybrid of the first two Strategies and represents a compromise
308 between Strategy 1 and Strategy 2. In Strategy 3, economies of scale are exploited, and
309 some of the load may be served under normal conditions from remote resources.
310 Strategy 3, assumes a requirement that at least 50% of the load could be served from local
311 resources (see IRP, Section 8.2.10), and hence the potential for greater levels of rotating
312 load shed during a major event is greater than the potential that exists under Strategy 2, but
313 available economies of scale should result in lower operating costs.

314 Q. **Why were these Strategies selected?**

315 A. In brief, similar to the Scenarios, the Strategies reflect work with PREPA, interactions with
316 the Energy Bureau and stakeholders, and our informed professional judgment. More
317 information may be found in the IRP, particularly Part 5, Section 5.2.

318 Q. **Are the Strategies a reasonable set of high-level approaches?**

319 A. Yes, they represent the range of decisions that a reasonable planner should consider to
320 address the benefits and costs of providing resiliency to Puerto Rico. More information
321 may be found in the IRP, particularly Part 5, Section 5.2.

322 Q. **IRP Exhibit 5.2, set forth above, refers to a Reference case. In brief, what does the**
323 **IRP mean when it refers to a reference case?**

324 A. A reference case represents the current understanding of expected circumstances to median
325 probability outcomes with respect to key variables as is the case for load forecast, fuel
326 forecasts, renewable and conventional generation costs, and battery storage costs. The
327 IRP also sometimes refers to the reference case as the "base case." More information may
328 be found in the IRP in the various sections of forecasts, where we added details on why the
329 Base Case or Reference Case, can be considered a median of outcomes.

330 Q. **In the context of the IRP, what is a "sensitivity"?**

331 A. Sensitivity analyses were used to isolate the impacts of certain important variables while
332 holding other assumptions constant. For the IRP, as described in Part 5, Section 5.5, nine
333 sensitivities were included in the core scope of this study:

Sensitivity 1: Deeper reduction in cost of solar and storage, coupled with high availability of storage and solar. In Sensitivity 1, higher yearly limits of PV/BESS

(photovoltaic / battery energy storage system) are assumed. See **Error! Reference source not found.** for the limits of this Sensitivity 1. As a reference, **Error! Reference source not found.** has the limits for the core LTCE and **Error! Reference source not found.** the limits for the ESM.

Sensitivity 2: Lower energy efficiency (EE) penetration (~1% reduction per year instead of 2%). This sensitivity was included in the previous filing of the IRP, prior Act 17-2019. Only EE materializations consistent with the Act 17-2019 were modeled.

Sensitivity 3: The Economic retirement of AES and EcoEléctrica regardless of contract term was analyzed as a sensitivity in the first filing of this IRP. Given the mandates of Act-17-2019, no extension of AES burning coal was assessed. EcoEléctrica was always modeled as being extended, subject to economic retirement.

Sensitivity 4: Ship-based LNG at San Juan could achieve permitting approval. The ship-based LNG at San Juan can basically supply the conversion of San Juan 5&6 and provide limited gas to other developments. It has reduced capacity in comparison to the land-based LNG option.

Sensitivity 5: High gas prices.

Sensitivity 6: High cost of solar and storage.

Sensitivity 7: Applies to Scenario 1, no San Juan 5 & 6 conversion to gas.

Sensitivity 8: Applies to Scenario 3, base cost of renewable generation and storage.

Sensitivity 9: Applies to Scenario 4, EcoEléctrica forced not to retire and used to identify the actual reduction on fixed payments that makes the case equivalent to the situation where it is replaced.

334 More information may be found in the IRP, particularly Part 5, Section 5.5.

335 Q. **How were these sensitivities selected?**

336 A. These were selected in a manner similar to the way in which the Scenarios were selected,

337 with input from PREPA, stakeholders, and Energy Bureau staff.

338 Q. **Were any sensitivities excluded?**

A. Yes. In theory, an infinite number of sensitivities could be included. As discussed in the IRP, Part 5, Section 5.5, additional sensitivities were proposed by stakeholders, including no "RPS" (renewable portfolio standard – Act 82-2010 as amended) and/or postponed "MATS" compliance (U.S. EPA Mercury and Air Toxics Standards regulation) to show the cost of compliance. However, all LTCE plans and the ESM had economic developments exceeding or close to the RPS limits. Also, most MATS non-compliant units were retired on economics rather than for compliance reasons, which forced the units to retire by 2025. The timing of unit retirements is predicated on new replacement resources and realization of load projections.

Q. **In the context of the IRP, what is a "MiniGrid"?**

A. A MiniGrid, as used in the IRP, is a zone (or island) of resilience into which the PREPA system can be segregated during and after a major storm or other weather event. MiniGrids are designed so that critical loads (i.e., those required to manage the event) can maintain supply throughout the event or recover supply shortly after and the priority loads (those required to return to normality and the functioning of the economy) are timely recovered and there is limited rotating shedding of the balance of the load.

Q. **Does the IRP consider MiniGrids?**

A. Yes. More information may be found in the IRP, for example, Part 8, Section 8.2.8, and Appendix 1, Section 2 – Transmission System - MiniGrid Analysis. Note that Appendix 1 is confidential due to its containing CEII, as I stated earlier, but there is a separate public version relating to MiniGrids.

Q. **Do the Scenarios and Strategies also consider emerging "microgrid" technologies?**

A. Yes. As detailed in Appendix 1, microgrids are a critical element ensuring a resilient supply to all customers in the island. More information may be found in the IRP Appendix 1, Section 2.3.4, Microgrid Considerations.

Q. **Does the IRP consider the development of distributed energy resources, including utility-scale production, distributed generation, battery storage, demand response, and energy efficiency?**

A. Yes. Distributed energy resources, including demand side resources (rooftop solar, CHP, energy efficiency, and demand response), battery energy storage systems ("BESS"), utility scale renewable resources, and small thermal resources, are central in the design of an economic and resilient system. More information may be found in the IRP, including not only the main Report but also Appendix 4 - Demand Side Resources (distributed energy resources).

D. Planning Environment

Q. **Does the IRP discuss the planning environment?**

A. Yes, please see the IRP, Part 2. The discussion of the planning environment focuses on legal and regulatory factors and aspects of efforts regarding the restructuring and transformation of PREPA, so I defer to the discussion in Part 2.

E. Load Forecast and Other Assumptions and Forecasts

Q. **Does the IRP discuss the load forecast?**

A. Yes, please see the IRP, Part 3. The load forecast was one of the main subjects of discussion in the 2015 IRP case. The new IRP used a robust reasonable approach and sought to comply with all applicable requirements, as shown in detail in the IRP.

Q. **Does the discussion of the load forecast address the subjects of energy efficiency and demand response?**

A. Yes. See IRP, Sections 3.1.6 – 3.1.11, and Appendix 4, Sections 1 and 2. These subjects were very carefully considered, as reflected in those Sections. These subjects also were considered in various other Sections, for example, Sections 10.3.5 – 10.3.6.

Q. **Does the IRP also discuss other assumptions and forecasts?**

A. Yes, please see the IRP, Part 7 on Assumptions and Forecast, as well as Part 9 on Caveats and Limitations. The IRP used reasonable assumptions and forecasts, as shown in detail in the IRP.

F. Resource Analysis

Q. **Does the IRP discuss the existing resources, resource needs, and new resource options?**

A. Yes, please see the detailed discussion in IRP, Parts 4, 5, and 6. Part 4 addressed PREPA's existing resources. See also IRP, Appendix 3, on PREPA's existing power purchase and operating agreements, and Appendix 4, relating to demand side resources (distributed energy resources). Part 5 addresses resource needs. I have discussed the substance of Part 5 earlier in this testimony. Part 6 addresses potential new resource options, including new fossil-generation resources (mainly involving natural gas), solar photovoltaic projects,

401 battery storage, and wind turbine generation projects, including offshore wind projects.
402 The analysis of new resource options was performed in a manner that took a neutral
403 approach to technologies and potential vendors. By neutral, I basically mean unbiased and
404 "vendor agnostic". In this IRP, wind generation (with improved capacity factors) was
405 explicitly offered as an option to the LTCE, but it was only marginally selected in the case
406 of Low Prices. Part 6 also complies with the March 14, 2019, order by providing
407 information on selected wind and solar profiles and a discussion of offshore wind.

408 **G. Resource Plan Development**

409 Q. **In the context of the IRP, what are "Resource Plans"?**

410 A. Resource Plans define what mix of generation resources (thermal and renewable), either
411 from the supply side or the demand side, are added to the system and their timing. Some
412 of these resources come from external forecasts (e.g., rooftop PV) and some are fixed
413 (minimum thermal generation to supply Critical Loads), but in the majority of the cases
414 they are selected by the AURORAxmp optimal capacity expansion plan. The Resource
415 Plans are referred to as LTCE plans to reflect the optimality used in its selection or as
416 "Portfolio Cases" to show their unique combinations of scenarios and strategies. Much
417 more information on Resource Plans and their development may be found in the IRP,
418 particularly Part 8.

419 Q. **How many Resource plans were considered by Siemens in working on the IRP?**

420 A. Siemens initially investigated over 78 LTCEs as potential Resource Plans for PREPA.
421 These plans included numerous plausible options, including those suggested by
422 stakeholders. Many of these LTCEs were dropped or blended into others, as was the case

of Scenario 2 and Scenario 4. These cases were narrowed down in subsequent assessment, finalizing in the 35 LTCE cases presented in this IRP.

Q. **How were the 35 final Resource Plans that were studied most closely determined?**

A. As IRP Section 1.1 states in part:

> In the development of the IRP, over 78 Long-Term Capacity Expansion (LTCE) plans were investigated to assess plausible options and numerous uncertainties, taking into account stakeholder input. These points were critical for the final product and included multiple aspects, for example: a) the timing of investments in traditional thermal generation units, b) practical limits to the ability of PREPA to effectively interconnect additional battery energy storage and renewables generation, c) uncertainty associated with fuel price forecasts and infrastructure options, d) uncertainty associated with the customer demand forecast, and d) assessment of resource candidates provided by PREPA's management and the Puerto Rico Public-Private Partnership Authority (P3). As detailed in Part 7 – Assumptions and Forecasts, this effort resulted in the identification of second set of 34 LTCE plans that were assessed and presented in the first draft of this document. Subsequent to the PREB review and to account for the provisions of Act 17-2019, a final set of 35 Cases (not all of which implied an LTCE run) were created and used to identify the recommended resource plan with a primary focus on the next 5 years, while also considering the long-term planning horizon of 20 years. Part 8 – Resource Plan Development of this IRP provides the details of assessment and inputs of the resources. A summary of the main resource additions of the 35 Cases are provided in Exhibit 1-[8].[6]

Please note that the ESM plan is included among the 35 cases.

Q. **How does the IRP identify the combinations of scenarios and strategies?**

A. The unique combinations of scenarios and strategies, referred to as Portfolio Cases or Resource Plans, are named using the convention "Scenario ID + Strategy ID + Sensitivity ID + Load Forecast (High, Base or Low)". For example, Portfolio Case S1S2S1B represents Scenario 1, Strategy 2, Sensitivity 1, Base load forecast. The 35 Portfolio Cases

[6] The IRP main Report, Section 1.3, contains a typographical error that refers to Exhibit 1-8 as 1-6.

considered in the IRP are found in the below chart (Exhibit 5-4). Additional information can be found in the IRP, particularly Part 5, Section 5.6.

Exhibit 5-4. PREPA 2018 IRP Portfolio Cases Summary

Count	Case ID	Scenario	Strategy	Sensitivity	Load	AURORA LTCE
1	S1S2B	1	2		Base	Yes
2	S1S2H	1	2		High	Yes
3	S1S2L	1	2		Low	Yes
4	S1S3B	1	3		Base	Yes
5	S1S2S1B	1	2	1	Base	No
6	S1S2S5B	1	2	5	Base	No
7	S1S2S6B	1	2	6	Base	No
8	S1S2S7B	1	2	7	Base	Yes
9	S1S1B	1	1		Base	Yes
10	S3S2B	3	2		Base	Yes
11	S3S2H	3	2		High	Yes
12	S3S2L	3	2		Low	Yes
13	S3S3B	3	3		Base	Yes
14	S3S2S5B	3	2	5	Base	No
15	S3S2S8B	3	2	8	Base	No
16	S4S2B	4	2		Base	Yes
17	S4S2H	4	2		High	Yes
18	S4S2L	4	2		Low	Yes
19	S4S2S9B	4	2	9	Base	No
20	S4S3B	4	3		Base	Yes
21	S4S2S1B	4	2	1	Base	No
22	S4S2S4B	4	2	4	Base	Yes
23	S4S2S5B	4	2	5	Base	No
24	S4S2S6B	4	2	6	Base	No
25	S4S1B	4	1		Base	Yes
26	S5S1B	5	1		Base	Yes
27	S5S1S5B	5	1	5	Base	No
28	S5S1S1B	5	1	1	Base	No
29	S5S1S6B	5	1	6	Base	No
30	ESM				Base	Yes
31	ESM High				High	Yes
32	ESM Low				Low	Yes
33	ESMS1B			1	Base	No
34	ESMS6B			6	Base	No
35	ESMS5B			5	Base	No

Q. **In brief, how would you characterize the IRP's assessment of the 35 Resource Plans?**

A. I find it very difficult to briefly describe the results of the IRP for 35 different Resource Plans. In Part 8 of the IRP, Section 8.1 provides an Overview of Scenario results, which can be used to understand at a high levels pros and cons of the scenarios in comparison to each other; Section 8.2 (and its subsections) discusses the Scenario 4 results; Section 8.3 (and its subsections) discusses the ESM results; Section 8.4 (and its subsections) discusses the Scenario 1 results; Section 8.5 (and its subsections) discusses the Scenario 3 Base Case results; and, Section 8.6 (and its subsections) discusses the Scenario 5 Base Case results, all in great detail. As I mentioned earlier, Scenario 2 ultimately was merged with Scenario 4. Please note that IRP Part 8, Section 8.7.1 – 8.7.3 separately discusses the subject of the Planning Reserve Margin.

Q. **How did you use the results of the Resource Plans to reach recommendations?**

A. PREPA, the IRP consulting team, and I used the results of the multiple LTCEs produced to identify what we call "minimum regret" or "no regret" decisions: that is, those robust recommendations that, once approved by the Energy Bureau and taken by PREPA, are expected to result in favorable outcomes for Puerto Rico, irrespective of the ways current uncertainties are resolved, and that would limit harm to electricity consumers and the economy if a condition different from one assumed in the reference scenario (e.g., high load growth) were to be experienced. We used the multiple outcomes of the LTCEs to identify these decisions; as a reference please see Exhibit 1-7, 1-8 and 1-9 of the IRP.

H. PREPA's Action Plan

Q. **What is an Action Plan in the context of the IRP?**

A. An Action Plan essentially is a plan (a set of recommendations) for the next five-year period, here 2019 to 2024. I should note that an Action Plan is just that, a plan, by which I mean that it proposes approaches and major items that are *expected to be* carried out based on the IRP analysis and outcome. But the plan is not a rigid set of inflexible and granular directives that are anticipated to govern the next five years regardless of actual events. You can see this reflected in, for example, the three-year IRP cycle adopted in Puerto Rico.

Q. **How is the Action Plan presentation structured in the IRP?**

A. The Action Plan (IRP, Part 10) is structured in three overall Sections that address supply resources (Section 10.1 and its subsections) (Greening the Supply), the transmission system (Section 10.2 and its subsections) (Creating a Resilient Grid), and the distribution system (Section 10.3 and its subsections) (Engaging the Customer: Distribution System, Energy Efficiency and Demand Response). The recommendations as to supply resources and major transmission items naturally tend to be much more specific than other transmission and distribution ("T&D") items. The IRP, Appendix 1, provides further discussion of T&D planning.

Q. **Please generally describe the Action Plan presented in the IRP.**

A. The Action Plan discusses implementation actions to be performed during the first five years of the planning period. From a resource point of view, the ESM and Scenario 4, Strategy 2, are similar, with the ESM resource plan better suited to address uncertainties in load forecasts and future cost of generation resources / storage. Therefore, the Action Plan recommends that the Energy Bureau approves and PREPA generally follow the ESM resource plan's actions that were also selected under the optimization process of Scenario 4

as well as the preliminary engineering and permitting activities of other projects with "off ramps" to be taken if the forecasted conditions in this IRP (low load growth, low cost of renewables, and high EE gains), do materialize, making them a suboptimal decision. However, and on the contrary, if there is higher load growth and/or higher cost of renewable and BESS and /or reduced success in EE, then these projects may be the best option for Puerto Rico as new LTCE assessments at the time should ratify.

In short, the Action Plan allows PREPA to immediately begin long-lead development activities and reevaluate their need prior to making any large contractual commitments for equipment purchase or construction. Should later conditions not support ESM fuel infrastructure and generation options, then PREPA would cancel them effectively reverting to Scenario 4, Strategy 2 plan.

In summary, we are providing for a plan that will provide greater flexibility than either plan alone and will offer opportunities to make the most of an uncertain future. As IRP Section 10.1 states in part:

> The ESM plan was selected as the recommended plan since it represents a low cost, practical option that provides the high level of renewable energy contribution and significantly improves the resiliency of the system. The ESM plan also includes flexibility that will allow PREPA to alter its implementation to follow the S4S2 or S4S2S9 plans should the Puerto Rico load and progress of the new unit additions warrant such an adjustment. The following supply resource actions summarize the plan action to implement the ESM plan. The action plans include new generation and fuel infrastructure resources, modifications to existing resources, and recommended modifications to the existing PPOA with EcoEléctrica. In addition, the section includes a discussion of the recommended activities associated with generation and fuel infrastructure additions to Yabucoa and Mayagüez that provide the ESM plan a further hedge against uncertainties.

The Action Plan is discussed in much more detail in Part 10 of the IRP.

Q. **In brief, what actions does the Action Plan require or involve?**

A. The Action Plan is highly detailed, far too detailed for it to be useful for me to simply repeat all of that detail here. However, as I mentioned earlier, from a supply side point of view, the Action Plan is centered on the ESM Plan with off ramps identified from Scenario 4, Strategy 2. In brief, the Action Plan, with respect to the supply side, provides ranges for the addition of photovoltaics (Section 10.1.1) and battery storage (Section 10.1.2), assumes the conversion to gas of San Juan Units 5& 6 (as the Energy Bureau has directed), renegotiation of EcoEléctrica contract and conversion of certain generators to synchronous condensers (Section 10.1.3), provides for unit retirements subject to the availability of new generation resources (Section 10.1.4), provides for the installation of a combined cycle unit (the Palo Seco CCGT) and 18 mobile gas turbine peaking units (Section 10.1.5), provides for new natural gas infrastructure at San Juan (Section 10.1.6), and finally provides those additions whose engineering and permitting should be advanced to preserve options and provide hedges against uncertainties, i.e., the new Yabucoa CCGT and associated LNG infrastructure, the conversion of the Aero-Mayagüez units to gas and associated LNG terminal as well as the possibility of a future combined cycle there (Section 10.1.7). Section 10.1.8 provides a Summary Timetable for the first 5 years. Section 10.1.9 provides a summary of capital expenditures for the first 5 years. Section 10.1.10 discusses permitting and regulatory activities. As indicated earlier, the Action Plan also incorporates a number of infrastructure projects for the transmission system and the screening of possible projects at the distribution system. See Sections 10.2 and 10.3 and their subsections.

Q. **What is PREPA's Preferred Resource Plan?**

A. I am not part of PREPA management, but the IRP reflects that PREPA's Preferred Resource Plan is the Action Plan, which incorporates the ESM Plan with the off ramps identified in the IRP report with respect to the parallel processes that should be advanced and with later "go / no go" decisions and discussed in more detail in the IRP. The selection of the Action Plan as the Preferred Resource Plan is discussed by PREPA witnesses José Ortiz Vázquez (PREPA Ex. 3.0), Todd Filsinger (PREPA Ex. 4.0) and Matthew Lee (PREPA Ex. 5.0). More information also may be found in the IRP.

III. CONCLUSION

Q. **Does this complete your Direct Testimony?**

A. Yes.

PREPA Ex. 6.0

ATTESTATION

Affiant, Dr. Nelson José Bacalao Urdaneta, being first duly sworn, states the following: The prepared Pre-Filed Direct Testimony and the information, documents and workpapers attached thereto and the portions of the IRP filing I am sponsoring constitute the direct testimony of Affiant in the above-styled case. Affiant states that he would give the answers set forth in the Pre-Filed Direct Testimony if asked the questions propounded therein at the time of the filing. Affiant further states that, to the best of his knowledge, his statements made are true and correct.

Nelson José Bacalao Urdaneta

Affidavit No. 2144

Acknowledged and subscribed before me by Dr. Nelson José Bacalao Urdaneta, in his capacity as Senior Consulting Manager — Siemens Power Technologies International, who is personally known to me or whom I have identified by means of his driver's license number 16101472, in San Juan, Puerto Rico, this 13 day of June 2019.

Public Notary

EXENTO PAGO ARANCEL
LEY 47
4 DE JUNIO DE 1982

LIONEL E SANTA CRISPIN
ABOGADO - NOTARIO