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

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Senior Consulting Manager
Siemens Power Technologies International

February 12, 2019

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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 PREPA.

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

A. I have 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.

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 and

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

Appendices, PREPA Exhibit ("Ex.") 1.0 (see also PREPA Ex. 2.0, IRP supporting documents);

2) I identify and describe, at a high level, the strategies, scenarios, 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 the Action Plan.

Please note that the IRP 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 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, subject to a Motion that PREPA is filing 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 uses appropriate data, software, and techniques. The IRP's results are reasonable and provide what is, in my 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.

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 35 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. More detail is found in PREPA Ex. 5.01, which is my *curriculum vitae*, as noted above.

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

A. I have worked at Siemens as a consultant since January 2006 and I am currently the senior manager of the Siemens PTI Houston Office.

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 meeting 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. **Did the development of PREPA's IRP include stakeholder processes?**

A. Yes, the development of PREPA's IRP included robust stakeholder processes, as I describe later in my Direct Testimony.

Q. **Can you please broadly describe 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 development of the IRP also took into account the stakeholder processes 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, a number of sensitivities were run on selected cases including high fuel costs, lower and higher cost of renewable, economic retirement of existing PPOA generation, etc. During the IRP's development, the process produced a great number of LTCEs that were developed using industry accepted modeling software, AURORAxmp. The IRP also includes professional analysis performed by experts in the fields of engineering, economics, statistics, and regulatory process, among others.

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 the 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 economic growth engine. Instead of focusing on new resources to meet load

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

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

A. The write-up of the IRP is comprised of a standalone document and accompanying technical Appendices, as directed by the Energy Bureau's Regulation No. 9021. The main body of the document is divided into ten Parts:

1) Part One - Introduction and Summary of Conclusions
2) Part Two - Planning Environment
3) Part Three - Load Forecast
4) Part Four - Existing Resources
5) Part Five - Resource Needs Assessment
6) Part Six - New Resource Options
7) Part Seven - Assumptions and Forecasts
8) Part Eight - Resource Plan Development
9) Part Nine - Caveats and Limitations
10) Part Ten - Action Plan

The IRP also includes an attachment about the Gas Pipeline Competition Model ("GPCM") used in the IRP and another attachment which provides details on recommended transmission and distribution projects and that should be considered confidential information.

Finally, the IRP also contains five technical Appendices:

1) Appendix 1 - Transmission and Distribution Planning
2) Appendix 2 - Prior Action Plan Implementation Status
3) Appendix 3 - Renewable Energy Project Status
4) Appendix 4 - Demand-Side Resources
5) Appendix 5 - New and Existing Supply-Side Resources Supplemental Data[2]

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 the massive amounts of battery storage correctly, 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.

[2] 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.

B. Stakeholder Processes

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

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 process. 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.

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

A. Yes. For example, PREPA and Siemens considered inputs on the merits of the Strategies and accordingly modified the IRP in certain respects. Because of stakeholders' input, PREPA did not originally include Strategy 1, the centralized generation approach, into the model runs as the majority of them 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 model runs. At the third technical conference, on November 2, 2018, we presented certain preliminary results of the Long Term Capacity Expansion Plan, which then were discussed.

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, based on further analysis and discussions with the Energy Bureau and its staff / consultants, Scenarios 2 and 4 were combined. More specifically, the Energy Bureau's November 8, 2018, Resolution and Order made a number of directions regarding the IRP, including the direction that Scenarios 2 and 4

should be combined unless PREPA showed that the least cost solution for Scenario 4 did not also meet the restrictions of 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 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.
> **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 combined with Scenario 4]
> **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.

ESM: Energy System Modernization (ESM): this is a plan advanced by PREPA and that includes a set of pre-defined investments decisions that considers ongoing RFP processes. The ESM is benchmarked against the formulated least cost plans. The investments included in the ESM plan reported include adjustments made during the analysis carried out under the IRP.

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.[3]

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

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?**

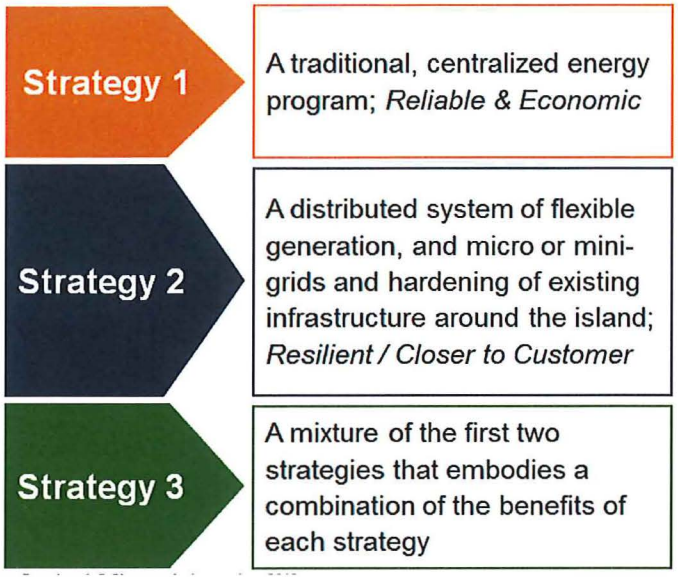
A. Yes. The ESM was studied in the IRP in the same manner as the other Scenarios, as reflected in for example, the discussion in the IRP, Part 5. More information may be found in the IRP, Part 8, Section 8.3.

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.

[3] 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.

IRP Exhibit 5-1. PREPA IRP Strategies



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

Strategy 3 reflects a hybrid of the first two strategies and represents a compromise between Strategy 1 and Strategy 2. In Strategy 3, economies of scale are exploited, and some of the load may be served under normal conditions from remote resources. Strategy 3, assumes a requirement that at least 50% of the load could be served from local resources and hence the potential for greater levels of rotating load

shed during a major event is greater than the potential that exists under Strategy 2, but available economies of scale should result in lower operating costs.

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

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

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

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

Q. **In brief, what does the IRP mean when it refers to a Reference case?**

A. A Reference case represents the current understanding of expected circumstances to median probability outcomes with respect to key variables as is the case for load forecast, fuel forecasts, renewable and conventional generation costs, and battery storage costs. The IRP also sometimes refers to the reference case as the "base case." More information may be found in the IRP under the various sections of forecasts.

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

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

1) **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 [Long Term Capacity Expansion] LTCE and **Error! Reference source not found.** the limits for the ESM.

2) **Sensitivity 2:** Lower ***energy*** efficiency penetration (~1% reduction per year instead of 2%).

3) **Sensitivity 3:** Economic retirement of AES and EcoEléctrica regardless of contract term. In practice, if AES is not forced to retire, it will not retire, and as indicated earlier EcoEléctrica's contract needs to be modified.

4) **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.

5) **Sensitivity 5:** High gas prices.

6) **Sensitivity 6:** High cost of solar and storage.

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

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

A. These were selected in a manner similar to the way in which the Scenarios were selected, with input from PREPA, stakeholders, and Energy Bureau staff.

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) and/or postponed "MATS" compliance (US EPA Mercury and Air Toxics Standards regulation) to show the cost of compliance. However, all LTCE plans and the ESM exceeded the current

RPS limits (in some cases widely). Also, most MATS non-compliant units were retired on economics rather than for compliance reasons, which forced the units to retire by 2025.

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

A. A MiniGrid, as used in the IRP, is a zone 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. More information may be found in the IRP, for example, Part 8, Section 8.2.8, and Appendix 1, Section 2 - MiniGrid analysis.

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

A. Yes. More information may be found in the IRP main document and Appendix 1, Section 2.

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 2.2.4, 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 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, but further discussion is found in Appendix 4 to the IRP. These subjects were very carefully considered, as reflected in Part 4 and Appendix 4.

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

A. Yes, please see the IRP, Part 7, 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 addressed 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, battery storage, and wind turbine generation projects. The analysis of new resource options was performed in a manner that took a neutral approach to technologies and potential vendors. By neutral, I basically mean unbiased and "vendor agnostic".

G. Resource Plan Development

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

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

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

A. Siemens investigated over 78 LTCEs as potential Resource Plans for PREPA. These plans included numerous plausible options, including those suggested by stakeholders. Many of these LTCEs were dropped or blended into others, as was the case of Scenario 2 and Scenario 4.

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

A. Thirty two (32) Resource Plans were studied in detail and, as a result of the assessment, two more were added. One of these was the ESM plan under the hypothetical conditions that sometime in the future Puerto Rico decides to require 50% renewable penetration by 2040; the other posited a modification of Scenario 4 under Strategy 2 to reduce the number of peaking generation technologies added at the same plants.

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 initial 32 Portfolio Cases considered in the IRP are found in the below chart. Additional information can be found in the IRP, particularly Part 5, Section 5.6.

IRP Exhibit II-2. PREPA 2018 IRP Portfolio Cases Summary

Count	Case ID	Scenario	Strategy	Sensitivity	Load	Aurora LTCE	Nodal Run	PSSE
1	S1S2B	1	2		Base	Yes	Yes	
2	S1S2H	1	2		High	Yes		
3	S1S2L	1	2		Low	Yes		
4	S1S3B	1	3		Base	Yes		
5	S1S3H	1	3		High	Yes		
6	S1S3L	1	3		Low	Yes		
7	S1S2S1B	1	2	1	Base	No		
8	S1S2S2B	1	2	2	Base	Yes		
9	S1S2S3B	1	2	3	Base	Yes		
10	S1S1B	1	1		Base	Yes		
11	S3S2B	3	2		Base	Yes		
12	S3S2H	3	2		High	Yes		
13	S3S2L	3	2		Low	Yes		
14	S3S3B	3	3		Base	Yes		
15	S3S3H	3	3		High	Yes		
16	S3S3L	3	3		Low	Yes		
17	S4S2B	4	2		Base	Yes	Yes	Yes
18	S4S2H	4	2		High	Yes		
19	S4S2L	4	2		Low	Yes		
20	S4S3B	4	3		Base	Yes		
21	S4S3H	4	3		High	Yes		
22	S4S3L	4	3		Low	Yes		
23	S4S2S3B	4	2	3	Base	Yes		
24	S4S2S4B	4	2	4	Base	Yes		
25	S4S2S5B	4	2	5	Base	Yes		
26	S4S2S6B	4	2	6	Base	Yes	Yes	
27	S4S1B	4	1		Base	Yes		no
28	S5S1B	5	1		Base	Yes	Yes	
29	S5S1S5B	5	1	5	Base	Yes		
30	ESM Plan	4	2		Base		Yes	Yes
31	ESM high	4	2		High			
32	ESM low	4	2		Low			

Q. **In brief, how would you characterize the IRP's assessment of the 32 Resource Plans?**

A. I find it very difficult to briefly describe the results of the IRP for 32 different Resource Plans. In Part 8 of the IRP, the Section 8.1 provides an Overview of the results, 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 results, and Section 8.6 (and its subsections) discusses the Scenario 5 results, all in great detail. As I mentioned earlier, the Energy Bureau directives caused Scenario 2 to be merged with Scenario 4. Please note that IRP Part 8, Sections 8.7 through 8.9, separately discusses the subject of planning reserve margins.

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

A. PREPA, the 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 1.1 of the IRP Report.

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. The Action Plan (IRP, Part 10) involves supply resources (Section 10.1), the transmission system (Section 10.2), and the distribution system

(Section 10.3). The recommendations as to supply resources and major transmission items naturally tend to be much more specific that other transmission and distribution ("T&D") items. The IRP, Appendix 1, provides further discussion of T&D planning.

I should note that the 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 in Puerto Rico.

Q. **Please 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. The Action Plan has three elements: generation resources, transmission investments and distribution screening of investments. From a resource point of view, the Action Plan recommends that the Energy Bureau approves and PREPA generally follow the ESM resource plan and add preliminary activities from selected elements of the Scenario 4 Strategy 2 plan that will provide greater flexibility than either plan alone and will offer a hedge against potential issues that may arise with the planned development of new resources, the continued reliance on PREPA's aging generation fleet and changes in the future system demand that must be served. The Action Plan is discussed in Part 10 of the IRP.

Q. **How is the Action Plan structured?**

A. The Action Plan is divided into four subsections:

- Supply Resources;

- Transmission System;
- Distribution; and
- Energy Efficiency and Demand Response.

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 make sense 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 elements of the Scenario 4 Strategy 2. It provides ranges for the addition of photovoltaics (Section 10.1.1.1) and battery storage (Section 10.1.1.2), assumes (as the Energy Bureau has directed) the conversion to gas of San Juan Units 5& 6 as well as the conversion to gas of the Mayagüez aeroderivative GTs (Section 10.1.2), assumes the installation of a number of combined cycle units (Palo Seco CCGT and Yabucoa CCGT), proposes to advance the studies of other combined cycle units (Costa Sur and Mayagüez), and adds a number or gas turbines to the system (Section 10.1.4). 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.

Please see the IRP, Part 10, Sections 10.1 through 10.3.3.

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

A. PREPA's Preferred Resource Plan is the Action Plan, which incorporates the ESM Plan with the modifications identified in the IRP report with respect to the parallel process that should be advanced and identified from Scenario 4. 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.

ATTESTATION

Affiant, Dr. Nelson Bacalao, 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 Bacalao

Affidavit No.____

Acknowledged and subscribed before me by Dr. Nelson Bacalao, 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 Houston, Texas, this 11th day of February 2019.

Public Notary

MARGARET VARGAS
Notary Public, State of Texas
Comm. Expires 09-25-2022
Notary ID 129890536