GOVERNMENT OF PUERTO RICO
PUBLIC SERVICE REGULATORY BOARD
PUERTO RICO ENERGY BUREAU

IN RE:	CASE NO.:
REVIEW OF THE PUERTO RICO ELECTRIC POWER AUTHORITY INTEGRATED RESOURCE PLAN	CEPR-AP-2018-0001

AES-PR'S MOTION SUBMITTING WRITTEN TESTIMONIES

TO THE HONORABLE PUERTO RICO ENERGY BUREAU:

AES-Puerto Rico, L.P., ("AES-PR") respectfully submits the following Pre-filed Written Direct Testimonies, pursuant to (1) Regulation No. 9021, Regulation on Integrated Resource Plan for the Puerto Rico Electric Power Authority (PREPA); (2) Regulation 8543, Regulation on Adjudicative, Notice of Noncompliance, Rate Review and Investigation Procedures, and; (3) the Resolutions and Orders signed by the Puerto Rico Energy Bureau (PREB) on July 3, 2019 and August 21, 2019, in which some instructions regarding the submission of written testimonies by intervenors was included (collectively, "PREB's Resolutions").

Pursuant to the PREB's Resolutions, AES-PR reserves its right to file substantive and legal arguments, based on information presented during discovery and the evidentiary hearings, at the Final Brief filing, due on December 20, 2019. AES-PR submits with this motion two duly attested Pre-filed Written Direct Testimonies from Ronald Moe and Kristina Lund respectively.

AES-PR respectfully requests that the PREB takes notice of what is stated in this motion and accepts the testimonies we include.

RESPECTFULLY SUBMITTED.

CERTIFICATE OF SERVICE

We certify that this motion submitting written testimonies was submitted to the Puerto Rico Energy Bureau through its electronic filing tool at https://radicacion.energia.pr.gov, sent via email to wcordero@energia.pr.gov, secretaria@energia.pr.gov; legal@energia.pr.gov; sugarte@energia.pr.gov and viacaron@energia.pr.gov, and sent to the Puerto Rico Electric Power Authority through the following email addresses: Katiuska Bolaños (kbolanos@diazvaz.law); Nitza D. Vázquez Rodríguez (n-vazquez@aeepr.com); Carlos M. Aquino Ramos (c-aquino@prepa.com); Astrid I. Rodríguez Cruz (astrid.rodriguez@prepa.com); Jorge R. Ruíz Pabón (jorge.ruiz@prepa.com), and Maralíz Vázquez (mvazquez@diazvaz.law). We also certify that on this date we sent a copy of this Requirement of Information to: rtorbert@rmi.org; victorluisgonzalez@yahoo.com; corey.brady@weil.com; presidente@ciapr.org; secretaria@energia.pr.gov; csanchez@energia.pr.gov; ireyes@energia.pr.gov; asanz@energia.pr.gov; bmulero@energia.pr.gov; nnunez@energia.pr.gov; gmaldonado@energia.pr.gov; sierra@arctas.com; tonytorres2366@gmail.com; cfl@mcvpr.com; gnr@mcv.com; info@liga.coop; amaneser2020@gmail.com; hrivera@oipc.pr.gov; jrivera@cnslpr.com; carlos.reyes@ecoelectrica.com; ccf@tcmrslaw.com; manuelgabrielfernandez@gmail.com; acarbo@edf.org; pedrosaade5@gmail.com; rmurthy@earthjustice.org; rstgo2@gmail.com; larroyo@earthjustice.org; jluebkemann@earthjustice.org; acasellas@amgprlaw.com; loliver@amgprlaw.com; epo@amgprlaw.com; robert.berezin@weil.com; marcia.goldstein@weil.com; jonathan.polkes@weil.com; gregory.silbert@weil.com; agraitfe@agraitlawpr.com; maortiz@lvprlaw.com; rnegron@dnlawpr.com; castrodieppalaw@gmail.com; voxpopulix@gmail.com; paul.demoudt@shell.com; sproctor@huntonak.com; giacribbs@huntonak.com; javier.ruajovet@sunrun.com; escott@ferraiuoli.com; mgrpcorp@gmail.com, and aconer.pr@gmail.com.

In San Juan, Puerto Rico, on October 23, 2019.

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COMMONWEALTH OF PUERTO RICO
PUBLIC SERVICE REGULATORY BOARD
PUERTO RICO ENERGY BUREAU

IN RE:	**Case No.:** CEPR-AP-2018-0001
REVIEW OF THE PUERTO RICO ELECTRIC POWER AUTHORITY INTEGRATED RESOURCE PLAN	**SUBJECT:** PRE-FILED TESTIMONY OF AES PUERTO RICO, L.P.

PRE-FILED DIRECT TESTIMONY OF RONALD MOE FOR INTERVENOR AES PUERTO RICO, L.P.

I. INTRODUCTION

A. Witness Identification

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

A. My name is Ronald Moe. I am a Vice President at Leidos Engineering, LLC ("Leidos"). My business address is 1417 Fourth Avenue, Suite 300, Seattle, WA 98101.

Q. On whose behalf are you testifying before the Puerto Rico Energy Bureau (the "Energy Bureau" or "PREB) in this proceeding?

A. I am testifying on behalf of AES Puerto Rico LP ("AES-PR").

Q. Have you testified previously before the Energy Bureau?

A. No.

B. Purpose of Testimony

Q. What are the purposes and subjects of your direct testimony?

A. My testimony summarizes the findings of a critical review of two documents that Siemens Power Technologies International ("Siemens") prepared for and at the direction of the Puerto Rico Electric Power Authority ("PREPA") and the associated work papers and analysis files:

1. The *Puerto Rico Integrated Resource Plan 2018-2019* ("PREPA IRP") that PREPA filed with the Energy Bureau in this proceeding on June 19, 2019.[1]

2. The *AES Coal Plant Conversion Assessment* ("Siemens Report") that PREPA filed with the Energy Bureau in this proceeding on August 23, 2019.[2]

I then make recommendations regarding changes that should be made to the PREPA IRP and Siemens Report and steps the Energy Bureau should take.

Q. In brief, what are your conclusions regarding the PREPA IRP?

A. My conclusions are:

1. PREPA/Siemens deviated from standard (or common) utility practice for integrated resource planning and related analyses. These deviations include the way in which PREPA/Siemens used the long-term capacity expansion AURORAxmp® model, by forcing decisions into the model, instead of allowing the model to determine the least cost resource additions and retirements. It also failed to run scenarios and sensitivities to address varying core assumptions that are uncertain and likely to have a large impact on the IRP results. These need to be corrected.

2. PREPA/Siemens did not devote sufficient time and resources to analyze fully i) resiliency and MiniGrids and ii) the battery storage requirements associated with the renewable penetration to support their consideration in the PREPA IRP. Additional analyses are needed to fully assess these issues.

[1] *Puerto Rico Integrated Resource Plan*, Siemens PTI Report Number: RPT-015-19, submitted by Siemens Industry, Prepared for Puerto Rico Electric Power Authority, PREPA Ex. 1.0, Draft for the Review of the Puerto Rico Energy Bureau, Rev.[2.1] 6/7/19 Corr., June 19, 2019.

[2] *In re: Review of the Puerto Rico Electric Power Authority Integrated Resource Plan*, Case No. CEPR-AP-2018-001, Submittal of Redacted AES Coal Plant Conversion Assessment, Aug. 23, 2019.

3. The preferred expansion plans derived from the IRP analysis may not be achievable. The preferred plans require PREPA to attract approximately $2 billion in new capital over the next two years and $6 billion of new capital over the next seven years. That is an unprecedented amount of new capital for PREPA and may be far more than can be attracted to Puerto Rico. In addition, the plans may be so expensive to implement that all or portions of the strategies or policies upon which they are based may ultimately have to be aborted or modified. Yet, the IRP offers no apparent backup plans in the event this happens. More analysis is needed to address these risks.

4. The PREPA IRP assumes (appropriately) continued operation of the AES-PR plant as currently configured through the end of November 2027. However, PREPA/Siemens deviated from utility standard practice for IRPs and related analysis by assuming retirement of the AES-PR plant at the end of November 2027 when its current Power Purchase and Operating Agreement ("PPOA") ends, and not considering a possible extension of the PPOA to allow for the conversion of the AES-PR plant or other use of the resource as may be allowed by Puerto Rico law at that time. Further consideration should be given to this option.

5. The use of a 20-year planning horizon in the PREPA IRP may not be appropriate in this instance given the post-2038 Renewable Portfolio Standard ("RPS") requirements recently passed by the Legislature.

6. In analyzing sensitivity cases that involve potential retirement of the AES-PR coal plant prior to the end of 2027, PREPA/Siemens incorrectly ignored the Capacity

Purchase Price payments of more than $100 million per year that PREPA must pay AES-PR through the end of 2027 even if the plant is forced to retire.

Q. What are your recommendations regarding the PREPA IRP?

A. The Energy Bureau should approve the PREPA IRP filed on June 19, 2019 subject to modification to address the shortcomings described above that can be completed without affecting the overall schedule PREB has established for the PREPA IRP, namely 1) re-performing the most important cases using the AURORAxmp® model more appropriately, 2) executing additional scenarios/sensitivities, 3) analyzing backup plans, 4) re-performing the most important cases with extension of the AES-PR PPOA as an option, and 5) re-performing cases involving the potential retirement of the AES-PR plant prior to November 2027 with Capacity Purchase Price payments correctly reflected. In addition, the Energy Bureau should only approve PREPA requests to advance development of new fossil-fired generation and to implement the MiniGrid proposal until after PREPA/Siemens corrects the related shortcomings described above that would take more time to address, namely 1) re-performing the most important cases using a planning horizon through 2050, and 2) conducting a more rigorous assessment of resiliency and MiniGrids.

Q. What are your conclusions regarding the Siemens Report?

A. My conclusions are:

1. Foremost, Siemens does not adequately emphasize in the Siemens Report the overwhelmingly most important conclusion of their analysis: that forcing AES-PR to convert to gas or retire at the end of 2020 unambiguously will result in higher

costs to PREPA, by potentially as much as $580 million over the 2019-2038 period, as well as higher rates for its customers.

2. In addition, the Report indicates that in four of the five cases analyzed the conversion to gas was not an optimal investment, but does not present the dollar amount by which the conversion option(s) purportedly "lost" to the selected non-conversion options. Without that information, the cases cannot be vetted properly.

3. Moreover, PREPA/Siemens made assumptions that (i) likely overstated the feasibility of replacing AES-PR, (ii) understated the cost to retire AES-PR prior to the end of 2027, and (iii) likely overstated the cost to convert AES-PR to gas. Regarding the second of these issues, PREPA/Siemens failed to account in its analysis that PREPA will still have to pay AES-PR Capacity Purchase Price payments even if the AES-PR coal plant is forced to retire before the end of 2027. I estimate the value of these payments to be $530 million.

4. Finally, Siemens recognized the shortcomings of its own analysis and Report, stating in a Memorandum that PREPA filed with the Energy Bureau on August 30, 2019:

> *For this reason the study cannot and must not be understood as a [sic] recommending a course of action but rather just as the result of a sensitivity under the IRP carried out to inform the PREB as requested.*[3]

Q. What are your recommendations regarding the Siemens Report?

[3] *In re: Review of the Puerto Rico Electric Power Authority Integrated Resource Plan*, Case No. CEPR-AP-2018-001, Submittal of AES Coal Plant Conversion Report Caveats and Limitations, Aug. 30, 2019.

A. The Energy Bureau should:

1. Direct PREPA/Siemens to revise the Report to more accurately reflect the PREPA/Siemens analytic findings in the manner indicated above, particularly that forcing the AES-PR coal plant to retire or convert to gas at the end of 2020 will unambiguously result in higher PREPA costs.

2. Direct PREAP/Siemens to conduct additional analysis to address the shortcomings identified above, which will unambiguously result in even higher estimates of the cost to PREPA and its customers of forcing the AES-PR coal plant to retire and potentially convert to natural gas prior to November 2027.

3. Not take action on the Siemens Report until such activities have been completed.

C. Qualifications and Professional Background

Q. What is your educational background?

A. I received a M.A. in Economics from the University of Washington in Seattle, Washington in 1982; and a B.A. in Economics from the same university in 1980.

Q. What is your professional experience?

A. My *curriculum vitae* is provided as Exhibit 1. I have been an economic consultant to the U.S. and global electric power and energy industries for 36 years, and have held a variety of consulting management positions during most of that period. For the past nine years I have co-led the Power Transactions practice at Leidos, which provides independent engineering, market consulting, and related services in support of development, financing, purchase, sale, and restructuring of electric power assets and companies around the world. Previously I led the consulting practice for two years at Ventyx ABB, which provides market consulting and resource planning services to utilities and other participants in the global electric

power industry; led the electric power market consulting and utility resource planning practice for five years at R. W. Beck, a predecessor company to Leidos; and led similar practices at Jacobs Consulting for two years and Stone & Webster Management Consultants for five years.

Q. Have you provided consulting services in Puerto Rico previously?

A. Yes. In 2014, I led a team of professionals from Leidos and our subcontractor, Ventyx ABB, which prepared an IRP for PREPA.

Q. Did you utilize the results of that 2014 IRP in preparing your testimony?

A. No. At the completion of that 2014 assignment, I and all of my team members destroyed all of the records in our possession associated with the assignment, as required by the terms of the associated contract between Leidos and PREPA.

II. THE PREPA IRP

A. IRP Background

Q. What activities did you perform in preparing this testimony?

A. Along with colleagues at Leidos acting under my supervision, I reviewed the two reports and the supporting documents in the context of our understanding of standard practice for United States electric utility integrated resource planning and related analysis. My understanding of standard IRP practice is based on my own experience and that of Leidos in conducting IRPs for United States utilities, as well as our familiarity with the IRPs of many other United States electric utilities.

Q. In your opinion, what is standard utility practice for IRP and related analyses?

A. Most electric utilities throughout the United States periodically prepare IRPs or similar studies under a different name. Generally, the key determinant of a utility's IRP process,

including but not limited to frequency, specific analytic requirements, and specific reporting requirements, are the corresponding requirements of the governing utility regulatory commission. Given that these requirements vary across jurisdictions, the IRP processes electric utilities employ also vary, and the published documents that summarize the process and the results vary as well. Given this, it is quite natural that the process PREPA follows in developing its IRP, as well as the resulting document, very much follow the relevant PREB requirements, and differs from other utilities' IRPs because the regulatory requirements differ. The basic requirements that PREPA must fulfill are specified in Regulation 9021 that PREB adopted in April 2018.[4] Other PREB orders have also specified how PREPA is to address specific issues.

IRPs typically also reflect the various laws that either prescribe or proscribe the investment or operating behavior of the utilities subject to them. To the extent that these laws vary across jurisdictions, the IRP processes and resulting documents may vary as well. For example, as discussed further below, the Puerto Rico Legislature adopted Act 17-2019 in April 2019 that, among other things, prohibits the burning of coal for power generation after the end of 2027 and establishes the RPS, requiring that 40 percent of load be satisfied by renewable power by 2025, 60 percent by 2040, and 100 percent by 2050.[5] These two provisions materially affected the process PREPA followed, the results it derived, and the resulting documentation.

Finally, IRPs reflect the vision or overarching strategy(ies) that the governing body of each utility, in this case the PREPA Governing Board, have adopted. In February 2018, the PREPA Governing Board adopted its "Vision for the Future of Power in Puerto Rico," which

[4] Puerto Rico Energy Commission, Regulation 9021, *Regulation on Integrated Resource Plan for the Puerto Rico Electric Power Authority*, April 24, 2018.

[5] Government of the Commonwealth of Puerto Rico, Act No. 17-2019 (S.B. 1121), *Puerto Rico Energy Public Policy Act*, April 11, 2019.

includes five pillars: Customer-Centric, Financially Viable, Reliable and Resilient, Model of Sustainability, and Economic Growth Engine.[6] These strategic pillars are materially different from those adopted by other utilities across the United States, and so the resulting IRP differs from others as well. This is particularly the case with the pillar of Reliability and Resiliency, which is motivated in part by the damage Puerto Rico suffered from Hurricanes Irma and Maria in 2017, an experience unlike that experienced by any other United States state or territory (or utility).

Nonetheless, in the context of specific issues, standard or best practices for integrated resource planning have developed over time. I note below where PREPA has not followed those best practices in preparing the IRP.

B. PREPA/Siemens Analysis

Q. What analytic activities did PREPA/Siemens perform in developing the PREPA IRP?

A. As is customary in preparing an IRP, PREPA/Siemens conducted substantial analyses. These analyses, generally fall into the following categories:

1. Development of forecasts of loads, energy efficiency savings, and customer-sited distributed generation, as well as sensitivity cases for the load forecast.
2. Analysis of the costs and operating characteristics of existing resources.
3. Development of strategies to pursue, scenarios to evaluate, and sensitivities to consider in the modeling. This included three strategies, six scenarios (one was later dropped), two load sensitivities and seven other sensitivities.

[6] As presented in Exhibit 2-2 on page 2-11 of *PREPA IRP*.

4. Evaluation of, and development of estimates of the capital and operating costs and operating characteristics for, a broad set of resource options to be considered for selection in the modeling.

5. Evaluation of, and development of estimates of the capital and operating costs for, a range of fuel infrastructure facilities considered in the modeling; development of forecasts of prices for fuel delivered to PREPA generating facilities and sensitivity cases of these forecasts; and estimation of the value of lost load to PREPA's customers.

6. Development of capacity expansion plans for various combinations of scenarios, strategies, and sensitivities using the AURORAxmp® model. Using the model, PREPA/Siemens analyzed 35 combinations of the strategies, scenarios, and sensitivities, which are referred to as "cases."

Two important assumptions PREPA/Siemens made were that the AES-PR plant would retire at the end of its current PPOA at the end of 2027 in all cases; and that the EcoElectrica gas-fired plant would retire at the end of its current PPOA at the end of 2024 in 16 of the 35 cases for which results are reported.

Q. Did PREPA/Siemens perform any additional analytic activities that are important to note?

A. Yes, following submittal in June 2019 of the PREPA IRP Report, consultants for the Energy Bureau as well as multiple intervenors, including AES-PR, have submitted Requirements for Information ("ROIs") to PREPA. Some of these ROIs requested clarification of points made in the June IRP Report and/or data that were used in the original PREPA/Siemens analysis; however, a number of ROIs requested PREPA/Siemens to analyze new cases using the

AURORAxmp® model. As a result, as of the date that I am submitting this testimony PREPA/Siemens has run many more than the 35 cases described above and will be running additional cases through the end of October 2019. With the exception of 1) three sensitivities that PREPA/Siemens summarized in a filing with the Energy Bureau on October 18, 2019 in response to PREB ROI 06-03[7] and 2) the cases PREPA/Siemens summarized in the Siemens Report , both of which I discuss below , the remainder of my testimony will focus on the 35 cases presented in the June 2019 report.

C. PREPA/Siemens Analytic Results

Q. What are the most important analytic results developed by PREPA/Siemens?

A. The PREPA IRP reports the results for 35 cases, but two of the cases, labelled "S4S2B" and "ESM" (Base), receive the most attention, and clearly constitute PREPA's preferred plans. The S4S2B consists of Scenario 4, which involves development of liquefied natural gas (LNG) gas regasification terminals on the north, east, and west sides of the island (in addition to the existing one on the south side[8]); Strategy 2, which reflects more distributed, flexible generation, including the establishment of MiniGrids; and the base case load forecast. The ESM Base case is a derivative or variant of the S4 scenario, and also involves distributed, flexible generation and MiniGrids. Key results for the two cases are as follows:[9]

1. S4S2B:

[7] *In re: Review of the Puerto Rico Electric Power Authority Integrated Resource Plan*, Case No. CEPR-AP-2018-001, Requirements of Information, Sep. 18, 2019.

[8] This list of LNG regasification terminals in the S4S2B case is based on Exhibit 5-2 on page 5-5 of the PREPA IRP. Workpapers *S4S2B_Metrics_Base_Case_SII.xlsx* and *ESM_Metrics_Base_SII.xlsx* suggest a shorter list, possibly only including the one terminal on the north side of the island.

[9] All information describing the S4S2B and ESM Base cases presented here are from Exhibits 1-7 through 1-9 on pages 1-15 through 1-21 of *PREPA IRP*.

a. Net present value (NPV) of power supply costs over the 2019-2038 period of $14.4 billion, average power supply cost to customers over the 2019-2028 period of $99.3/MWh, and capital investment costs of $6.6 billion.

b. Addition of 975 MW of new gas-fired generation capacity, 2,820 MW of new solar photovoltaic (PV) capacity, and 1,640 MW of battery storage capacity, plus conversion of 400 MW of existing units to burn gas; of these capacity additions, 952 MW, 2,220 MW, 1,320 MW, and 400 MW, respectively, are to be brought online no later than the beginning of 2025

c. Retirements of 4,133 MW of existing generation capacity, including the AES-PR and EcoElectrica plants.

2. ESM Base:

a. NPV of power supply costs over the 2019-2038 period of $14.4 billion, average power supply cost to customers over the 2019-2028 period of $99.0/MWh, and capital investment costs of $5.6 billion.

b. Addition of 1,025 MW of new gas-fired generation capacity, 2,580 MW of new solar photovoltaic (PV) capacity, and 1,640 MW of battery storage capacity, plus conversion of 600 MW of existing units to burn gas; of these capacity additions, 979 MW, 2,400 MW, 920 MW, and 600 MW, respectively, are to be brought online no later than the beginning of 2025

c. Retirements of 3,726 MW of existing generation capacity, including the AES-PR plant but not the EcoElectrica plant.

D. PREPA IRP Report

Q. How did the PREPA/Siemens report the analytic activities and associated results you just summarized?

A. The primary mechanism PREPA/Siemens used to report or document the analytic activities and results is through the PREPA IRP Report, filed June 19, 2019. PREPA/Siemens has also prepared and disseminated a number of working papers. The main report is comprehensive, comprising 346 pages plus multiple appendices. The main report contains an Introduction and Summary of Conclusions (Part 1) and a summary of the Planning Environment (Part 2), followed by six parts summarizing the six analytic activities I discussed above, followed by a summary of Caveats and Limitations (Part 9) and an Action Plan (Part 10). Nearly 100 pages of the main report is devoted to results of the modeling activities (Part 8, covering step 6 listed above).

E. Critique of the PREPA IRP

Q. What is your critique of the PREPA IRP?

A. All IRP exercises require making decisions about assumptions, alternatives to be considered, sensitivities and scenarios to analyze, and results to report, and sometimes these decisions are difficult. In this case, the environment in which Siemens prepared the PREPA IRP was and is extremely challenging, making some of these decisions even more difficult. However, it is my opinion that the PREPA IRP deviates from standard utility practice in several important ways and that as a result of these deviations, it is less useful in achieving its intended purpose of serving as a roadmap for Puerto Rico's electric future than it should or could be. Specific deviations from standard practice that should be addressed include:

1. The misuse of the AURORAxmp® model.

2. Several input assumptions that are highly uncertain and likely to have a material impact on the results but are not addressed in sensitivities.

3. Inadequate assessment outside of the IRP process of Mini-Grids and battery storage requirements.

4. Potentially unachievable or unacceptably costly capacity expansion plans and the lack of any backup plans.

5. Lack of consideration of extending the AES-PR PPOA.

6. The use of a 20-year planning horizon.

Q. In your opinion, how did PREPA/Siemens misuse the AURORAxmp® model?

A. Principally, PREPA/Siemens erred because it did not allow the model to determine the range of outcomes based on available data, but instead forced decisions into the modeling analysis. Standard utility practice for IRPs is to use a long-term capacity expansion ("LTCE") model to select the optimal set of resource additions and retirements over the planning period. PREB Regulation 9021 requires this as well. As importantly, standard practice involves using the LTCE model to select all or nearly all of the resource additions and retirements, the only notable exception being forcing the retirement of existing resources for technical, non-economic reasons (e.g., expiration of operating license).

PREPA/Siemens used AURORAxmp® as the LTCE model for the PREPA IRP. The choice of model is not the concern, as I have not identified any reasons to question its selection for use in preparing the IRP. However, the way it has been applied is not standard. Specifically, in many if not most of the cases reported in the PREPA IRP, the majority of the non-renewable resource decisions were not determined by the model, but were forced into the model by

PREPA/Siemens. For example, regarding the ESM case, PREPA/Siemens writes:[10] "The thermal additions are largely the ones identified as input to the plan," which are listed as[11] 18 new GTs (23 MWs each, for a total of 418 MW), 302 MW CCGTs at Yabucoa and Palo Seco, and conversion to gas of 200 MW of GT capacity at Mayaguez. It appears that all of the resource retirements and the conversion of San Juan 5&6 to natural gas are forced decisions as well. AURORAxmp® appears only to have been used to determine, based on these forced decisions, whether to add solar PV or wind to achieve the RPS, as well as the associated required energy storage additions.

In effect, by forcing these decisions into the model, PREPA/Siemens decided in advance what fossil-fired resources would be available and when. As such, PREPA/Siemens simply did not employ AURORAxmp® to do its job – to determine cost effective resource additions and retirements. This is not consistent with standard utility practice, and does not satisfy the direction of PREB Regulation 9021, which mandates that the "IRP shall use a Capacity Expansion Model to develop the least-cost Resource Plans that meet customer needs …" Moreover, because PREPA/Siemens forced these decisions into the model, it is not possible to determine what capacity additions and retirements decisions would actually comprise an optimal or least-cost plan, or how similar any of the presented plans are to such a true least-cost plan. In addition, this limited use of the model makes comparisons of the power supply costs across cases very difficult to interpret, because it is not possible to determine if cost differences are caused by the forced decisions made by PREPA/Siemens or are associated with decisions that the model would have made (and can therefore be considered optimal).

Q. What are the input assumptions that should be addressed in sensitivities?

[10] *PREPA IRP*, p. 8-51.
[11] *PREPA IRP*, p. 8-47.

A. Developing an IRP requires making many, many assumptions. Most are explicit (e.g., the load forecast), but there are also implicit assumptions included in every IRP. Standard utility practice for IRPs and related analyses require that IRPs also include identification of the assumptions that have a combination of the highest uncertainty and largest impact on the results, and execution of either (or both) scenarios or sensitivity cases addressing the identified fragile assumptions. PREB regulations require this as well. PREPA/Siemens recognize this principle, and executed a number of scenarios and sensitivity cases that are included in the PREPA IRP. These address high and low load forecasts, high and low renewable and energy storage costs, high renewable and energy storage availability, a high natural gas price forecast, and the availability of natural gas at specific locations.

Although the assumptions addressed in these scenarios and sensitivities are uncertain, and variations in those assumptions have an impact on both the expansion plans and the estimated power supply costs, uncertainty about the following assumptions arguably has a greater impact on the IRP results:

1. **Energy efficiency savings** – Act 17-2019 requires a 2 percent annual reduction in electric consumption attributable to energy efficiency measures for the duration of the planning horizon. It is therefore appropriate to include this assumption in the base case. However, it is highly uncertain that the maximum achievable cost-effective potential is sufficient to satisfy this requirement. That is, even if 100 percent of the cost-effective potential is captured, the requirement may not be reached. As a result, at some point in the future the requirement may have to be relaxed. The fact that PREPA/Siemens included a 1 percent annual reduction sensitivity case in prior versions

of the 2018-2019 PREPA IRP (before enactment of Act 17-2019) suggests PREPA/Siemens is also aware of this fragile assumption.[12]

Unrelated to uncertainty and sensitivity cases, it is also highly uncertain that whatever energy efficiency measures are implemented will have nearly as large an impact on peak demand as PREPA/Siemens assumes. For example, a comparison of Exhibits 3-24 and 3-25 indicate that energy efficiency measures are assumed to save 5,438 GWh in gross generation in 2035, which equals 621 average MWh/hour; the peak savings are assumed to be 722 MW in the same year. Given the high assumed proportion of PREPA's sales to the commercial sector (44 percent in 2035, according to Exhibit 3-10), the low commercial class peak coincidence (70 percent, according to Exhibit 3-23), and the high proportion of energy savings that are assumed to come from the commercial sector (66 percent in 2035, based on a comparison of Exhibits 3-10 and 3-14), peak savings will likely be lower than average energy savings.[13]

Finally, also unrelated to uncertainty and sensitivity cases, achieving even the lower target of a 1% improvement in efficiency suggested above and incorporated into previous IRP versions likely will require substantial subsidies to consumers to motivate them to install the measures. The PREPA IRP does not discuss how these subsidies will be funded, in particular, whether or not PREPA will pay for them and recover their payments through customer rates. To the extent that is the intent, an estimate of such costs should be included in the customer rate exhibits in Section 8 of the IRP (e.g.,

[12] *Puerto Rico Integrated Resource Plan*, Siemens PTI Report Number: RPT-015-19, submitted by Siemens Industry, Prepared for Puerto Rico Electric Power Authority, PREPA Ex. 1.0, Draft for the Review of the Puerto Rico Energy Bureau, Rev.[1] 2/12/2019, page 5-6.

[13] The Exhibits referenced in this paragraph appear on the following pages of PREPA IRP: Exhibit 3-24, p. 3-21; Exhibit 3-25, p. 3-22; Exhibit 3-10, p. 3-10; Exhibit 3-23, p. 3-19; Exhibit 3-14, p. 3-13.

Exhibit 8-37[14]). Moreover, regardless of how they are funded, an estimate of their costs should be included in all of the exhibits portraying system production costs.

2. **RPS** – Similarly, the RPS levels and timing included in the PREPA IRP are mandated in Act 17-2019, and are therefore appropriate to include in the base case. However, based on my experience, I am skeptical that the mandated levels (outlined above) will be achieved on the specified schedule. This is particularly the case for the short term (i.e., through 2025), during which PREPA and potential PPOA counterparties need to bring online 2,400 MW of solar and 920 MW of energy storage capacity additions as specified in the ESM base plan. My skepticism is based on the magnitude of these additions relative to the size of the utility, which had a peak load in 2018 of 2,705 MW; as well as PREPA's experience bringing renewable projects online. As discussed on pages 4-14 and 4-15 of the PREPA IRP, between 2008 and 2012 PREPA signed 68 renewable PPOAs with more than 1,480 MW of capacity; as of the end of 2018, only eight with capacity of 200 MW were in commercial operation. My skepticism is also based on PREPA IRP itself, which states:

> *The IRP assumes an accelerated timeline for solar and storage projects, assuming fast track of permitting, proper submittal of project design for evaluation by PREPA, and securing the land for the interconnection line and facilities. In addition to unforeseen events that could delay these tasks, this timeline could be delayed by limitations on the amount of annual installations that can effectively be carried out in parallel [while] maintaining the continuous operation of the power system.*[15]

3. **Cost of Capital** – PREPA/Siemens assumed that new generation would be developed by independent power producers ("IPPs") that would execute long-term

[14] *PREPA IRP*, p. 8-44.

[15] *PREPA IRP*, pp. 9-3 through 9-4.

PPOAs with PREPA. PREPA/Siemens further assumed a Weighted Average Cost of Capital ("WACC") for the IPPs of 8.5 percent, based on a cost of equity of 12.91 percent, a cost of debt of 5.00 percent, a 47/53 debt-equity split, and a tax rate of 32 percent. These cost-of-capital assumptions are based on the qualitative assumption that "PREPA [will] obtain financial backing to contract as a credit-worthy counterparty, if and as needed."[16]

It is not inappropriate to use the assumed WACC for the base case, particularly in light of the qualitative assumption just quoted. However, for this process it is important to 1) treat the assumed WACC as an assumption, that will remain an assumption at least until one or more PPOAs have been executed; and 2) acknowledge that the risk is to the high side, i.e., a materially higher WACC is both more likely and would have larger impacts on the preferred plans than a lower WACC. In my experience, it is much more likely that IPPs would face a higher WACC of 11.5 percent (3 percent higher than the assumed value) based on a 16 percent cost of equity and an 8 percent cost of debt, than it is that they would face a lower WACC of 5.5 percent (3 percent less than the assumed value) based on rates of 10 percent and 2 percent, respectively. Moreover, it cannot be known with certainty unless and until the analysis is performed, but using a WACC of 11.5 percent likely would lead to more material changes in the preferred plans (relative to the same plans developed using an 8.5 percent WACC) than using a 5.5 percent WACC would.

Q. In what ways was PREPA/Siemens' assessment of MiniGrids inadequate?

[16] *PREPA IRP*, p. 6-2.

A. MiniGrids are a key element of the PREPA IRP, as indicated on page 1-9 of the document:

> *Central to the IRP is developing the capability to segregate the system into eight MiniGrids to improve the system resiliency. The MiniGrids require the recommended generation and battery energy storage projects described below and the recommended transmission and distribution additions (mostly underground facilities) and hardening projects described in Appendix 1. The recommended MiniGrids are designed to operate in grid-isolated mode following a major storm or other disruptive event.*

It is important to note that AES-PR and its affiliates proposed the establishment of MiniGrids in Puerto Rico to the Energy Bureau in a filing in November 2017 in Docket CEPR-IN-2017-0002.[17] The company continues to support the establishment of MiniGrids in Puerto Rico.

Implementation of MiniGrids in the preferred plan(s) (S4S2B and ESM Base) involved installing approximately 400 MW of small GTs located across the island at a direct capital cost of approximately $400 million, plus $7.9 billion of capital costs for transmission and distribution upgrade projects to implement the MiniGrids, and the unreported capital costs to develop the infrastructure to be able to deliver containerized natural gas to these power plants.[18] These GTs likely also have an indirect cost, as it appears they "crowd out" (i.e., make uneconomic) more efficient generation alternatives, i.e., an incremental 400 MW of capacity that produce low-cost energy is less likely to be selected as economically optimal given that these 400 MW of capacity producing high- cost energy have been forced into the model.

[17] *In re: Energy Commission Investigation Regarding the State of Puerto Rico's Electric System After Hurricane Maria*, Case No. CEPR-IN-2017-0002, Comments of the AES Companies, November 17, 2017.

[18] For GTs and containerized gas, see *PREPA IRP*, p. 10. For transmission and distribution upgrade projects, see *PREPA IRP, Exhibit 1.01C Appendix 1 Section 2*.

In response to the damage caused by Hurricanes Irma and Maria in 2017, the legislature enacted Act 17-2019 to create a power system that is more resilient to weather events and other natural disasters. Moreover, the PREPA Governing Board's Vision for the Future of Power in Puerto Rico emphasizes the need for energy reliability and resiliency. As a result, future PREPA IRPs necessarily should consider investments in generation, transmission, and distribution facilities that will increase the system's resiliency. However, PREPA/Siemens has not had enough time or dedicated sufficient resources to analyze how best to accomplish the resiliency objective. PREPA acknowledged this in its response to ROI 2-40 from the Environmental Defense Fund, in which it stated:

> *The IRP represents the first time microgrids are considered to be deployed in a system-wide level. As such, the detail presented in this process represents the analysis PREPA has undertaken so far with regards to micro-grids and mini-grid implementation.*[19]

Standard utility practice is that new issues such as MiniGrids are assessed rigorously and comprehensively outside the formal IRP process, and not considered in the formal IRP until they have been fully vetted. Hence, this IRP should not be the forum where these issues are addressed for the first time. Further, the assessment of resiliency in general and MiniGrids in particular that PREPA/Siemens has been able to perform was not adequate to support incorporation of the results of that assessment into the PREPA 2018-2019 IRP.

Q. In what ways was PREPA/Siemens' assessment of battery storage requirements inadequate?

A. Act 17-2019 includes an RPS of 40 percent by 2025, 60 percent by 2040, and 100 percent by 2050. These requirements would be satisfied in the preferred plans by installing a

[19] *In re: Review of the Puerto Rico Electric Power Authority Integrated Resource Plan*, Case No. CEPR-AP-2018-001, Discovery, October 18, 2019.

combination of utility scale and customer sited solar generation, totaling nearly 4,000 MW by 2038 (2,820 utility scale plus 1,176 customer-sited in S4S2B, 2,580 utility scale plus 1,176 customer-sited in ESM Base).[20] PREPA/Siemens recognizes that the addition of this much solar generation will require a material amount of energy storage, and adds 1,640 MW of lithium-ion battery storage by 2038 in both cases.[21] The installed storage comprises a mix of two-, four- and six-hour batteries (i.e., each MW of storage capacity can store 2, 4, or 6 MWhs of energy), and the weighted average is approximately 4 MWh per 1 MW.[22] As indicated above, PREPA/Siemens also recognize that this amount of energy storage additions is unprecedented in the United States.

> *In the case of utility scale storage, it is noted that the amount recommended in the IRP is much higher than the total capacity currently installed in the whole United States. This represents an installation never done before in a power grid, especially nor [sic] in an isolated system like the one in Puerto Rico.*[23]

Yet, even these specified amounts of energy storage capacity may not be high enough; in particular, they likely do not hold enough MWh of energy. PREPA/Siemens' own analysis suggests batteries holding six hours of energy (i.e., 6 MWh of energy per 1 MW of capacity) may be necessary, not just batteries storing four hours of energy. Given Puerto Rico's unusual load shape (i.e., night peaking), more energy storage capacity will be required to achieve a specific RPS level than in other Untied States jurisdictions that has considered such high renewable requirements. It is not clear that PREPA/Siemens has had the time or been able to expend the resources to evaluate this issue fully.

[20] *PREPA IRP*, Exhibit 1-7 on p. 1-16.

[21] *PREPA IRP*, Exhibit 1-7 on p. 1-16.

[22] Workpaper *S4S2B_Metrics_Base_Case_SII.xlsx*.

[23] PREPA IRP, p. 9-4.

If the results of such analysis validate this concern, capital requirements, total power supply costs, and customer rates will all be higher than the projections presented in the PREPA IRP. The potential consequences of plans that cost more than presented in the PREPA IRP are discussed below.

Moreover, although this concern pertains to the planning horizon (ending in 2038) considered in the PREPA IRP, it is even stronger for the twelve-year period following that horizon (through 2050). Assuming the RPS is interpreted strictly (i.e., 100 percent RPS literally means zero non-renewable generation is allowed), squeezing the last MWh of non-renewable energy out of the PREPA system will be very expensive. The eventual recognition of this high cost may motivate more intense consideration of dispatchable renewable technologies such as biomass, landfill gas to energy, or dispatchable hydropower.

PREPA/Siemens' own analysis supports this view. In its response to Request 22 of the Energy Bureau's second set of ROIs, PREPA/Siemens provided an Excel file that shows that on a typical July day, serving residential load with a hypothetical 1 MW peak would require approximately 4 MW of solar PV and 2 MW of six-hour (not four-hour) storage just to shift energy from light to dark hours.[24] In a 100 percent renewable world, additional battery capacity would be required to provide ancillary services. It is important to note that PREPA/Siemens estimates six-hour storage costs approximately 40 percent more than four-hour storage on a per-MW basis.[25]

Q. In what ways are the capacity expansion plans developed in the IRP potentially unachievable or unacceptably costly?

[24] Workpaper *PREPA_ROI_2_22_Attach 1.xlsm.*

[25] *PREPA IRP*, Exhibit 6-30 on p. 6-32.

A. Most importantly, the preferred plan(s) may not be achievable. Several of the factors underlying that concern are discussed above, such as assumptions about energy efficiency savings and timing of RPS achievements that may be too optimistic.

Another factor contributing to the concern is the sheer magnitude of the new capital investment required to implement the preferred plan(s). For the S4S2B plan, for example, approximately $5 billion of capital investment needs to take place by the end of 2023 and another $1.2 billion (for a total of $6.5 billion) over the remainder of the planning horizon (almost entirely through the end of 2027).[26]

A closely related concern is the lack of an explicit optimized backup plan (i.e., "Plan B") in case the assumed energy efficiency savings, RPS achievements, and especially required capital investment do not occur as quickly as specified in the preferred plan(s). The IRP states:

> *The IRP recommends the retirement of the existing steam generating fleet at different times, including the Aguirre 1 & 2 units in 2019. However, these recommendations are based on other prerequisite developments which include the forecasted reduction in load, assumed levels of reliability of the remaining of the existing fleet at the time of retirement, and the commissioning of the new generation resources. The IRP commissioning dates formulated last year, are likely to slip and it is not unrealistic to expect the planned unit retirements presented in this document to be correspondingly postponed. Moreover, the retirement of existing generating units should be only implemented after all the prerequisites above have been met, particularly that all new resources are fully operational, and units planned for retirement are not required for reliable operation of the system.*[27]

While this may be sound advice, it falls well short of a Plan B, which involves answering the question, what is the optimal plan if only $1 billion (or $2 billion, or $3 billion) is available to invest in generation resources by 2023?

[26] *PREPA IRP*, Exhibit 8-14 on p. 8-23.

[27] *PREPA IRP*, p. 9-4.

Finally, the actual cost of the preferred plan(s) may be so high that all or portions of the policies or strategies upon which they are based, or the series of investment decisions that constitute the plan(s), will have to be aborted. Act 17-2019 establishes a goal of retail electric energy rates at or below $0.20/kWh. The PREPA IRP provides estimates of annual average rates for the preferred plans).[28] These Exhibits show that estimated customer rates are generally in the $0.18–0.20/kWh range over the entire planning horizon (in real 2018 $). However, these estimates do not include any repayment of existing debt, and it is not clear that they include the costs of regasification infrastructure or the $7.9 billion of costs for transmission hardening associated with the MiniGrid strategy.[29] Moreover, as discussed above, PREPA/Siemens has not included any costs for energy efficiency programs in the estimated customer rates (or power supply costs), potentially has underestimated the customer rates associated with new resources by assuming a cost of capital that is too low, and potentially has underestimated the cost of integrating renewable energy by assuming too low a ratio of storage capacity to renewable capacity. As a result, it is possible that the actual customer rates associated with the preferred plan(s) may be materially higher than $0.20/kWh, and the Legislature could react to such high rates by relaxing some or all of the policies contributing to them.

Q. Is PREPA/Siemens' failure to consider extending the AES-PR PPOA a shortcoming of the PREPA IRP?

A. Yes. The IRP should have considered the option of extending the AES-PR PPOA to operate on natural gas. The PREPA IRP does correctly assume the AES-PR plant continues to

[28] For case S4S2B, Exhibits 8-37 and 8-38 on pp. 8-44 and 8-45; for ESM, Exhibits 8-59 and 8-60 on pp. 8-64 and 8-65.

[29] *PREPA IRP, Exhibit 1.01C Appendix 1 Section 2*.

operate through the end of 2027 as currently configured, i.e., burning coal. This assumption is appropriate, because it is consistent with the terms of the PPOA and because the PREPA IRP projects AES-PR to be the least expensive source of electric energy on the island. This projection is demonstrated in Exhibit 6-20 of the PREPA IRP[30], which shows that AES-PR has the lowest Levelized Cost of Energy ("LCOE") of all of the existing or proposed new fossil-fired resources considered in the PREPA IRP at a capacity factor of 60 percent or higher. The projection was reaffirmed in PREPA/Siemens' response to PREB ROI 06-03, in which PREPA/Siemens stated:

> *the Aurora model does not retire the AES plants prior to 2027, [it] still being the most economic unit in the fleet, in terms of dispatch costs, despite the CO2 pricing and higher emission rate compared to the gas fleet.*[31]

In fact, because of its low cost, the prior PREPA IRP, which PREPA filed in 2015 and the predecessor to the Energy Bureau considered until 2017, assumed the current AES-PR PPOA would be extended beyond 2027;[32] and the February 2, 2019 version of the 2018-2019 PREPA IRP included the option of extending the PPOA as a sensitivity.[33]

Act 17-2019, which was passed earlier this year, prohibits the burning of coal for power production in Puerto Rico after the end of 2027. It was therefore appropriate for

[30] *PREPA IRP*, p. 6-15.

[31] *In re: Review of the Puerto Rico Electric Power Authority Integrated Resource Plan*, Case No. CEPR-AP-2018-001, Requirements of Information, Sep. 18, 2019.

[32] *Integrated Resource Plan Volume I: Supply Portfolios and Futures Analysis*, Siemens PTI Report Number: RPT-R054-15, submitted by Siemens Industry, Prepared for Puerto Rico Electric Power Authority, August 17, 2015.

[33] *Puerto Rico Integrated Resource Plan*, Siemens PTI Report Number: RPT-015-19, submitted by Siemens Industry, Prepared for Puerto Rico Electric Power Authority, PREPA Ex. 1.0, Draft for the Review of the Puerto Rico Energy Bureau, Rev.[1] 2/12/2019, p. 5-6.

PREPA/Siemens to assume in the 2018-2019 PREPA IRP that coal would not be burned at the plant after 2027.

However, PREPA/Siemens erred in dropping this resource from the analysis altogether, i.e., by assuming that AES-PR shuts down entirely when the PPOA expires at the end of 2027. PREPA/Siemens should have considered the option of converting the plant to burn natural gas, which is technically feasible as demonstrated in the Siemens Report discussed below. Additionally, AES-PR has invested hundreds of millions of dollars in power generation facilities on the island in the past, and has made it known that it is interested in continuing to produce power on the island, if it is permitted to do so. Given this, PREPA/Siemens' assumption that the AES-PR plant would shut down at the end of 2027 is essentially a judgment on its part that the AES-PR fuel conversion 1) would not or 2) should not be a part of a preferred plan:

1. **Would not** – if AURORAxmp® had been used to select non-renewable resources in the preferred plans, a judgment that the AES-PR fuel conversion would not be selected by AURORAxmp® as a resource in an optimized plan.

2. **Should not** – given that nearly all non-renewable resources included in the preferred expansion plan(s) were specified by PREPA/Siemens as inputs to the model and not by the model itself (as discussed above), a judgment that the AES-PR fuel conversion should not be forced into the model in the same manner as the other non-renewable resources.

Making this judgment without conducting the requisite analysis, and instead imposing the resulting assumption of plant shutdown on the entire remainder of the analysis (i.e., all considered plans reflect this assumption), is not consistent with standard utility practice for IRPs

and related analyses, and not consistent with the apparent treatment of the EcoElectrica plant in the PREPA IRP. At the very least it was an oversight on PREPA/Siemens' part, for two reasons:

1. Without obtaining the relevant information from AES-PR about the likely capital costs of the conversion and the post-conversion operating costs and characteristics, and performing the subsequent analysis (i.e., running AURORAxmp® with the AES-PR fuel conversion either forced in or as a resource option that the model could select), neither PREPA/Siemens nor PREB can be confident that the AES-PR fuel conversion should not be a component of one or more preferred plans.

2. Even if the AES-PR fuel conversion is not an element of a least-cost plan, it likely would be an element of one or more of the potential backup plans that should be considered. In particular, if available capital falls short of the amount(s) specified in the preferred plan(s), or the energy efficiency savings or renewable capacity additions fall short of the assumed amounts, AES-PR would be a readily available asset and thus the AES-PR fuel conversion would potentially be one of PREPA's preferred choices. Extending the AESP PPOA, and having AES-PR convert the plant to burn natural gas, is potentially the least expensive insurance policy PREPA can purchase.

Q. Is PREPA/Siemens' use of a 20-year planning horizon a shortcoming of the PREPA IRP?

A. Yes. Twenty years has become a common planning horizon in most utility planning environments, because there is no reason for the utility to expect that the planning environment in the 21st year or the 25th year or even the 32nd year will be systematically different from the 20th year, so that the first 20 years of a plan with a 32-year horizon would essentially be the same plan as what the utility developed for a 20-year horizon.

That is most definitely *not* the situation for PREPA, and a 20-year planning horizon therefore is inappropriate for the PREPA IRP. Given the RPS requirements of Act 17-2019, particularly the 100 percent RPS in 2050, there is a compelling reason for PREPA to expect that the planning environment for the 32nd year will be systematically different from the 20th year, and that the first 20 years of a plan with a 32-year horizon would be materially different from the plan developed for a 20-year horizon.

Act 17-2019 was passed after PREPA submitted the initial 2018-2019 PREPA IRP and just two months before it submitted the June 19, 2019 PREPA IRP. Thus, PREPA/Siemens did not have time between its passage and the submission due date to both re-execute all of its model runs with the higher RPS imposed *and* extend the analysis by twelve years. Hence, while using a 20-year planning horizon is a shortcoming of the PREPA IRP, it may not have been an avoidable one given the schedule requirements.

It is not certain exactly how the first 20 years of a 32-year plan would be different from the 20-year plan that was developed unless and until PREPA/Siemens actually develops a 32-year plan. However, in my experience, I would expect there would be substantially less capital investment in new fossil-fired capacity during the first 20 (and especially the first seven) years of the planning horizon in a 32-year plan with a 100 percent RPS in the 32nd year than in the 20-year plan. I also would expect in a 32-year plan that the generation to support establishment of MiniGrids would comprise renewable plus energy storage capacity, which was what AES-PR proposed in docket CEPR-IN-2017-0002, and not the fossil-fired generation that PREPA/Siemens assumed for the MiniGrids.

If my expectation is accurate, use of the 20-year planning horizon is likely to result in stranded costs. Typically, stranded costs occur if an investment in an asset is made because it is

cost-effective assuming that the current regulatory environment persists through the life of the asset, but is no longer cost-effective after the regulatory environment changes unexpectedly. The decision-maker is unable to recover and earn the expected return on the investment.

In the present instance, the stranded cost would result not from an unexpected change in the regulatory environment, but failure to appropriately consider a known change in the regulatory environment. Moreover, assuming the asset is built by a third party that executes a PPOA with PREPA that guarantees recovery of and expected return on the investment, the entity bearing the stranded cost will be ratepayers, who will continue to pay the capital charges on an asset that, in this circumstance, should not have been built.

Q. Do you have any additional comments about the PREPA IRP?

A. Yes. As part of its sixth set of ROIs (06-03), PREB directed PREPA/Siemens to re-run the S4S2B, ESM Base, and S3S2B cases assuming the Carbon Prices indicated in Exhibit 4-27 on page 4-29 of the PREPA IRP, allowing the AURORAxmp® model to retire (or not) the AES-PR coal plant. PREPA filed its response with the Energy Bureau on October 18, 2019.

As I discuss in detail below under "Siemens Report," under the terms of the PPOA PREPA must pay AES-PR a Capacity Purchase Price through the end of the PPOA in November 2027 even if the AES-PR coal plant is forced to retire prior to that date. The annual dollar amounts of the Capacity Purchase Price are provided in Exhibit 4-13 on page 4-13 of the PREPA IRP as well as Exhibit 2 of this testimony. They total more than $100 million per year.

PREPA/Siemens failed to account for these payments in conducting the sensitivity cases developed in response to ROI 06-03. By doing so, it understated the cost of options involving the retirement of the AES-PR coal plant. This, in turn, has the effect of increasing the likelihood

of selecting those options in the analysis, i.e., of retiring the AES-PR coal plant, relative to the case in which the Capacity Purchase Price payments were accounted for correctly.

In fact, in two of the three cases analyzed, the AES-PR coal plant was retired prior to the end of 2027: one unit in S3S2B at the end of 2024; and both units in ESM Base, one at the end of 2022 and the other at the end of 2024. PREPA/Siemens did not report the amount by which continued operation of the AES-PR coal plant "lost" to the selected option, so it is not possible to determine if correctly accounting for the Capacity Purchase Price in the analysis would have led to a different outcome.

Another important point about the response to ROI 06-03 is that it illustrates the problem described above regarding the incorrect use of the AURORAxmp® model. So many new fossil-fired units are forced into the AURORAxmp® model in the ESM Base Case that the model jumped at the opportunity to retire any plant and avoid the associated fixed costs (in the case of the AES-PR coal plant, incorrectly, given the terms of the PPOA described above). The only plant it was given the opportunity to retire was the AES-PR coal plant, so the model selected it to retire. Based on my experience, if the model had been given the choice to either not build or delay building any of the new fossil-fired units that were forced into the model, as well as the option to retire AES-PR, it likely would have not built or delayed building one of the new units instead of retiring AES-PR.

Q. What are your recommendations to the Energy Bureau regarding the PREPA IRP?

A. My recommendation is that the Energy Bureau should:

1. Approve the PREPA IRP filed on June 19, 2019 subject to modification to incorporate the following additional analyses, which I believe PREPA/Siemens should be

able to complete without affecting the overall schedule PREB has established for the PREPA IRP:

a. Re-perform at least the base case versions of each of the major cases (e.g., case ESM, but not necessarily ESM High, ESM Low, ESMS1B, ESMS6B, and ESMS5B) forcing in as few resource decisions as possible and allowing AURORAxmp® to select as many resource retirements and additions as possible.

b. Execute scenarios or sensitivities with a) one percent efficiency savings per year and peak reductions that are consistent with the sectoral composition of those energy savings, b) RPS levels reduced by half, and c) a WACC of 11.5 percent.

c. Analyze backup plans to address the contingencies that i) not enough capital investment is available to implement the preferred plan(s) and ii) the Legislature responds to higher-than-expected customer rates by relaxing some or all of the policies contributing to them.

d. Collaborate with AES-PR to develop the assumptions about capital cost and operating costs and characteristics associated with converting the plant to burn natural gas under an extended PPOA, and then re-perform at least the base case versions of the two preferred cases (ESM and S4S2B) with extension of the AES-PR PPOA as a resource option and allowing AURORAxmp® to select as many resource retirements and additions as possible.

e. Re-perform any and all analyses of sensitivities/scenarios involving the potential retirement of the AES-PR coal plant prior to the end of 2027, recognizing that PREPA will still have to pay AES-PR Capacity Purchase Price payments through 2027 even if the plant is retired early.

2. The analyses described below likely require more time to implement than the PREPA IRP schedule allows. I therefore do not recommend requiring their implementation prior to approval of the PREPA IRP, but that PREPA/Siemens complete them prior to other specified Energy Bureau actions:

a. Direct PREPA/Siemens to re-perform at least the base case versions of each of the major cases using a planning horizon through at least 2050 and allowing AURORAxmp® to select as many resource retirements and additions as possible, and only approve PREPA requests to take actions to advance the development of new fossil-fired generation in Puerto Rico once such analysis and those described in #1 above have been completed.

b. Direct PREPA to dedicate adequate time and resources to a rigorous assessment of resiliency and MiniGrids, and only approve PREPA requests to implement the MiniGrid proposal contained in the PREPA IRP once PREPA has completed that assessment.

c. Direct PREPA/Siemens to conduct more rigorous analysis of the storage or dispatchable renewable generation requirements associated with high and rising renewable generation penetration rates in Puerto Rico. Until such analysis can be completed, I recommend that the quantities of energy storage specified in the preferred plans be interpreted as lower bounds of

the amounts that will actually be required to achieve the corresponding solar build outs.

III. THE SIEMENS REPORT

A. Report Background

Q. What is the AES Coal Plant Conversion Assessment report, which you referred to earlier as the "Siemens Report"?

A. As discussed above, PREPA filed its first proposed IRP with PREB on February 13, 2019. On April 26, 2019, PREB ordered PREPA to "develop a set of sensitivities in which the fuel used at the AES plant is switched to another fuel in 2020."[34] PREB further ordered PREPA to use AURORAxmp® to develop these sensitivities, to develop sensitivities for four specified IRP base cases, and to file the results of the modeling runs on or before June 14, 2019. As directed, PREPA/Siemens developed a new sensitivity case for each of cases S1S2B, S3S2B, S4S2B, and S5S1B, as well as the ESM Base case. The Siemens Report summarizes the activities PREPA/Siemens conducted, as well as the findings associated with those activities.

B. PREPA/Siemens Analysis

Q. What is your understanding of the activities PREPA/Siemens performed?

A. Although some of the activities were not documented precisely, my understanding is that relative to the corresponding IRP base case, PREPA/Siemens changed the following modeling assumptions:[35]

[34] *In re: Review of the Puerto Rico Electric Power Authority Integrated Resource Plan*, Case No. CEPR-AP-2018-001, Resolution and Order, April 26, 2019.

[35] *Siemens Report*, section 3.

1. Forced the retirement of the AES-PR coal plant at the end of 2020.

2. Allowed, but did not force, the installation of one of three alternative specifications of the conversion of the AES-PR plant to burn gas, with the gas-fired plant beginning operation in 2023.

3. Allowed, but did not force, delay of retirements until later in the planning horizon of existing units that were selected (or forced) to retire in the corresponding IRP base case.

4. Allowed, but did not force, the installation of solar and energy storage capacity beginning in 2021, over and above the amounts installed in the corresponding IRP base case.

5. Allowed, but did not force, the installation of new gas-fired generation beginning in 2025, over and above the amounts installed in the corresponding IRP base case.

Q. What were the three alternative specifications of the conversion of the AES-PR plant to burn gas that PREPA/Siemens analyzed?

A. The three conversion options were:[36]

1. Direct conversion of both AES-PR boilers to burn natural gas, resulting in a 454-MW gas-fired steam unit.

2. Installation of two gas-fired GTs and heat recovery steam generators ("HRSGs") connected to the existing AES-PR steam turbine, resulting in a 585-MW gas-fired CCGT.

[36] *Siemens Report*, pp. 2-1 through 2-5.

3. Installation of a gas-fired GT whose exhaust would supply pre-heated combustion air to each of the existing AES-PR boilers, which would also be converted to burn natural gas, resulting in a 642-MW "heavily fired combined cycle" unit.

Q. How did PREPA/Siemens determine that these were the appropriate options, the capital costs to effectuate the conversions, and the operating characteristics and costs of the post-conversion plant?

A. My understanding, based primarily sections 1 and 2 of the Siemens Report, is that Siemens developed all of these assumptions based on internal analysis.

C. PREPA/Siemens Analytic Results

Q. What were the most important results of the PREPA/Siemens analysis?

A. The results of the PREPA/Siemens analysis are summarized in Exhibit 3 and are as follows:[37]

1. In all five cases analyzed, the NPV of power supply costs over the 2019-2038 planning horizon was materially higher, by as much as $580 million or 4.1 percent, if the AES-PR coal plant is forced to retire and potentially convert to burn gas than in the corresponding IRP base case, which assumes the plant continues to operate burning coal through the end of November 2027. The power supply component of customer rates for the 2019-2028 period will also be materially higher than in the corresponding base cases in all five cases, by as much as $5.80/MWh or 5.9 percent.

2. The option to convert AES-PR to burn gas to replace the retired AES-PR coal plant is selected in only one of the five analyzed (S5S1B). In the four other cases, the plant is forced to retire, but a variety of other options (e.g., delay retirements of other

[37] *Siemens Report*, section 3.

existing units, install additional solar and energy storage capacity) are selected to replace the lost energy and capacity from AES-PR.

3. In the event the new generation referred to in #2 above is delayed, the further additional cost to PREPA and its customers is material, with estimated additional costs in 2021 (i.e., a single year) of as much as $98 million (in ESM Base).

D. Critique

Q. What is your critique of the Siemens Report?

A. The Siemens Report does not accurately reflect the analytic results that were derived, and the analysis that Siemens conducted does not accurately reflect what would reasonably be expected to happen if the AES-PR plant was forced to either convert to natural gas or retire by the end of 2020.

Q. How does the Siemens Report not accurately reflect the results that were derived?

A. The Siemens Report does not accurately portray the analytic results that PREPA/Siemens derived in two important ways:

1. First, the Siemens Report does not clearly and directly present the most important conclusion of the analysis -- that forcing the AES-PR coal plant to retire at the end of 2020 would materially increase power supply costs and customer rates in all five cases analyzed. For example, in Section 1, "Introduction and Main Findings," the first paragraph with findings (which is the fourth paragraph of the section) highlights the finding that the conversion option was only selected in one of the five scenarios considered, while the plant was retired in the other four scenarios. The one sentence paragraph that follows (the first paragraph overall of Section 1) reads, "Under all cases

there was an increase in the generation revenue requirements as detailed below." However, the Section never identifies the amount of increase in costs and rates.

Further, the Report does not emphasize properly the substantial cost-related risk of retiring AES-PR. In four of the five sub-sections, Siemens presents estimates of the *additional* cost (i.e., over and above those presented in Exhibit 3) associated with a one-year delay in the installation of the resources that would "replace" AES-PR if it retired. These *additional* costs range from $65 million to $98 million. As noted in the PREPA IRP, successful implementation of the near-term expansion plans comes with significant risk. This further risk associated with an early retirement scenario is not discussed in the "Introduction and Main Findings" of the Siemens Report.

2. For the four cases in which none of the AES-PR conversion options was selected, the amounts (in millions of dollars of NPV) by which the non-conversion plan "beat" the plan(s) with conversions are not reported. Not reporting this amount is not in keeping with industry standards for resource planning and related analyses. To the extent PREB will rely on the Siemens Report to make decisions or order additional analysis, knowledge that the difference in costs between the retirement plan for a case and the lowest-cost conversion plan was small and well within a likely margin of error would likely lead to different decisions or analysis orders than knowledge that these differences were large and likely outside a likely margin of error.

Q. How did the analysis that Siemens conducted not accurately reflect what would actually happen if PREB ordered AES-PR to either convert to natural gas or retire?

A. The analysis summarized in the Siemens Report is deficient in four ways. First, the Report does not properly evaluate the economics of converting the AES-PR facility to

operate on natural gas. PREB ordered PREPA to assume AES-PR stopped burning coal at the end of 2020. However, PREPA/Siemens recognized that the AES-PR plant cannot be converted to natural gas by that time. As a result, for modeling purposes, it assumed the AES-PR coal plant retires at the end of 2020, but that the burning of natural gas would not commence there until the beginning of 2023.[38] Given the early timing of the resulting gap and the role of discounting, this assumption undermines the entire analysis of whether or not to convert the plant to operate on natural gas. Instead of assessing the economics of the conversion itself, the Report essentially assesses the least expensive way to bridge the gap between 2020 and 2023. That incorrectly subordinates the long-term economic benefits that might accrue from the conversion itself.

Q. What is the second way in which the analysis that Siemens conducted did not accurately reflect what would actually happen if PREB ordered AES-PR to either convert to natural gas or retire?

A. The Report makes flawed assumptions about the alternatives that it assumes are available instead of a converted AES-PR facility. In three of the four cases in which the conversion of AES-PR to gas is not selected, the ability of the resources selected to replace AES-PR to come online in time is questionable and not reasonably assumed. In case S4S2B-AES, for example, 2,820 MW of new solar PV and 1,560 MW of battery storage is installed by 2025, instead of 2,200 MW and 1,320 MW, respectively, in the corresponding IRP case.[39] This additional 620 MW of new solar and 240 MW of new battery capacity is assumed to be installed

[38] *Siemens Report*, p. 3-21.

[39] *Siemens Report*, pp. 3-1 through 3-2.

despite the warning PREPA/Siemens made in the IRP[40] that the solar PV additions in the IRP cases were already subject to delay and the size of the battery storage "installation [has] never been done before in a power grid."

In the fourth of these cases, cases (ESM-AES), AES-PR is "replaced" by delaying the retirements of, and increasing production from, four steam units (Palo Seco 3&4, San Juan 7&8) that burn heavy fuel oil. Historically these units have been out of compliance with the Federal Mercury and Air Toxics Standards ("MATS"), and were modeled in the IRP with limited operations so that they would comply with MATS. In the ESM-AES case, these heavy fuel oil fired units increase generation during the 2021-2024 period by 36 percent relative to the ESM Base Case in order to replace the energy produced by AES-PR. The aggregate capacity factor for the four units averages more than 55 percent in 2023 and 2024,[41] despite the units being classified as "limited use" to comply with MATS.[42] This suggests one or more of them may be projected to violate MATS in order to meet the demand for energy caused by the forced retirement of AES-PR. The absence of analysis of such potentially non-compliant operation renders this modeling output unusable.

Q. What is the third way in which the analysis that Siemens conducted did not accurately reflect what would actually happen if PREB ordered AES-PR to either convert to natural gas or retire?

A. The Report does not consider the full costs under the PPOA associated with an early retirement or conversion before the end of 2027. Under the terms of the PPOA, PREPA

[40] *PREPA IRP*, pp. 9-3 and 9-4.

[41] Workpapers *ESM_Metrics_Base_SII.xlsx* for the IRP case and *ESM_Metrics_Base_CEPR_Smooth.xlsx* for the Siemens Report case.

[42] *PREPA IRP*, pp. 4-25 through 4-26.

must pay AES-PR a Capacity Purchase Price, which is the sum of a Demand Charge and a Fixed O&M Charge. The annual dollar amounts of these two charges are provided in Exhibit 4-13 of the IRP.[43] I assume for purposes of my testimony that PREPA would be required to continue to pay the Capacity Purchase Price during the 2021-2027 period if the plant was forced to retire in the manner considered in the Siemens Report and did not convert to natural gas. Using the same discounting approach and parameters as in the IRP, and without opining on the validity of either the approach or parameters, I estimate the NPV of the payments specified in Exhibit 4-13 to be $530 million, of which $360 million is the Demand Charge and $170 million is the Fixed O&M Charge. The supporting calculations are provided in Exhibit 2.

Similarly, under the conversion option(s), PREPA would still be obligated to pay the Demand Charge but not the Fixed O&M charge on the existing AES-PR coal-burning plant. The post-conversion plant would incur its own fixed O&M, which is included in the PREPA/Siemens analysis, and so the fixed O&M of the existing coal-fired plant would be avoided.

Standard utility practice for analyses of potential conversion/retirement decisions is to include in the analysis all of the costs that the utility is reasonably likely to incur as a result of each of the alternatives considered. These amounts are included in the IRP cases, so excluding them from the analysis in the Siemens Report unambiguously understates the difference in power supply costs between each IRP case and the corresponding retirement case.

The results of these corrections are shown in Exhibit 4, which assumes that the least cost plan does not change as a result of the corrections. It is not possible to test this assumption because, as discussed above, the amounts by which the retirement options "beat" the best of the corresponding conversion options are not reported. If any of the selected non-conversion options

[43] *PREPA IRP*, p. 4-13.

"beat" the best of the corresponding conversion options by less than $170 million prior to the correction, correcting the costs would in fact lead to the selection of the best of the conversion options.

Exhibit 4 indicates that including these costs causes the increase in 2019-2038 PREPA power supply costs attributable to forcing the AES-PR coal plant to retire or convert to gas to rise to as much as $1.1 billion or 7.7 percent; and causes the increase in the power supply portion of 2019-2028 customer rates to rise by as much as $9.60/MWh or 9.7 percent.

Q. What is the fourth way in which the analysis that Siemens conducted did not accurately reflect what would actually happen if PREB ordered AES-PR to either convert to natural gas or retire?

A. Siemens acknowledges in its Report that:

> *AES did not provide specific design data about the existing plant. A small amount of published technical literature and press releases about the plant were found. So, assumptions were made for study purposes based on typical steam electric plant Rankine cycles and general knowledge of boilers and plant auxiliary systems. This analysis is not a substitute for the detailed studies that would be required to determine technical feasibility, approaches and costs of activities such as boiler fuel conversion, boiler combustion air systems changes, STG modifications, etc.*[44]

It is axiomatic that utility standard practice for IRPs and related analyses similar to the Siemens Report requires that they must reflect the best information that can be obtained cost-

[44] *Siemens Report*, p. 1-1.

effectively. In this case, this principle would require Siemens to have obtained the relevant information from AES-PR, and then for Siemens to validate the information using sources described in the Siemens Report. Not having this information does not only cause avoidable incremental imprecision in the results, which is problematic by itself. It also causes bias, because an experienced owner/operator can nearly always utilize its (and its consultants') knowledge of its own facility to identify a lower cost solution than can an outsider (even a knowledgeable one) that has not had access to the facility in question. Based solely on this principle, the capital and operating cost estimates for the conversion options that Siemens utilized in the analysis are likely too high. This cannot be stated definitively without Siemens actually doing the analysis, but using cost estimates provided by AES-PR may have led to the selection of one of the conversion options instead of the retirement alternative for one or more of the scenarios considered.

Q. Do you have any additional comments about the Siemens Report?

A. Yes. Correction of the deficiencies described above unambiguously will result in higher estimates of the cost to PREPA and its customers of forcing the AES-PR coal plant to retire and potentially convert to natural gas prior to November 2027. These corrections also increases the likelihood that one of the conversion options is selected in all five of the cases PREPA/Siemens analyzed.

In addition, it is important to repeat the caveat Siemens provided in a Memorandum about the Siemens Report that PREPA filed on August 30, 2019:

> *For this reason the study cannot and must not be understood as a [sic] recommending a course of action but rather just as the result of a sensitivity under the IRP carried out to inform the PREB as requested.*

Q. What are your recommendations to the Energy Bureau regarding the Siemens Report?

A. I have two recommendations to the Energy Bureau:

1. Prior to taking action on the Siemens Report, direct PREPA/Siemens to revise the Report to more accurately reflect the PREPA/Siemens analytic findings as indicated above, in particular, that PREPA's power supply costs and customer rates will be materially higher if the AES-PR coal plant is forced to retire and potentially convert to natural gas prior to November 2027.

2. Prior to taking action on the Siemens Report, direct PREPA/Siemens to conduct additional analysis to address the shortcomings identified above.

IV. CONCLUSION

Q. Does this conclude your testimony?

A. Yes, it does. I reserve the right to provide supplemental and rebuttal testimony, as allowed by the Bureau's orders.

FOR WITNESSING OR ATTESTING TO A SIGNATURE

State of Washington
County of Snohomish

Signed or attested before me on 10/22/19 by Ronald J. Moe.

THOMAS W CASON
NOTARY PUBLIC #208540
STATE OF WASHINGTON
COMMISSION EXPIRES
APRIL 15, 2023

Thomas W Cason
Notary Signature

Thomas W Cason
Name Printed, Notary Public in and for the State of Washington

4/15/23
My appointment expires

This notarization is attached to a Attestation

Making this page 2 of 2

Customer selected notary language: English

ATTESTATION

Affiant, Ronald J. Moe, being first duly sworn, states the following: The prepared Pre-Filed Direct Testimony and the information, documents and workpapers attached thereto 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.

Ronald J. Moe — 10/22/2019

Ronald J. Moe Date

Exhibit 1

Ronald J. Moe

Vice President

Ronald Moe co-leads the Power Transaction Services Practice of Leidos Engineering, LLC, which advises the financial community and energy developers in project risks and mitigation. Mr. Moe, an economist and statistician with more than 35 years of experience in energy industry consulting, applies his extensive experience and thorough understanding of commercial and market issues to strengthen clients' positions in complex transactions.

Mr. Moe's has served as project manager and/or principal investigator for development of power supply plans and resource acquisition strategies for electric utilities across the U.S.; due diligence of attempted corporate acquisitions; commercial development, financing, refinancing, and acquisitions of power plant portfolios; and due diligence assignments on behalf of creditor groups in the restructurings of three large merchant power/energy trading companies.

Prior to joining Leidos, Mr. Moe served as the senior vice president and head of Ventyx Advisors, which provides independent market opinions on power generation assets worldwide. He also held management positions at R. W. Beck, which was acquired by Leidos; Jacobs Consultancy; and Stone & Webster Management Consultants.

University of Washington

M.A. in Economics

B.A. in Economics

Key Expertise

- Integrated resource planning
- Transaction support
- Wholesale power market analysis

Project Experience

Mr. Moe has been the project manager or principal investigator on more than 60 integrated resource planning, power market assessment, and asset valuation assignments, including the following large, complex, highly visible assignments.

Utility Resource Planning

- Integrated Resource Plan, Puerto Rico Electric Power Authority (PREPA) – Project Manager/Principal Investigator. Mr. Moe led development of an IRP for PREPA, which formed the basis for negotiations between PREPA and its creditors concerning the potential restructuring and re-capitalization of the utility.
- Integrated Resource Plan, Muscatine (Iowa) Power & Water – Executive Sponsor/Contributing Investigator. Mr. Moe is supporting development of a stochastic resource supply planning for Muscatine Power & Water.
- Integrated Resource Plan, Tacoma (Washington) Power – Project Manager/Principal Investigator. Mr. Moe led development of a stochastic resource supply planning model for Tacoma Power, and worked with utility staff and management to use the model to develop a long-run resource acquisition plan.

leidos

- Integrated Resource Plan, Bryan Texas Utilities – Project Manager/Principal Investigator. Mr. Moe led development of a stochastic resource supply planning model for BTU, and worked with utility staff and management to use the model to develop short- and long-run resource decisions.
- Railbelt Energy Study, Alaskan Railbelt Electric Utilities— Project Manager/Principal Investigator. Mr. Moe led a team that developed a generating and transmission resource investment study for five of the six interconnected utilities in the Railbelt region of Alaska. In addition to overseeing the data development and model execution efforts, Mr. Moe developed a multi-area hourly stochastic dispatch model of the region and a stochastic dynamic programming investment model.
- Power Supply Analysis, Gillette (Wyoming) Municipal Power Department – Project Manager/Principal Investigator. Mr. Moe led an evaluation of Gillette's power supply options, including an assessment of the economic risk associated with the options.
- Power Supply Study, Home Electric Association (Alaska) – Project Manager/Principal Investigator. Mr. Moe led development of a power supply plan for HEA, including evaluation of options to become a standalone utility, remain a customer of its wholesale net requirements supplier, or partner with another utility to build a new power plant.
- Power Supply Study, Chugach Electric Association (Alaska) – Project Manager/Principal Investigator. Mr. Moe led development of a power supply plan for CEA, and worked with utility management to determine investment and wholesale customer retention strategies.
- Strategic Review of Thermal Resources, Benton County (Washington) Public Utility District – Project Manager/Principal Investigator. Mr. Moe led a strategic review of the District's thermal resources, which involved development and application of a stochastic model of the District's power supply costs.

Restructuring Support

- Energy Future Holdings Corp. Restructuring / Bankruptcy – Represented holders of unsecured Energy Future Intermediate Holdings Company notes. Oversaw and/or conducted development of independent market/financial projections for each of the EFH subsidiaries: Luminant, a merchant power generator and trader; TXU Energy, a retail electricity provider; and Oncor, a regulated transmission and distribution company.
- Calpine Bankruptcy – Represented Calpine's Second Lien Holders. Oversaw and/or conducted detailed analyses of debtor market/ financial projections and business plans; development of independent market/financial projections; independent valuation of the company's trading portfolio; and analysis and approval of debtor-proposed asset sales and trading transactions.
- NRG Bankruptcy – Represented insurer of bonds for a portfolio of plants. Oversaw and/or conducted detailed analyses of debtor market/financial projections; development of independent market/financial projections; and market, economic, and technical support for negotiations of new agreements between the debtor and insurer. Also led negotiations of several new agreements.

Acquisition Support

- Attempted Santee Cooper (South Carolina) Acquisition – Assisting confidential client attempting to acquire the South Carolina Public Service Authority (Santee Cooper). Reviewing Santee Cooper's generation resource plans and developing alternative resource plans for the electric utility.
- Attempted Ascendant Group Limited Acquisition – Assisted confidential client that attempted to acquire Ascendant, the parent company of Bermuda Electric Light Company Limited ("BELCO"). Oversaw technical due diligence of generation, transmission, and distribution assets; evaluated rate and regulatory issues; and prepared pro forma rate cases to support the client's valuation.

- Attempted Solar / Storage Development Company Acquisition – Assisted confidential client that attempted to acquire a 50 percent stake in a $500 million solar and storage development company. Oversaw evaluation of target's business processes, business plans, and forecasts, as well as assessment of target's markets; and led the valuation of the target.
- Confidential Utility Acquisition – Assisted confidential consortium that successfully acquired an equity share in an integrated electric and natural gas utility in the western U.S. Executive sponsor for technical due diligence of electric and natural gas assets.
- Confidential Attempted Utility Acquisition – Assisted confidential potential buyer seeking to acquire a portion of an integrated electric and natural gas utility in the upper Midwestern U.S. Executive sponsor for technical due diligence of electric and natural gas assets.
- Cleco Acquisition – Assisted acquiring consortium led by Macquarie. Executive sponsor for technical due diligence of integrated electric utility.
- Cogentrix Energy Acquisition – Assisted Carlyle. Oversaw condition assessment of company assets, projections of operating expenses and capital expenditures, evaluation of power purchase agreements, and development of projections of market prices, associated operating revenues, expenses, and operating cash flows.
- Attempted Solar Development Company Acquisition – Assisted confidential client that attempted to acquire a 30 percent stake in a $1 billion global solar development company. Oversaw evaluation of target's business processes, business plans, and forecasts, as well as assessment of target's markets; and led the valuation of the target.
- Merchant Power Company Acquisition – Assisted confidential buyer in its acquisition of a merchant power company with a 12,000 MW portfolio of gas- and coal-fired generating plants located throughout the United States. Oversaw condition assessment, projections of operating expenses and capital expenditures, evaluation of power purchase agreements, valuation of associated trading book, and development of projections of market prices and associated operating revenues and expenses.
- Puget Energy Acquisition – Assisted acquiring consortium led by Macquarie. Oversaw technical due diligence of electric and natural gas assets, conducted review of Puget's generation resource plans, developed an alternative generation resource plan, and worked with consortium members to develop pro forma financial model of the integrated electric and gas utility.
- Attempted Northwestern Energy Acquisition – Assisted consortium of Montana cities. Oversaw development of pro forma financial model of the integrated electric and gas utility, worked with investment banks to specify acquisition financing and valuation, led negotiations with regulators, and participated in negotiations with company and its shareholders.
- Attempted Montana Power Company Acquisition – Assisted confidential bidder for the electric and gas utility business of Montana Power Company. Oversaw the due diligence effort; supervised development of revenue, expense, and capital expenditures forecasts; and developed and implemented financial model for calculating the bid price.
- Attempted Solar Company Acquisition – Represented confidential potential buyer. Managed assignment for a confidential client attempting to acquire a U.S. solar development company with a 1,300 MW pipeline of projects. Oversaw evaluation of EPC, equipment, O&M, and power purchase contracts; and solar resource and environmental assessments.

Additional Wholesale Power Market Assignments

- Insurance Claim Support, Confidential Merchant Power Generator – Project Manager/Principal Investigator. Mr. Moe conducted a study to develop estimates of the lost revenues and net margins

a merchant power plant incurred as a result of an insured 15-month forced outage, and is participated in negotiations with the plant's insurer.

- Power Market Studies, Multiple Clients – Project Manager/Contributing Investigator. Mr. Moe managed and/or served as contributing investigator on independent power market studies performed for the Seneca pumped storage hydroelectric facility in Pennsylvania; a confidential proposed pumped storage hydroelectric project in the Midwestern U.S.; a confidential portfolio of run-of-river hydroelectric plants throughout the U.S.; a confidential gas-fired plant in the western U.S.; a confidential proposed "ultra-flexible" gas-fired power plant in Texas; two separate confidential proposed Compressed Air Energy Storage (CAES) facilities; the Midland Cogeneration Ventures power plant in Michigan; the Montana-Alberta Transmission Line; and a confidential proposed gas-fired power plant in New York. These studies were used to support equity and debt financing, debt re-financing, purchase, and / or sale of the associated plants.
- Contract Support, Topaz Power Group Lenders – Project Manager/Principal Investigator. Mr. Moe assisted the lenders to a portfolio of power plants in Texas in their negotiations with the borrower concerning borrower's proposed changes to offtake agreements.
- Contract Valuation, Alberta Revenue Department/Canada – Project Manager/Contributing Investigator. Mr. Moe managed a study to develop estimates of the market value of several power purchase agreements that Alberta-based power companies executed.
- Electric Utilities Strategy Development – Project Manager/Principal Investigator. Mr. Moe developed domestic business strategies for the unregulated development subsidiaries of two separate electric utilities.
- Municipal Utility Restructuring Strategy Development – Project Manager/Contributing Investigator. Mr. Moe developed a strategy for participating in the restructured electric industry for a large municipal utility.
- Electric Utility Stranded Cost Mitigation Strategy, Citizens Utilities – Project Manager/Contributing Investigator. Mr. Moe, to estimate and help mitigate the electric utility's stranded costs, oversaw estimation of market prices, developed a financial model of stranded costs, and participated in development of utility's mitigation strategy.
- Generating Resource Strategy, City of Sikeston, Missouri – Project Manager/Contributing Investigator. Mr. Moe developed an action plan for the City's generating plant. He oversaw the development of forecasts of wholesale power market prices and estimation of the annual net income of the plant. Mr. Moe also participated in development and implementation of the City's strategy.
- Merchant Plant Development Analysis, U.S. Utility Holding Company – Project Manager/Contributing Investigator. Mr. Moe, on assignment for a development subsidiary of major U.S. utility holding company, identified the most profitable sites for merchant plant development in the Eastern Interconnection and the Electric Reliability Council of Texas. This was based on a detailed analysis of local power markets, transmission and fuel availability, and environmental factors.
- Restructuring Analysis, Colorado Public Utilities Commission – Project Manager/Contributing Investigator. Mr. Moe evaluated the impacts of alternative industry restructuring scenarios on electricity prices and economic activity.
- Wholesale Market Forecast, U.S. Utility Holding Company – Project Manager/Contributing Investigator. Mr. Moe forecasted the wholesale market prices throughout the Eastern Interconnection in support of merchant plant developments, acquisitions, and trading for a major U.S. utility holding company.

- Merchant Power Plant Feasibility Studies, Various Merchant Power Plant Developers – Project Manager/Contributing Investigator. Mr. Moe conducted feasibility studies of merchant power plants in the upper Midwest, the Mid-Atlantic area, Texas, New England, and the Southwest. He developed a financial model of each plant and oversaw the development of forecasts of market prices, plant revenues, and plant expenses.
- Wholesale Market Price Forecast, Confidential Coal Company – Project Manager/Contributing Investigator. Mr. Moe forecasted wholesale electric market prices in the Northeast for a fuel supplier.
- New Jersey Board of Public Utilities Management Audit – Co-principal Investigator. Mr. Moe performed a management audit of Rockland Electric Company's stranded cost filing, forecasted wholesale market prices, and assessed market power by generators in New Jersey.
- Wholesale Power Market Pricing, Multiple Bidders for Generation Assets – Project Manager/Principal Investigator. Mr. Moe assisted consortia bidding to purchase the generating assets of the New England Electric System, Niagara Mohawk Company, United Illuminating Company, General Public Utilities, Western Massachusetts Electric Company, and Consolidated Edison Company of New York. On each assignment, he oversaw the development of forecasts of wholesale power market prices, annual revenues, and annual expenses for each generating plant. He also developed financial models to estimate the market value of each plant and participated in development of a bidding strategy.
- Power Plant Fire Analysis, Confidential Client – Contributing Investigator. Mr. Moe, on behalf of a client that was sued for damages following a fire at a power plant, was responsible for estimating the increased power production costs and reduced profits from off-system sales attributable to the fire. The suit was settled favorably to Mr. Moe's client following his deposition.

Additional Utility Consulting Assignments

- Proposed Rate Reduction Bond Issuance Due Diligence, Bahamas Power & Light – Project Manager/Contributing Investigator. Mr. Moe is managing the independent engineering and market consulting due diligence assignment in support of BP&L's planned bond issuance, which exceeds $500 million.
- Potential Strategic Transaction Due Diligence, JEA (Jacksonville, Florida) – Project Manager. Mr. Moe is managing the independent engineering due diligence assignment in support of JEA's potential strategic transaction.

Testimony and Litigation Experience

- New Jersey Board of Public Utilities – Mr. Moe testified as an expert witness before the NJBPU *In the Matter of the Energy Master Plan Phase II Proceeding to Investigate the Future of the Electric Industry* (Dockets EO9707457, EO97070460, EO97070463, EO97070466, EA97060395, EA97060396, EA9706397, EA97060398, and EX9412058Y).
- Illinois District Court – Mr. Moe was deposed as an expert witness by opponent's counsel as part of the Power Plant Fire Analysis assignment described above.
- Arizona Corporation Commission – Mr. Moe prepared Citizens Utilities Company's stranded cost filing filed with the ACC in Docket E-01032e-98-0474.

Exhibit 2
Calculations of Capacity Purchase Price NPV

	Values from Exhibit 4-13		Adjusted Values[1]		
Year	Capital Costs (Nominal 000 $)	Fixed O&M Costs (Nominal $/kW)	Demand Charge (Nominal 000 $)	Fixed O&M Charge (Nominal 000 $)	Total (Nominal 000 $)
2019	122,916	79.83	0	0	0
2020	122,991	81.75	0	0	0
2021	108,311	83.71	108,311	38,004	146,315
2022	94,026	85.72	94,026	38,917	132,943
2023	83,779	87.78	83,779	39,852	123,631
2024	74,127	89.88	74,127	40,806	114,933
2025	74,865	92.04	74,865	41,786	116,651
2026	75,627	94.25	75,627	42,790	118,417
2027	76,390	96.51	70,024	40,164	110,188
NPV @ 9%			360,046	169,974	530,020

1. To reflect retirement scenario: zero out 2019 and 2020; multiply FOM values by 454 MW; multiply 2027 values by 11/12

Exhibit 3
Siemens PTI Report Critical Findings

	NPV of 2019-2038 Power Supply Costs (Billion $)			Average 2019-2028 Power Supply Costs ($/MWh)		
Scenario/Strategy	**Base Case**	**AES Case**	**% Increase**	**Base Case**	**AES Case**	**% Increase**
S4S2B	14.4	14.9	4.0%	99.3	104.9	5.6%
ESM Base	14.4	14.6	1.2%	99.0	101.5	2.5%
S1S2B	14.8	15.2	3.1%	102.2	106.8	4.5%
S3S2B	13.8	14.0	1.4%	96.4	99.7	3.4%
S5S1B	14.1	14.7	4.1%	98.4	104.2	5.9%

Exhibit 4

Siemens PTI Report Critical Findings, Corrected for Missing AES-PR Capacity Purchase Price

	NPV of 2019-2038 Power Supply Costs (Billion $)			Average 2019-2028 Power Supply Costs ($/MWh)		
Scenario/Strategy	**Base Case**	**AES Case**	**% Increase**	**Base Case**	**AES Case**	**% Increase**
S4S2B	14.4	15.5	7.7%	99.3	108.9	9.7%
ESM Base	14.4	15.1	4.9%	99.0	105.5	6.6%
S1S2B	14.8	15.8	6.7%	102.2	110.8	8.4%
S3S2B	13.8	14.6	5.2%	96.4	103.7	7.6%
S5S1B	14.1	14.9	5.3%	98.4	106.9	8.7%

COMMONWEALTH OF PUERTO RICO
PUBLIC SERVICE REGULATORY BOARD
PUERTO RICO ENERGY BUREAU

IN RE:	**Case No.:** CEPR-AP-2018-0001
REVIEW OF THE PUERTO RICO ELECTRIC POWER AUTHORITY INTEGRATED RESOURCE PLAN	**SUBJECT**: PRE-FILED TESTIMONY OF AES PUERTO RICO, L.P.

PRE-FILED DIRECT TESTIMONY OF KRISTINA LUND FOR INTERVENOR AES PUERTO RICO, L.P.

AES Puerto Rico, L.P. ("AES-PR") respectfully submits this pre-filed testimony of Kristina Lund.

I. Introduction

Q: Please introduce yourself.

A: My name is Kristina Lund.

Q: What is your educational background?

A: I have a bachelor's degree in Economics from Wellesley College and a Master's in Business Administration from Harvard Business School.

Q: Where are you employed?

A: I am the Chief Financial Officer of the Mexico, Central America, and Caribbean ("MCAC") business unit of The AES Corporation ("AES").

Q: What is The AES Corporation ("AES")?

A: AES is a Fortune 500 global power company. It provides reliable, affordable, sustainable energy in 13 countries across the Americas, Asia, and Europe, through its diverse portfolio of distribution businesses as well as thermal and renewable generation facilities. AES's portfolio includes solar, wind, hydro, natural gas, coal, and landfill gas power plants, distribution companies in the United States and El Salvador and liquefied natural gas (LNG) terminals in the

Dominican Republic and Panama. In addition, AES was an early developer of utility-scale energy storage (batteries) and now has more than 160 MW of batteries in operation around the world.

Q: What is the corporation mission of AES?

A: The corporate mission of AES is to improve lives by accelerating a safer and greener energy future. AES has set ambitious goals to achieve this mission. Its goal is to achieve a 50% reduction in the carbon intensity of its portfolio by 2022 (from a 2016 baseline) and a 70% reduction by 2030. To achieve this goal, AES is targeting the addition of 2 to 3 gigawatts (GW) of renewable capacity, primarily wind and solar, each year. In 2019, AES was named to the Dow Jones Sustainability Index (DJSI) for North America for the sixth consecutive year. AES has been recognized by the Great Place to Work Institute among the best places to work in many of our markets, including Puerto Rico.

Q: What are your responsibilities as Chief Financial Officer of AES' MCAC business unit?

A: As CFO, I am the senior business executive responsible for leading and managing all financial matters for the MCAC business unit. The business unit includes power generation facilities diversified by technology, including coal, natural gas, hydro, wind and solar. We also own and operate energy storage (batteries) in the Dominican Republic, distribution companies in El Salvador, and LNG terminals and storage tanks in the Dominican Republic and Panama. My responsibilities include providing strategic recommendations to the MCAC president and members of the MCAC executive leadership team, managing the processes for financial forecasting and budgets, overseeing debt and equity financings in the portfolio, engaging with our partners and lenders, including multi-lateral development banks, and managing the preparation of all financial

reporting. I also advise on long-term business and financial planning for the business unit, which includes all planning for our Puerto Rico operations including AES-PR.

Q: What were your prior positions within AES?

A: I have 13 years of experience with the AES Corporation. From 2017 to 2018, I was the CFO of AES's Eurasia business unit, covering AES's operations in eight countries from Vietnam to the United Kingdom. Previously, I served as the Vice President of the AES Corporate Strategy and Investment group. In this role, I facilitated AES's Investment Committee, which sets the Company's strategy and approves investments into AES's growth projects around the world. I have held positions in several groups in AES's finance organization, including mergers and acquisitions, financial planning and analysis, and investor relations.

Q: Has AES-PR reviewed the analysis in the IRP?

A: Yes, I have reviewed the IRP and our team has reviewed the IRP and discovery responses by PREPA in this proceeding. AES-PR has also retained the international engineering and power consulting firm of Leidos to provide independent expert analysis of the IRP and resource requirements for PREPA, as well as on the supplemental report prepared for PREPA by Siemens Industries, Inc., Siemens Power Technologies International ("Siemens Report"). Leidos' work will be presented through the testimony of Ronald Moe a Vice President in the Energy and Infrastructure Group of Leidos ("Leidos Testimony") who details how PREPA can improve the IRP.

II. Purpose of Testimony and Summary

Q: Why has AES-PR intervened in this proceeding?

A: The Bureau is considering the *Puerto Rico Integrated Resource Plan 2018-2019* (the "IRP"), which will chart the course for future electricity generation in Puerto Rico as the island

transitions to cleaner generating assets. AES-PR has a direct stake in the proceeding as it is a large, reliable thermal generator of baseload power with the lowest cost of production and its continued supply to PREPA under the PPOA is important for the responsible transition to renewable energy sources on the island. AES also wishes to be a part of the island's transition and future. It has the experience and expertise to play a major role in the island's energy transition over the next 20 years. The company is actively exploring opportunities to develop renewables, energy storage and natural gas on the island. PREPA's IRP and the decisions made in this proceeding are critical to the company's future operations in Puerto Rico.

Q: Please summarize AES-PR's conclusions and recommendations.

A: AES-PR fully agrees with the strategic direction of the IRP. By addressing the execution, financial and stranded cost risks in the IRP, AES-PR believes that Puerto Rico can successfully transition to an energy future that is cleaner, more reliable and affordable for customers.

AES-PR supports Puerto Rico in this transition, and the Company is in preliminary discussions with PREPA and other stakeholders on how to serve PREPA's needs, at acceptable terms. AES-PR's preferred option is the Green Blend and Extend, which contemplates the gradual build-out of solar capacity prior to the end of the AES-PR's contract with PREPA in November 2027 and an extension of the contract beyond 2027 for solar-based electricity. The solar energy can be used to replace the coal energy or other fossil-fuel energy on the island. Another alternative is to redevelop the AES-PR site to utilize natural gas. With more than 20 years of development, financing, construction and operations experience in Puerto Rico, AES-PR is willing to explore these and other options to make the island's energy transition as successful as possible.

AES-PR recommends approval of the IRP subject to modifications to incorporate additional analysis that should be performed without affecting the overall IRP schedule. These are detailed in the Leidos report and include:

a. Additional base case and sensitivity analyses.

b. Back-up plans to address contingencies and higher-than-expected customer rates.

c. Collaborate with AES-PR to develop assumptions about the potential redevelopment of the AES-PR site to utilize natural gas. A final technical solution will require detailed studies, but AES-PR, PREPA and Siemens can work together to estimate costs and operational characteristics of a potential AES-PR site redevelopment to enable PREPA and Siemens to reperform cases with an extension of the AES-PR PPOA as an option.

d. Re-perform any and all analyses of sensitivities and scenarios involving the retirement or conversion of AES-PR prior to 2027, recognizing that PREPA will still have to pay AES-PR Capacity Purchase Price payments through 2027 even if the plant is retired early.

III. AES-PR Background

Q: What is AES-PR?

A: AES-PR is a subsidiary of AES based in Puerto Rico that owns and operates a 454 MW coal-fired power plant located in Guayama along Puerto Rico's southern coast. The plant commenced operations in 2002, and has 110 employees working with the Company. AES-PR has community engagement and social impact programs that focus on education and training for young

people, safety education, and support to entrepreneurship (fondos concursables/competitive funds).

Q: Where does AES-PR sell its electricity?

A: All the electricity generated from the plant is sold to the Puerto Rico Electric Power Authority ("PREPA") under the terms of a Power Purchase and Operating Agreement, as amended, ("PPOA") between AES-PR and PREPA, as described below.

Q: Does AES own other generation assets in Puerto Rico?

A: Yes. AES also indirectly owns AES Ilumina, a 20 MW solar array that can power 6,500 homes. When commissioned in 2012, it was the first and largest solar project in the Caribbean and the first utility scale solar plant to connect to the grid in Puerto Rico.

Q: How did AES come to invest in Puerto Rico?

A: Historically, all of the power plants in Puerto Rico were owned and operated by PREPA. In the early 1990's, faced with an aging, inefficient fleet of oil-fired generating assets, the Puerto Rico government received proposals from independent power producers, including AES-PR, to build and operate new power generating facilities in order to diversify PREPA's resource mix. In 1994, the government selected AES-PR's proposal. With this project, AES invested over $800 million – the largest private investment ever in Puerto Rico at that time – to build the 450+ MW, state-of-the-art coal-fired circulating fluidized bed (CFB) power plant in Guayama.

Q: As part of the government's selecting AES's proposal, did PREPA enter into a contract with AES-PR?

A: Yes. In order to justify this large financial investment, AES-PR and PREPA entered into the contract called the Power Purchase and Operating Agreement ("PPOA"), which

was executed on October 11, 1994, and has been amended twice. The PPOA requires AES-PR to sell exclusively to PREPA the capacity and energy the plant produces. The PPOA is in effect through November 29, 2027.

Q: What is AES-PR's role in ensuring reliable electricity service for Puerto Rico's consumers?

A: AES-PR supplies 17% of the electricity in Puerto Rico. AES-PR's facility is important for the reliability of the grid in Puerto Rico and it has a demonstrated track record of low forced outage rates and high availability. The IRP properly identifies (at section 4.2.1) that AES-PR is highly reliable, with an assumed 3% forced outage rate, which measures the percentage of time a unit stops operating unexpectedly. A lower forced outage rate indicates a more reliable power generation unit. By way of comparison, the Aguirre Steam Units 1 and 2 have an assumed forced outage rate of 20%, and the San Juan Combined Cycle Units 5 & 6 have a forced outage rate of 18%. AES-PR is one of very few reliable power plants on the island. After accounting for both planned maintenance and forced outages, the equivalent availability factor (or the percentage of time a plant is available for dispatch) of the AES-PR plant was 88.4% in 2018.

Q: How does the reliability of AES-PR help Puerto Rico?

A: Reliable power plants are essential to maintaining the steady supply of electricity for when businesses, governments, hospitals, schools, and families need it most. Without reliable generation, the power supply may not be sufficient to meet demand and customers may lose all access to electricity for a period (a "black out") or may need to reduce their consumption for certain times (a "brown out.")

In addition, with its location in the hurricane belt, Puerto Rico requires generation that is resilient after strong storms. AES Puerto Rico has consistently returned to service quickly after severe storms. AES-PR declared availability to PREPA within a few weeks of Hurricane Maria.

Q: What data demonstrates that AES-PR is the lowest cost provider in Puerto Rico?

A: The IRP emphasizes two cases, S4S2B and ESM. In both of these cases, of the large, existing generators on the island, AES-PR is shown to have the lowest cost per megawatt-hour in every year from 2019 through 2027, until the plant is assumed to retire.[1] The IRP further summarizes costs data in the levelized cost of energy ("LCOE") analysis of Section 6.3.4. The LCOE analysis shows that above a 60% capacity factor, AES-PR's LCOE is the lowest, as compared to proposed new combined cycle generator models, as well as existing fossil fuel generators EcoEléctrica and Costa Sur units 5 & 6, as reflected in the IRP at Exhibit 6-20. Finally, the low cost positioning is reaffirmed in PREPA/Siemens' response to PREB ROI 06-03[2], in which PREPA/Siemens stated:

> *The Aurora model does not retire the AES plants prior to 2027, [it] still being the most economic unit in the fleet, in terms of dispatch costs, despite the CO2 pricing and higher emission rate compared to the gas fleet.*

[1] IRP Workpapers, ESM_Metrics_Base_Sii.xlsx, S4S2B_Metrics_Base_Case_SII.xlsx, "Costs by Resource" tab.

[2] *In re: Review of the Puerto Rico Electric Power Authority Integrated Resource Plan*, Case No. CEPR-AP-2018-001, Requirements of Information, Sep. 18, 2019.

Q: How does this low cost electricity help Puerto Rico?

A: The low cost power provided by the AES-PR facility provides substantial overall value to the Puerto Rico economy. According to a report by the Office of Comptroller of Puerto Rico, the lower cost of power produced by AES-PR saved PREPA more than $550 million from December 2002 through June 2007. *See* Estado Libre Asociado de Puerto Rico, Oficina del Contralor, Informe de Auditoría CP-10-02, at 10 (Aug. 4, 2009) (Unidad 3075, Auditoría 12867)[3]. Extended through 2019, this is equivalent to saving the island's consumers approximately $2.0 billion in total energy costs. And that may be a conservative estimate. Thus, the continued operation of the AES-PR facility will provide substantial annual savings – savings that will free up resources for consumers and other investments in Puerto Rico.

IV. AES-PR Comments on the IRP and the Cleaner Energy Transition in Puerto Rico

Q: What does the IRP assume for AES-PR?

A: Consistent with the express terms in the existing PPOA, the IRP at Section 5.4 assumes that AES-PR will continue to supply PREPA through 2027.

Q: How can AES-PR support the responsible transition to cleaner energy on the island of Puerto Rico?

A: The IRP assumes that AES-PR continues to supply PREPA under the PPOA through 2027, as required by the PPOA. PREPA's judgment in this regard is sound because AES-PR is important to the reliability and affordability of electricity on the island, and Act 17-2019 allows electricity generation from coal capacity through the end of 2027.

AES-PR is evaluating and discussing with PREPA and other stakeholders in Puerto Rico several options for replacement of the coal energy in the future. AES-PR's preferred option is a

[3] https://iapconsulta.ocpr.gov.pr/OpenDoc.aspx?id=3ecc8bd7-c701-4385-96a6-4026408a6313&nombre=CP-10-02

"Green Blend and Extend" structure, whereby AES-PR builds new solar capacity to partially replace the coal. The second option is a redevelopment of the AES-PR site to utilize natural gas. Essential to both the Green Blend and Extend and the redevelopment of the AES-PR site is for PREPA to honor the existing PPOA and provide for a fair rate of return on new capital investment by AES-PR. AES-PR is ready to develop these and other alternatives, under acceptable terms and with appropriate credit support, to serve PREPA's needs during the cleaner energy transition.

Q: What is the Green Blend and Extend proposal?

A: AES-PR's preferred option, a "Green Blend and Extend" ("GB&E"), contemplates the gradual build-out of solar capacity prior to the end of the PPOA in November 2027 and an extension of the PPOA beyond 2027 for solar-based electricity. As the solar capacity begins operations, PREPA could choose to either reduce the dispatch of coal energy or reduce the dispatch of diesel and oil generation on the island. In either case, the GB&E facilitates the reduction of fossil fuel-based electricity and could accelerate the achievement of Puerto Rico's renewable energy goals. With short construction timelines, the GB&E is a relatively near-term option for making progress on Puerto Rico's objectives. In the GB&E structure, PREPA fulfills its commitments under the existing PPOA and provides a fair rate of return on new capital investment by AES-PR. The GB&E is consistent with the AES Corporation's global strategy of generating renewable energy. AES currently has 3 GW of wind and solar capacity operating around the world, including 20 MW of solar in Puerto Rico. AES is targeting to add 2 to 3 GW of new renewable capacity each year.

Q: What is the second alternative proposal that AES-PR is considering?

A: The second alternative AES-PR is exploring is the redevelopment of the AES-PR site utilizing natural gas. The redevelopment could involve a conversion of the existing AES-PR

plant to utilize natural gas, instead of coal. Alternatively or in combination, AES-PR could add new gas turbines. Relative to building a new gas plant, the key advantages of this option are the potential cost savings. Cost savings could result from using some of AES-PR's existing equipment and/or constructing the replacement capacity on a shorter timeline compared to a greenfield project. The AES Corporation is a leader in bringing liquefied natural gas to markets without domestic gas reserves, as AES operates LNG import terminals and natural gas power plants in the Dominican Republic and Panama. The redevelopment of the AES-PR site utilizing natural gas could also be an attractive back-up option for reliability, in the event the expansion plan is delayed.

Over more than 20 years in Puerto Rico, AES-PR has a demonstrated track record of investment, development and construction experience, and operational expertise. Working closely with AES-PR to transition the coal plant to renewables and/or natural gas can help mitigate the execution risk of the IRP, while potentially also reducing costs for customers.

Q: Does AES-PR agree with the strategic direction outlined in the IRP?

A: In general, yes. The strategic direction of the IRP is well-aligned with the most important trends driving the global electric sector, including the transition to renewable energy and the replacement of oil-fired generation with natural gas. AES-PR also proposed MiniGrids in 2017 to enhance the resiliency of the electric grid in Puerto Rico.[4] By proactively managing the risks of such an ambitious expansion plan for new generation capacity, it is AES's view that Puerto Rico can successfully transition to an energy future that is cleaner, more reliable and affordable for its customers. Prices for renewables and energy storage are dropping rapidly. According to

[4] *In re: Energy Commission Investigation Regarding the State of Puerto Rico's Electric System After Hurricane Maria*, Case No. CEPR-IN-2017-0002, Comments of the AES Companies, November 17, 2017.

Bloomberg New Energy Finance[5], solar PV module, wind turbine, and battery prices are down 89%, 40%, and 80%, respectively, since 2010. Looking forward, solar PV modules, wind turbines and batteries are expected to decline an additional 34%, 36% and 64% from today to 2030. The investments in renewable energy in the IRP offer the means to "clean" the energy portfolio in Puerto Rico and lower costs for customers, compared to the costs of continued generation from petroleum fuels.

In addition, natural gas prices are highly competitive and expected to remain that way because of the abundance and low cost of production of gas in the United States. [6] Thus, customers in Puerto Rico may benefit from cost savings from replacing oil-fired electricity with natural gas.

Q: What are the key risks in the IRP as currently drafted?

A: The key risks of the IRP are execution, financial and stranded cost risk. First, the IRP has significant **execution risk** with regard to the scope and scale of the transformation contemplated. The IRP assumes closure or repowering of most of the existing generation capacity on the island over a timeline that will be challenging, especially while maintaining reliability. The IRP states that retirements should only be implemented after new generation resources are fully operational:

> *The IRP recommends the retirement of the existing steam generating fleet at different times, including the Aguirre 1 & 2 units in 2019. However, these recommendations are based on other prerequisite developments which include the forecasted reduction in load, assumed levels of reliability of the remaining of the existing fleet at the time of retirement, and the commissioning of the new generation resources. The IRP commissioning dates formulated last year, are likely to slip and it is not unrealistic to expect the planned unit retirements presented in this document to be correspondingly postponed. Moreover, the retirement of existing generating units should be only implemented after all the prerequisites above have*

[5] Bloomberg New Energy Finance, New Energy Outlook 2019, page 13.

[6] https://www.iea.org/countries/United%20States/

been met, particularly that all new resources are fully operational, and units planned for retirement are not required for reliable operation of the system.[7]

To replace the energy supply from the retired units, the IRP assumes an ambitious expansion of new capacity in a very short period of time, specifically 4.5 GW to be built by 2025, which is approximately 90% of the current installed capacity in Puerto Rico. Achieving this rapid transformation on this timeline will be difficult. As an example, in case S4S2B, the IRP assumes 604 MW of new combined cycle natural gas-fired capacity are fully operational by the beginning of 2025, roughly five years and two months from now. But even section 6.3.3 of the IRP recognizes that it takes approximately five and a half years to develop, permit, finance, build and begin operating a large combined cycle gas plant of 300 MW or more. Therefore, the combined cycle plants assumed in the IRP are already delayed, even assuming each element (permitting, financing, etc.) can be achieved without further delay. Any further delays in the operations of new gas or renewable capacity would prolong reliance on PREPA's existing fleet that includes many old, unreliable and inefficient diesel resources that create very high costs for customers.

Second, the IRP has significant **financial risk** because it contemplates accessing $6 billion of capital investments over 5 years. It is obvious to say that the pricing and availability of capital for PREPA will depend largely on the success of PREPA's restructuring under Title III and expectations of the long-term investment climate in Puerto Rico. Investors in long-term assets, such as power plants, underwrite their willingness to fund capital based on their confidence in the rule of law and a respect for contracts, as well as the credibility of the resource plan for PREPA. Without these protections, investors will likely demand higher returns to cover increased risks of loss, or require other credit support such as U.S. government backing. The cost of capital for

[7] *PREPA IRP* at p. 9-4.

PREPA to effectuate the future envisioned by the IRP is a critical factor in evaluating the IRP because without new capital investment, none of that future will be realized. A higher cost of capital will ultimately mean higher electricity rates for customers. Thus, the IRP must present a credible plan for resource supply and cost-effectiveness. Otherwise, the IRP and its assumed capital formation will not be feasible on the terms the Energy Bureau expects for retail electricity rates to customers.

Finally, the IRP presents significant **risk of stranded costs**. Stranded costs arise when investment in long-term power generation facilities is approved and expended, but the facilities are not used and useful for their expected lifetime. Typically, customers reimburse investors for the upfront capital investment in a power plant over a long-term period, such as twenty years or more. Power plants are designed to provide electricity for thirty years, or even longer, depending on the technology. So customers generally utilize power plants to produce energy well beyond the period over which the initial capital investment is paid. However, with the ambitious renewable energy targets in Puerto Rico (40% by 2025, 60% by 2040 and 100% by 2050), the maximum length of time a new natural gas plant can generate is twenty-five years, if it begins operations in 2025. However, with the increasing renewable energy generation, the natural gas plants will be used to generate less and less energy even before 2050. Indeed, the IRP contemplates reductions in the capacity factors (or the percentage of time a power plant is generating energy each year) of the new natural gas plants through 2038, the last year of the IRP analysis. In our example of a new natural gas plant that begins operations in 2025, 2038 would be year fourteen of the power plant's life. Therefore, it is possible that, in the years just after 2038, customers are still repaying the initial capital investment of the natural gas plants when those plants are no longer generating

electricity. With the objective of lowering rates for customers, the Energy Bureau and PREPA should consider methods for minimizing stranded costs.

Q: How should the Energy Bureau and PREPA address the execution, financial and stranded cost risks in the IRP?

A: AES-PR recommends approval of the IRP subject to modifications to incorporate additional analysis that should be performed without affecting the overall IRP schedule. These are detailed in the Leidos report and include:

a. Additional base case and sensitivity analyses.

b. Back-up plans to address contingencies and higher-than-expected customer rates.

c. Collaborate with AES-PR to develop assumptions about the potential redevelopment of the AES-PR site to utilize natural gas. A final technical solution will require detailed studies, but AES-PR, PREPA and Siemens can work together to estimate costs and operational characteristics of a potential AES-PR site redevelopment to enable PREPA and Siemens to reperform cases with an extension of the AES-PR PPOA as an option.

d. Re-perform any and all analyses of sensitivities and scenarios involving the retirement or conversion of AES-PR prior to 2027, recognizing that PREPA will still have to pay AES-PR Capacity Purchase Price payments through 2027 even if the plant is retired early.

V. AES-PR Comments on the Siemens Report

Q: Let's turn to the Siemens Report – what does that document evaluate?

A: As requested, PREPA has submitted the Siemens Report to the Bureau that evaluates ending use of AES-PR as a supply resource or converting the units to fire on natural gas, by the end of 2020.

Q: How should the Bureau utilize the Siemens Report in evaluating the IRP?

A: The Siemens Report includes scenarios under which PREPA would cease purchasing electricity from AES-PR as early as 2021. Such scenarios ignore both the legal obligations that PREPA has to AES-PR under the PPOA and grossly underestimate the technical risks and costs that would be incurred. Moreover, there is no requirement within current law to make such assumptions. The Energy Policy Act permits coal-fired generation through 2027. Thus, the Energy Bureau should not rely on the Siemens Report as it currently exists because the Siemens Report is fundamentally flawed.

Q: Can you expand on why it is unrealistic to assume that PREPA would cease using AES-PR as a supply resource before 2027?

A: Yes. Mr. Moe explains this in detail in the Leidos Testimony. At a high level, AES-PR provides essential energy to the Puerto Rico electric grid--454 MW of baseload electric capacity and 17% of the electric energy on the island. That amount of capacity and energy cannot be economically replaced by any resource in the near term – and certainly not by 2021. As stated in the IRP in p. 9-4, "The retirement of existing generating units should be only implemented

after…all new resources are fully operational, and units planned for retirement are not required for reliable operation of the system."

Q: Does the Siemens Report reflect that early retirement of AES-PR's facility would cause an increase in the cost of electricity to the people of Puerto Rico?

A: Yes. Despite its title and focus, the data contained within the Siemens Report does not change the fundamental logic supporting PREPA's determination to retain the AES-PR facility through 2027. Specifically, the Siemens Report evaluates converting to natural gas or retiring AES-PR at the end of 2020. Careful review, however, reveals the Siemens Report supports a finding that AES-PR *should not be retired* by the end of 2020. Rather, *in all scenarios analyzed,* the Siemens Report finds that PREPA's *power supply costs and customer rates will be substantially higher* if the IRP adopted this scenario, when compared to AES-PR continuing to operate through the end of the PPOA. In a supplemental filing, Siemens wrote, "The report in reference, unequivocally identifies that the option of retiring (or converting) the plant is more costly than the option of continuing operations, resulting in higher costs to the economy and the ratepayers."[8]

Q: So, despite the flaws, the data in the Siemens Report actually do not support early retirement or conversion in 2020 – or before the end of 2027?

A: Correct. *In all scenarios analyzed,* the Siemens Report still affirms that PREPA's power supply costs and customer rates will be substantially higher if AES-PR were retired by the end of 2020, when compared to the IRP, which recommends AES-PR continuing to operate through the end of the PPOA.

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[8] *In re: Review of the Puerto Rico Electric Power Authority Integrated Resource Plan*, Case No. CEPR-AP-2018-001, Submittal of AES Coal Plant Conversion Report Caveats and Limitations (Aug. 30, 2019), *available at* http://energia.pr.gov/wp-content/uploads/2019/08/0012-f-SUBMITTAL-OF-AES-COAL-PLANT-CONVERSION-REPORT-08302019.pdf at 1.

Q: Would additional information from AES-PR provide further important input to a credible IRP review by the Bureau?

A: Yes. To be successful and credible, best practices require that an integrated resource planning process include a meaningful stakeholder process that carefully considers feedback from interested and knowledgeable parties. Siemens acknowledges in the Siemens Report that it did not receive cost or design data about AES-PR's facility from AES-PR, and instead relied on "[a] small amount of published technical literature and press releases about the plant" and assumptions based on typical facilities. In order for the Energy Bureau to issue a credible decision that satisfies applicable requirements and best practices, the record developed in this proceeding must include accurate information about existing electric generators in Puerto Rico, such as AES-PR, as recommended by the Leidos Testimony.

Q: What specific information does AES-PR request Siemens/PREPA consider as part of the IRP process going forward?

A: While AES-PR recognizes PREPA's and Siemens' efforts towards transparency throughout the planning process, the IRP and the Siemens Report are missing key, factual information regarding AES-PR's operations and potential conversion.

For example, the IRP assumes that AES-PR will be retired in 2028 because Act 17-2019 prohibits coal as a fuel source for electric generation beginning that year. The IRP at 8.2.3 states: "AES is retired by 2028, not economically but by model input and in line with Act 17-2019." As a result, the IRP did not input AES-PR's conversion capital costs and post-conversion operating costs into the AURORAxmp modeling system, but rather forced into the model decisions about retirements and conversions. The IRP would be improved if PREPA considered AES-PR's

estimated conversion and post-conversion costs. Using those costs in the AURORAxmp modeling system would achieve a more robust and reliable result.

Second, Siemens/PREPA did not have complete information about AES-PR's operations to consider the costs and benefits of those operations under each scenario considered in the Siemens Report. PREPA and its consultants at Siemens should work with AES-PR and other parties to estimate costs and operational characteristics for a potential redevelopment of the AES-PR site, so that Siemens can reperform the most important cases with an extension of the PPOA as an option in the analysis.. Of course, a final technical solution for a redevelopment of the AES-PR site will require detailed studies, but these can be undertaken after the IRP is concluded.

Q: Overall, how does AES-PR's active engagement in the IRP process benefit Puerto Rico consumers?

A: When integrated meaningfully into the process, generators like AES-PR can provide thorough, first-hand knowledge of the actual costs and benefits of the options under consideration in the IRP process. With meaningful consultation between Siemens and AES-PR, the modeling and resulting IRP and Siemens Report would not only be more comprehensive, but its conclusions would be more robust, more accurate, and more likely to advance the common goals of all stakeholders as envisioned by the government of Puerto Rico.

Q: Has AES been involved in other resource plans where there was a focus on implementing cleaner generating resources?

A: AES is a leader of solar and battery installations in different parts of the world and is dedicated to improving lives by seeking an energy future that is safer and more ecological. For example, this year AES was selected for the Edison Electric Institute's (EEI) 2019 Edison Award

for introducing the world's largest solar and storage system in operation on the Hawaiian island of Kauai.

Additionally, as one of the largest electric generators in Chile, an AES subsidiary, AES Gener is taking steps to support the country's transition to cleaner energy. AES and other large generators worked with the government over many months to develop a plan to gradually retire coal generation plants in Chile, while maintaining system reliability. The resulting agreement was announced in June 2019. Initially, eight coal plants will be closed within five years of the agreement. In addition, every five years, working groups will be established to allow the determination of future closure schedules, with a goal of eliminating coal-fired generation by 2040. AES is also innovating with renewable energy in Chile, as exemplified by its recent groundbreaking on a new 10MW battery back-up facility for the 178-MW Alfalfal I hydropower plant. We believe this is the first energy storage system in the world for run-of-river power stations and reflects AES's dedication to being a leader in renewable energy solutions.

Q: Does this conclude your opening testimony for AES-PR?

A: Yes. I reserve the right to supplement this testimony in response to other intervenor testimony and discovery responses.

ATTESTATION

Affiant, Kristina Lund, being first duly sworn, states the following: The prepared Pre-Filed Direct Testimony and the information, documents and workpapers attached thereto constitute the direct testimony of Affiant in the above-styled case. Affiant states that she 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 her knowledge, her statements made are true and correct.

Kristina Lund
Chief Financial Officer
The AES Corporation
Mexico, Central America, and Caribbean
business unit

County/City of Arlington
Commonwealth/State of Virginia
The foregoing instrument was subscribed and sworn before me this 23rd day of October 2019, by Kristina Lund
(name of person seeking acknowledgement)
Monica C. Thom
Notary Public
My Commission Expires: 11/30/2019

Monica C. Thom
Commonwealth of Virginia
Notary Public
Commission No. 7388002
My Commission Expires 11/30/2019