

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

**NEPR**

**Received:**

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**IN RE:**

**REVIEW OF THE PUERTO RICO  
ELECTRIC POWER AUTHORITY  
INTEGRATED RESOURCE PLAN**

NO. CEPR-AP-2018-0001

SUBJECT:  
PREPA's Rebuttal Testimony

**REBUTTAL TESTIMONY OF NELSON BACALAO, PH. D. IN SUPPORT OF  
PREPA'S DRAFT INTEGRATED RESOURCE PLAN**

TO THE HONORABLE ENERGY BUREAU:

COMES NOW the Puerto Rico Electric Power Authority and hereby submits the Written Rebuttal Testimony of Nelson Bacalao, PH. D. in support of PREPA's draft Integrated Resource Plan<sup>1</sup>.

In San Juan, Puerto Rico, this 20<sup>th</sup> day of December 2019.

/s/ Katuska Bolaños  
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<sup>1</sup> Dr. Bacalao's written testimony was sworn before an official authorized to administer oaths outside the jurisdiction of Puerto Rico. PREPA will submit the corresponding apostille on or before January 3, 2020.

**CERTIFICATE OF SERVICE**

It is hereby certified that, on this same date I have filed the above motion using the Energy Bureau's Electronic Filing System, at the following address: <http://radicacion.energia.pr.gov> and that a courtesy copy of the filling was sent via e-mail to: sierra@arctas.com; tonytorres2366@gmail.com; cfl@mcvpr.com; gnr@mcvpr.com; info@liga.coop; amaneser2020@gmail.com; hriviera@oipc.pr.gov; jriviera@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; jluebke@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; rnegrn@dnlawpr.com; castrodieppalaw@gmail.com; voxpopulix@gmail.com; paul.demoudt@shell.com; javier.ruajovet@sunrun.com; escott@ferraiuoli.com; SProctor@huntonak.com; GiaCribbs@huntonak.com; mgrpcorp@gmail.com; aconer.pr@gmail.com; axel.colon@aes.com; rtorbert@rmi.org; apagan@mpmlawpr.com; [mpietrantoni@mpmlawpr.com](mailto:mpietrantoni@mpmlawpr.com).

In San Juan, Puerto Rico, this 20<sup>th</sup> day of December, 2019.

s/ Katuska Bolaños  
Katuska Bolaños

**GOVERNMENT OF PUERTO RICO  
PUERTO RICO ENERGY BUREAU**

IN RE: REVIEW OF THE PUERTO RICO  
ELECTRIC POWER AUTHORITY  
INTEGRATED RESOURCE PLAN

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**No.** CEPR-AP-2018-0001

**SUBJECT:** Rebuttal Testimony of Nelson  
Bacalao, Ph.D.

Rebuttal Testimony of  
**NELSON BACALAO, PH. D.**  
Senior Consulting Manager  
Siemens Power Technologies International  
December 20, 2019

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1 **I. INTRODUCTION**

2 **A. Witness Identification**

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

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

7 **Q. On whose behalf are you testifying before the Puerto Rico Energy Bureau (the  
8 “Energy Bureau”) (formerly known as the Puerto Rico Energy Commission)<sup>1</sup> in this  
9 proceeding?**

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

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

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

15 I also prepared testimony as part of PREPA’s February 13, 2019, IRP filing in this  
16 current docket and the subsequent June 7, 2019 IRP filing.

17 **Q. What is the purpose of your Rebuttal Testimony?**

18 A. My Rebuttal Testimony provides response to issues brought by various intervenors as  
19 identified below, how they are considered in the IRP and/or the reasons why we disagree  
20 or agree as applicable with the position(s) taken.

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<sup>1</sup> References in my testimony to the Energy Bureau include the former Puerto Rico Energy Commission when applicable.

21 Q. **Does your Rebuttal Testimony address all points raised by the intervenors?**

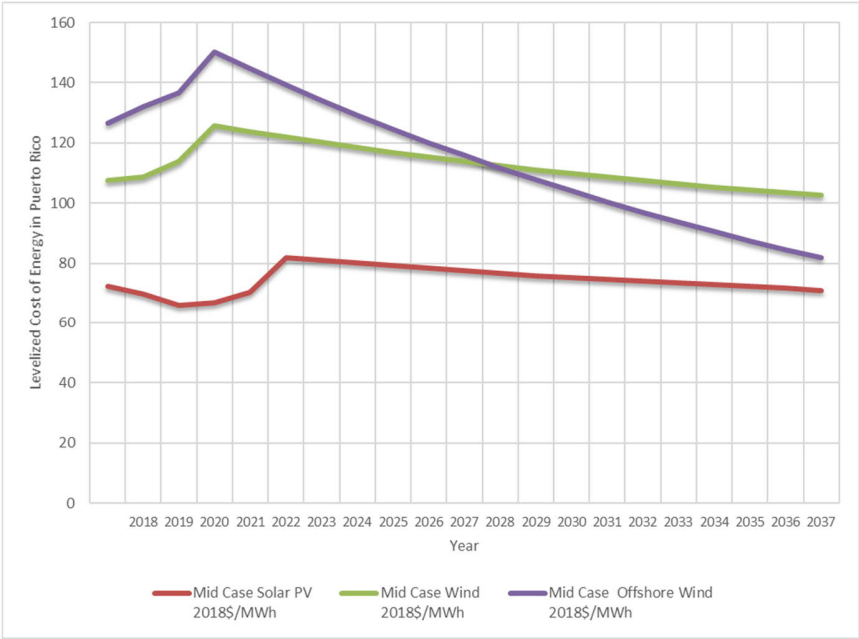
22 A. No, that would result in a very lengthy response of little value, what I suggest instead is to  
23 combine similar assertions by intervenors and provide my view on those. Also, there are  
24 other assertions made by the intervenors that will be addressed by other witnesses and I  
25 will not cover here.

26 **B. REBUTTAL TESTIMONY**

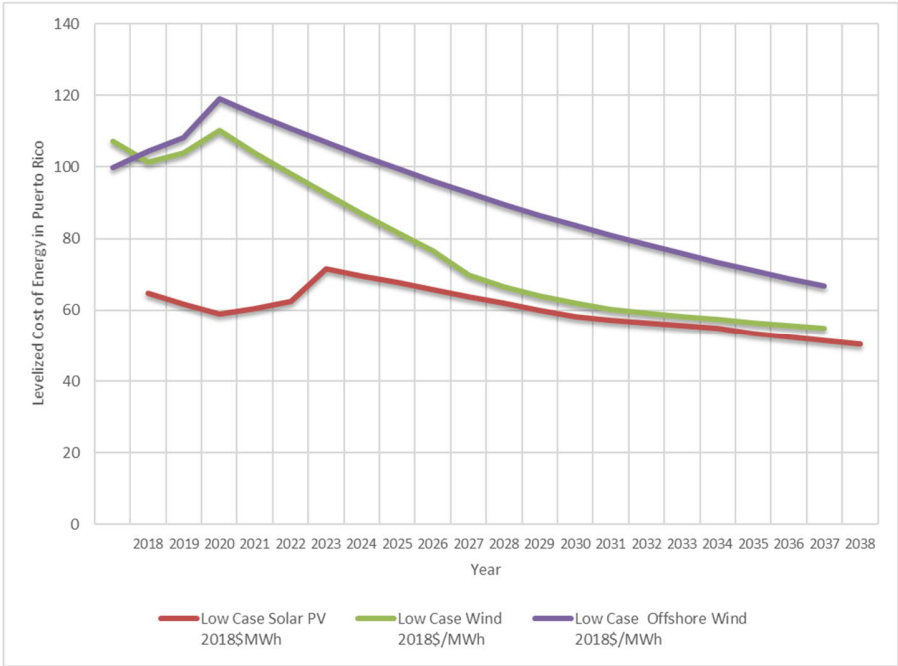
27 Q. **Witnesses for Intervenors Environmental Defense Fund and Progression Energy**  
28 **point out that the IRP failed to include a thorough analysis of offshore wind energy**  
29 **and the basis for excluding offshore wind resources is not valid. Does this represent a**  
30 **major flaw on the IRP as filed?**

31 A. No, I do not think that this represents a flaw on the IRP. The consideration of offshore wind  
32 was discussed earlier on with the Energy Bureau and it was agreed that as the economics  
33 of offshore wind were a function of location and the available wind speed resource that  
34 would take time to assess with the development of meteorological models, as was done for  
35 the onshore resources, and that the available studies indicated that it was unlikely to be  
36 economic, it was decided to reference those studies in the IRP and not include them in the  
37 analysis. At the time onshore wind was included and as expected only on the “Low” case  
38 limited amount of wind was selected in the optimization procedure and none using the base  
39 costs. Further supporting our opinion that offshore wind possibly will not be economic in  
40 Puerto Rico, using the 2019 NREL Annual Technology Base line (ATB) that contains a  
41 projection for Offshore wind, we assessed the economics of offshore wind in Puerto Rico  
42 using the same assumptions as for the other resources with respect of the adjustments for  
43 local conditions. This analysis identified that using the TRG-8 that has an starting capacity  
44 factor in the 50% to 52% range and increasing to 54 to 57% by 2038, offshore wind is not

45 expected to compete with solar PV, only it would be expected to compete with onshore  
46 wind by 2028 on the mid-case as shown in the figures below that show the levelized cost  
47 of energy first for mid cost and followed by low costs.



48



49

50 Q. **Witnesses for Intervenors Environmental Defense Fund and AES Puerto Rico have**  
51 **taken PREPA and Siemens to task for failing to consider the risk that it may not be**  
52 **possible to obtain loans supporting development of gas-fired generation at what they**  
53 **would consider reasonable interest rates. How would you respond to this criticism?**

54 A. This risk exists with respect to all generation resources, in fact all resources, which PREPA  
55 must procure, and it exists in all Scenarios examined in the IRP. Regardless of whether  
56 the resource PREPA seeks to procure is a gas-fired generating facility, a utility-scale  
57 photovoltaic array or a battery energy storage system, the developer of the resource is likely  
58 to require third party financing in order to fund development and construction. Interest  
59 rates at which lenders are willing to lend to a project entity, whether it is developing a gas-  
60 fired or renewable project, will be determined by a number of variables, among which one  
61 of the most important will be the creditworthiness of the project offtaker (which likely will  
62 be PREPA). Another important factor is the ratio of debt to equity employed in the  
63 financing of the project. The proponent's track record and financial wherewithal, the terms  
64 of the underlying power purchase and operating agreement, the tenor of the debt and  
65 lenders' perception of the general economic and regulatory climate, are also important  
66 considerations for lenders, whether they are considering a gas-fired facility or some other  
67 category of project. The IRP draws no distinction among generation resources with regards  
68 to the risk that financing will not be available on reasonable terms; in effect, it assumes  
69 that financing will be available on terms the market will accept. This is appropriate for a  
70 planning tool such as an IRP.

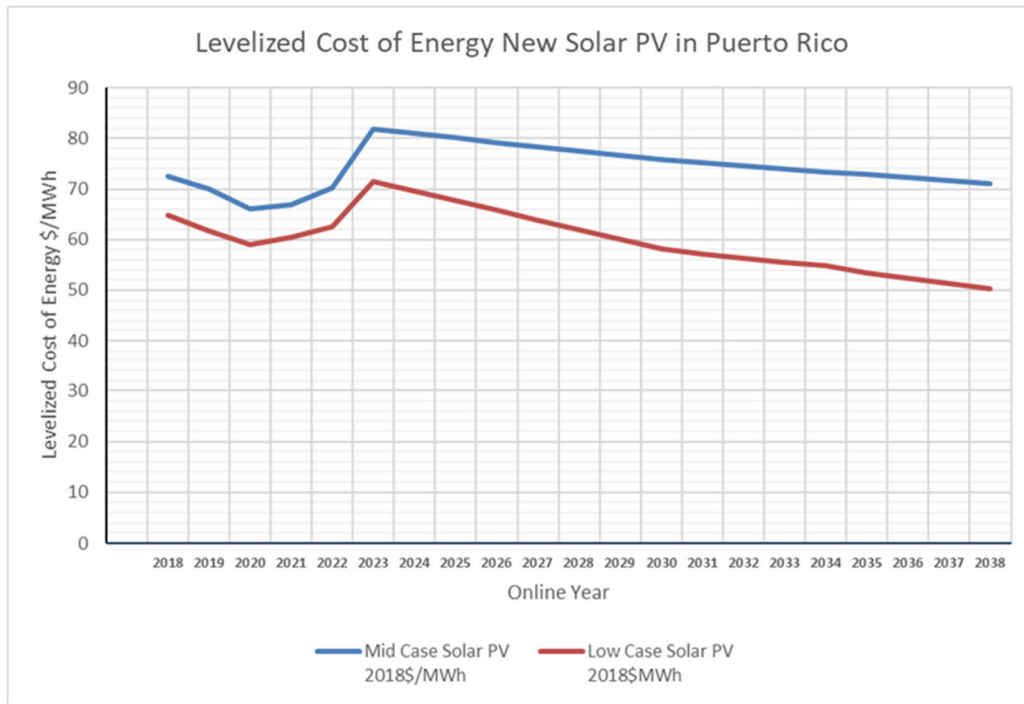
71 Q. **Witness for Not For Profit indicates that the cost of "LNG-fired generation" is**  
72 **already well above the costs of utility-scale renewable, battery storage and distributed**



73 **energy resources. It adds that PREB should approve “only 1000 MW of central**  
74 **station generation that is lower in costs than combined solar and storage (battery**  
75 **costs of \$0.025/kWh” (costs which “as proven in more northern environments in the**  
76 **continental U.S., are attainable now”). Do you agree?**

77 A. No, I don't. The IRP has been based on Puerto Rico costs, which have been extensively  
78 discussed in the IRP report filed on June 7, 2019, the technical hearings in August and  
79 September of 2019, and in ROI responses. The combined solar and battery storage costs  
80 of \$25/MWh (\$0.025/kWh) are in the very low ranges of recent PPAs reported in the  
81 continental U.S., and other countries like Mexico. It is still not the norm, much less for  
82 Puerto Rico, where installing new generation is a lot more expensive due to import costs  
83 (maritime and air transport only), land and labor costs, among others. PREPA and Siemens  
84 used Capital (CAPEX) and Operating expenditure (OPEX) estimates from NREL's Annual  
85 Technology Baseline adjusted for Puerto Rico. As shown in the chart included for this  
86 response, even in the low CAPEX case (based on NREL's low case), the expected levelized  
87 costs for solar are not much higher than the \$25/MWh stated by NFPI witness.

88 In addition, as it has been mentioned in ROI responses and technical hearings, having  
89 natural gas in the system is not only driven by costs but for reliability and resilience  
90 purposes, two fundamental objectives of the IRP.



91

92 **Q. Witnesses for Intervenors Environmental Defense Fund, Not For Profit, Sunrun and**  
 93 **Local Environmental Organizations contend that Siemens should not have treated**  
 94 **investments in demand-side resources as predetermined fixed amounts, but instead**  
 95 **should have permitted these investments to compete with supply-side resources and**  
 96 **indicated that customer load should have been treated as an asset to be managed;**  
 97 **distributed energy resources should have been specifically included in the generation**  
 98 **resource mix analyzed in the IRP. How would you respond to this criticism?**

99 **A.** It is not uncommon to include customer size resources as a forecast in the exact same way  
 100 that the customer load is forecasted using econometric models. This was our approach for  
 101 the distributed solar (roof top) and during the analysis we confirmed that the economies  
 102 driving the development of customer owned generation were likely to stay; this was  
 103 included in the Rate Impact sections of the IRP report. Moreover, it must be stressed that

104 the IRP can only forecast load and customer owned resources, but it cannot not compel  
105 demand-side resources to be available only as and when required.

106 Q. **Witnesses for Not For Profit indicate that PREPA should be directed to revise its**  
107 **approach to the design of MiniGrids to minimize their reliance on thermal resources**  
108 **and should make only minimal investment in natural gas-fired generating facilities**  
109 **and infrastructure. Do you agree?**

110 A. No, I do not.

111 Q. **Please elaborate.**

112 A. A fundamental design criterion of the MiniGrids is to be able to supply the critical loads,  
113 if not during the major event, right after the event is over and the recovery process that they  
114 are to support, starts. Thermal generation was selected to support this function because  
115 their inherent characteristics of compact/protected locations and dependence of locally  
116 stored fuel. This supports the expectation that these facilities will be readily available after  
117 the event. Other resources as photovoltaic generation may take longer time to be available  
118 as panels are inspected and reconnected. I do understand, however, that solar panels can  
119 be certified to withstand high winds (e.g.140 mph) and depending on the design of the  
120 racking and anchoring systems they could withstand hurricane conditions. Thus, in as much  
121 as other resources are certified and guaranteed to match the expectation of availability, they  
122 could be considered to supply the critical load.

123 Q. **Witnesses for Not For Profit content that the 2019 IRP does not properly include and**  
124 **prioritize hydroelectric generation resources. Do you agree?**

125 A. No, I do not.

126 Q. **Please elaborate.**

127 A. Hydro resources are limited in the Island even if all of them were in full operational  
128 conditions this would amount to only 105 MW and the associated capacity factors are fairly  
129 low under 30%, due to the size of the reservoirs and available inflows. Currently the  
130 operational units amount approximately 34 MW with a capacity factor of less than 20%.  
131 The IRP did consider and increase the output and performance of these hydroelectric  
132 resources and considered and increase hydroelectric capacity to 70 MW and 28% capacity  
133 factor as a possible outcome of a refurbishing project. However hydro will continue being  
134 a smaller contributor to the energy mix (under 2%).

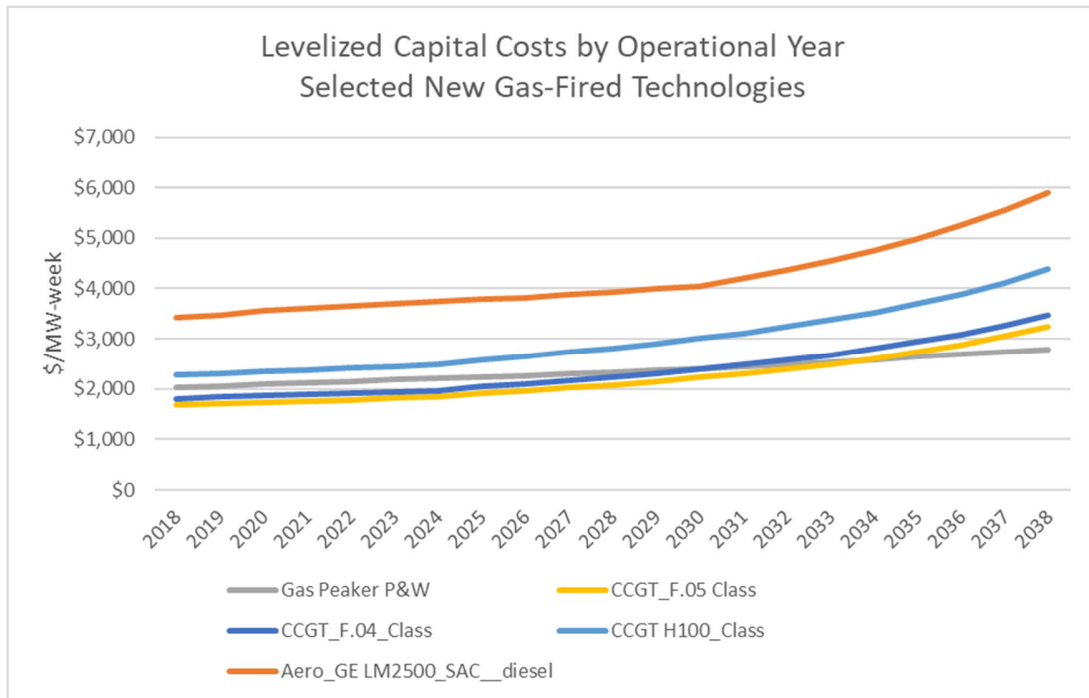
135 Q. **Witnesses for SESA PR content that the IRP's projections of demand are too low,**  
136 **because electric vehicle and charging stations already in place and electric vehicle**  
137 **adoption projections are not included. How do you react to this observation?**

138 A. This is a central issue with forecasting; there is always uncertainty. As the witness rightly  
139 points out the Electric Vehicle (EV) demand was not factored in the load forecast. To  
140 support this decision, we developed a high-level estimate to assess the potential impact of  
141 EV on peak demand and we estimated potential levels of adoption based on total light duty  
142 vehicles registered in Puerto Rico and different paths of forecast penetration nationwide  
143 and for selected states in the U.S. We included the case of Hawaii, California and West  
144 Virginia, and nationwide. As a result of this analysis we estimated that the impact on peak  
145 demand was only is in the order of 20 to 57 MW by 2038 and we did not include this in  
146 the forecast. However, on the responses of PREP's ROI-9 a case with low and no Energy  
147 Efficiency (EE) were included that can be considered as proxy to the cases which higher

148 EE gains but compensated by beneficial electrification that includes transportation  
149 electrification.

150 **Q. Witness for Environmental Defense Fund warns that investment in new gas-fired**  
151 **generating facilities are not assumed to be fully amortized by the time they must be**  
152 **shut down to meet Puerto Rico’s 100% renewables target, which may lead to the**  
153 **prospect of stranded gas assets with higher total system costs than are assumed in the**  
154 **IRP. Do you Agree?**

155 **A.** No I do not and the statement is incorrect. All the gas-fired units assumed in the IRP,  
156 including new units selected by the Aurora model are assumed to be fully amortized by  
157 2050, even units that come online later in the study period, such as the gas-fired CCGTs or  
158 gas peakers installed in 2028. As shown in the chart included for this response, the  
159 levelized costs of energy for different thermal technologies rise through time, particularly  
160 after 2030. This is due to the shorter time frame to amortize fixed and variable costs prior  
161 to 2050, as the units are installed later in the study period.



162

163 Q. **Witness for Wärtsilä alleges that inaccurate cost inputs were used in the IRP,**  
 164 **including current cost of RICE technology in Puerto Rico; failure to consider start-**  
 165 **up costs; failure to model accurately minimum downtime for RICE technology; and**  
 166 **inaccurate modeling of variable O&M costs in CCGTs. Do you agree?**

167 A. No, I do not.

168 Q. **Please elaborate.**

169 A. First the cost values used in the study include all costs for the installation in Puerto Rico,  
 170 which Wartsila may not be aware or has different views These values are reasonable based  
 171 on experience in other similar studies. For capital cost, the pricing is not meant to be the  
 172 best possible pricing obtained in a competitive EPC bidding situation, but a reasonable and  
 173 conservative expectation of achievable EPC costs. A premium is added to reflect the costs  
 174 of executing projects in Puerto Rico vs. US mainland. Also, total project costs include  
 175 Owner's non-EPC costs such as development, project management, taxes, financing,

176 project interconnection, etc. In summary I think the costs used are reasonable. Second with  
177 respect of the start up and down times, all units that have very short up times and down  
178 times were modeled with two hours. The maximum resolution of the LTCE is two hours  
179 as it is formulated by modeling every other hour, so 5 minutes would not make a difference  
180 in the selection of the technologies. Final runs to capture costs were done every hour. With  
181 respect of the O&M costs for CCGT's we believe that these are representative of conditions  
182 in Puerto Rico and are based on our extensive experience in this area. Finally, yes the  
183 hourly model did not consider the startup costs, but the consideration of this will not change  
184 the operation or the findings as these startups are driven by the need to minimize the  
185 renewable curtailment, so the added cost is not likely to change this decision. Additionally,  
186 it should be mentioned that the selection of the optimal thermal resource mix is related with  
187 their performance during operations for base load resources or their capital and fixed  
188 operating costs for peaking resources as is the case of the RICE.

189 **Q. Witnesses for Wärtsilä and AES Puerto Rico indicate in their testimonies that the IRP**  
190 **is not a suitable roadmap given its use of software (Aurora) that leads to less accurate**  
191 **results than could be achieved with other software (e.g., Plexos). Do you agree?**

192 **A.** No I don't. Aurora is a simulation software widely used in the U.S and other countries. It  
193 has proven to provide accurate results and have more functionalities than other software  
194 such as Strategist and Prosym, which have been used in the industry for decades. Siemens  
195 have used the Aurora software for over 13 years not only for other IRP studies but for  
196 numerous asset evaluation studies, national power market outlooks and scenario analysis.  
197 Siemens is aware of the excellent capabilities of Plexos, which is own by Energy Exemplar,  
198 the same developer of the Aurora model. Both models have advantages and disadvantages

199 compared to each other to the extent that we are aware but none of particular concern for  
200 the IRP analysis. In fact, Aurora has a larger market share than Plexos in the U.S., as  
201 reported s by Energy Exemplar, with around 100 companies using Aurora compared to ~  
202 50 using Plexos, across all sectors of the energy industry (utilities, developers, consultants,  
203 etc.).

204 **Q. Witness for Wärtsilä and AES Puerto Rico indicate in their testimonies that PREPA**  
205 **and Siemens used the Aurora model improperly by forcing decisions into the model**  
206 **instead of allowing the model to determine the least cost resource additions and**  
207 **retirements. Do you agree?**

208 **A.** No, I don't. The only fixed decisions common across most scenarios is regarding a set of  
209 peakers assumed to start operation in 2021, included to support the mini-grids  
210 development. There is 371 MW of gas peakers for Scenario 4, 421 MW for the ESM and  
211 348 MW for Scenario 3 included as input decisions. To illustrate how all three plans will  
212 perform in absence of those fixed (input) decisions, the Siemens team run a sensitivity for  
213 each case, in which the LTCE plan is fixed (solar, CCGTs and storage additions and  
214 retirements), except for gas and diesel peakers to be determined economically by the  
215 Aurora model. Results for all three cases showed that the model built more peakers  
216 (LM6000 and Reciprocating engines) than the fixed input decisions, all based on economic  
217 decisions but with some of the units online in later years. In Siemens expert opinion,  
218 developing these peakers later in the study period will slow down the transition to the mini-  
219 grids and maintain the exposure to disruptions from hurricanes for a longer time. Please  
220 refer to responses to PREB Request of Information 07-06.



221 In the ESM case, there is also fixed decisions regarding two new CCGTs, which is part of  
222 the preferred plan by PREPA to develop new gas terminals in Yabucoa and Palo Seco and  
223 make it comparable to the other Plans and Scenarios.

224 **Q. Witness for AES Puerto Rico asserts that PREPA should not be permitted to advance**  
225 **the development of new fossil-fired generation and MiniGrids until all shortcomings**  
226 **in the IRP, including those that will take substantial time to address, have been**  
227 **corrected. Do you agree with this position?**

228 **A.** No, I do not. Witness seems to be advocating in favor of delay in pursuit of a perfect IRP.  
229 He seems to acknowledge that this delay could be substantial because, in his view, it will  
230 take substantial time to remedy the shortcomings he sees in the IRP. This would not be in  
231 the interest of Puerto Rico's energy consumers, of proponents wishing to develop new  
232 generation resources, or of PREPA.

233 **Q. Please explain.**

234 **A.** The IRP is a gating item for PREPA's transformation, and for the Puerto Rico electric  
235 grid's revitalization. It must be approved before PREPA can take any meaningful steps to  
236 unlock the massive amount of new investment that is needed to meet the requirements of  
237 Puerto Rico law and the demands of Puerto Rico's energy consumers. As I understand it,  
238 Puerto Rico law requires that PREPA have an approved IRP in order to pursue the  
239 acquisition of new generation resources. That is, until the Energy Bureau approves the  
240 IRP, PREPA is very limited in its ability to initiate requests for proposals for the acquisition  
241 of new renewable resources, battery energy storage systems, gas-fired generating facilities  
242 and the assets required to establish MiniGrids. While it may be true that there are elements  
243 of the IRP and the Action Plan that could be improved upon, deferring final action on the

244 IRP until every such element is resolved to the satisfaction of all would be to defer approval  
245 of the IRP indefinitely. Puerto Rico cannot afford this. In fact, delays in the approval of  
246 the IRP mean delays in the procurement of new generation resources, both conventional  
247 and renewable, that will enable PREPA to retire much of its costly, inefficient and  
248 environmentally suboptimal oil-fired generation fleet. In a very real sense, deferring action  
249 on new fossil fired generation and the development of MiniGrids will cost Puerto Rico  
250 money, for no quantifiable benefit. This is in no one's interest. The Energy Bureau should  
251 disregard calls, such as Witness's, to delay action on the filed IRP.

252 **Q. Witness for AES Puerto Rico warns that the amount of new capital required to**  
253 **implement PREPA's preferred expansion plans may not be available to Puerto Rico.**  
254 **He suggests that the preferred plans may be too expensive to implement. What is**  
255 **your response to this warning?**

256 **A.** I respond to this warning in the same way I respond to the concern that debt may only be  
257 available to finance gas-fired generation development at unreasonably high interest rates.  
258 The risk that capital may not be available in adequate amounts, like the risk that available  
259 debt would be too costly, is one that exists under all Scenarios examined in the IRP. For  
260 long term capacity planning purposes, we must assume that adequate capital will be  
261 available on acceptable terms at the time when new resources must be financed and  
262 developed. Making any other assumption would essentially freeze the planning process in  
263 place, which would render the integrated resource planning process an entirely meaningless  
264 exercise. In order to provide in the IRP a basis for planning for the future, we must take it  
265 as a given that the capital required will be available as and when needed.

266 Q. **Witness for AES Puerto Rico requests that the Siemens Report should be revised to**  
267 **make it clear that forcing the AES coal plant to retire or convert to gas by the end of**  
268 **2020 would result in higher costs to PREPA. What is your response to this request?**

269 A. There is no need to modify the IRP report, if this is the document in reference a ‘the  
270 Siemens Repot” as the early retirement of the AES coal plant was not part of the  
271 considerations of the IRP and hence the impact of such decision was not assessed.  
272 However, in a response to an AES-PR Request for Information and Additional Cases,  
273 Siemens in behalf of PREPA assessed the impact of this early retirement and in the filed  
274 response it was clearly identified that this retirement would have a negative impact to the  
275 rate payers with an increase on the net present value of the revenue requirements of over  
276 \$900 million. I should also add that at the request of AES this analysis considered the  
277 alleged obligation of PREPA to pay AES-PR the capacity payments of the plant until  
278 contract expiration, regardless of the plant operating or not.

279 Q. **Witness for AES Puerto Rico indicates that the IRP should have considered the**  
280 **possibility that the AES PPOA could be extended in order to support plant conversion**  
281 **or other use. What is your response to this opinion?**

282 A. The IRP identified the need and preferred location of thermal resources and AES is be free  
283 to propose a new resource in the appropriate solicitation for new fossil generation.  
284 However, it is important to realized that in the response to an AES-PR Request for  
285 Information and Additional Cases, we assessed the convenience of repowering the AES  
286 coal units into a combined cycle (CCGT) at the expiration of the current contract and it  
287 was not identified to be the least cost option at this time. In future IRP’s revisions this  
288 option could be revisited.

289 Q. **The Local Environmental Organizations assert, through their witness Irizarry-**  
290 **Rivera (at 6-7, 10-16), that the LCOE calculated using “current Puerto Rico cost”**  
291 **results in a LCOE in 2019 of 7.8¢/kWh, “almost half of the cost calculated by**  
292 **Siemens/PREPA of 15.3¢/kWh.” Do you accept this calculation?**

293 A. No, I do not.

294 Q. **Why not?**

295 Q. Dr. Irizarry-Rivera is making a comparison with our estimation of residential roof top  
296 photovoltaic generation rather than the utility scale generation in which the IRP is based.  
297 The differences between Dr Irizarry-Rivera and our estimation of the cost of residential  
298 roof-top solar can be probably traced back to differences in financing assumptions that can  
299 be debatable. However this is beside the point, the most fundamental flaw that we find with  
300 this assessment regardless of the fact if the said price can be achieved or not, is that it is  
301 for residential rooftop solar installations, rather than utility-scale photovoltaic installations,  
302 can be financed, acquired, installed, maintained and operated in a manner that will ensure,  
303 when integrated with storage and thermal installations, that the capacity and energy which  
304 Puerto Rico will need will actually be available as and when required to satisfy the  
305 customers’ demands. In other words, PREPA cannot prudently plan the system relying on  
306 customer owned generation that may or may not appear in the amounts required Dr.  
307 Irizarry-Rivera envisions would require thousands of individuals and entities to undertake  
308 a number of complex and costly actions to commit to the financing and installation of solar  
309 and battery facilities within the next few years. If they do not, the required capacity will  
310 simply not be available, and PREPA will have to obtain the required capacity and energy  
311 from other resources. Utility planning simply cannot depend on the unproven assumption

312 that thousands of individual actors will be able and willing to make, and will be successful  
313 in making, the necessary financial and other commitments, given the extraordinarily  
314 negative consequences of being wrong.

315 Nor can prudent utility planning depend on the assumption that adequate financing of the  
316 sort Dr. Irizarry-Rivera assumes – personal loans – will be available in sufficient quantities  
317 and on acceptable terms to support the envisioned rooftop solar buildout. Dr. Irizarry-  
318 Rivera offers no basis on which PREPA or the Energy Bureau could confidently conclude  
319 that the financing on which Dr. Irizarry-Rivera’s LCOE calculations depend will actually  
320 be employed to the extent that would be necessary. Even in the unlikely case that Dr.  
321 Irizarry-Rivera is right and the forecasted level of roof-top solar installation does exceeds  
322 the current projections, this will only result in a reduction of the substantial amounts of  
323 utility scale photovoltaics projected in the IRP and make it more important than ever the  
324 need for the utility (PREPA in this case), to ensure that the distributed generation is  
325 integrated in a way that does not harms the power system both in voltage regulation and  
326 frequency control.

327 Dr. Irizarry-Rivera bases his LCOE calculations on costs which are not likely to be  
328 representative of costs of photovoltaic installations in Puerto Rico. The Local  
329 Environmental Organizations’ Response to Request for Information PREPA-LEO-01  
330 states that in calculating “the correct cost for distributed solar PC as \$2.37/W AC,” he used  
331 “actual costs of solar photovoltaic equipment in Puerto Rico.” But this is not entirely  
332 accurate. That same response states that Dr. Irizarry-Rivera “used the costs reported in  
333 ‘U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018,’ October 2018, a report from  
334 the National Renewable Energy Laboratory (‘NREL’) (NREL/PR-6A20-72133),”

335 adjusting such costs downward to reflect the exemption from Puerto Rico sales tax  
336 available for solar photovoltaic modules and inverters. These are not in fact “actual costs  
337 of solar photovoltaic equipment in Puerto Rico.” Rather, they are estimates based on  
338 average costs observed in the mainland U.S. As the Local Environmental Organizations’  
339 own witness Anna Sommer acknowledges (Local Environmental Organizations’ Response  
340 PREPA-LEO-06), it cannot be known with certainty whether NREL’s Annual Technology  
341 Baseline and the cases it incorporates, which seek to “approximate solar costs on the  
342 mainland,” can be viewed as representative of solar costs in Puerto Rico, given that “Puerto  
343 Rico lacks reliable, RFP based renewables cost data.” If experience in comparing mainland  
344 costs to Puerto Rico costs in other contexts is any guide, it is more likely than not that Dr.  
345 Irizarry-Rivera’s “actual costs” actually understate the costs of Puerto Rico rooftop solar  
346 installations, and therefore that his LCOE is likewise understated. Recall that Siemens  
347 made important corrections to the US-mainland cost to reflect likely conditions in Puerto  
348 Rico.

349 **Q. The Local Environmental Organizations assert that PREPA’s reserve margins are**  
350 **“extraordinarily high,” and results are “counterintuitive”, probably implying that**  
351 **there is something wrong with the IRP as proposed. Do you accept this**  
352 **interpretation?**

353 A. No, I do not.

354 **Q. Why not?**

355 A. The assertion above appears to be based on a belief that the system is planned to meet a  
356 given planning reserved margin over the expected peak load at least cost, which was at best  
357 a rough approximation when only conventional thermal resources are considered, but

358 breaks down completely in the presence of renewable generation and storage. The  
359 optimization objective of the long term capacity expansion (LTCE) plan is to minimize the  
360 cost of supply subject to a number of requirements one of which is to maintain a global and  
361 local planning reserve margins (this last only under Strategy 2 and 3). Analyzing the results  
362 of the LTCE plans we observe that even under Strategy 1 (no local reserve margins), the  
363 least cost plan has reserve margins well above the target and this is traced back to the  
364 economics of renewable generation integration; that is storage, peaking generation and  
365 flexible CCGT's all of which are necessary to achieve the optimization objective of least  
366 cost of supply.

367 **Q. The Local Environmental Organizations assert that Siemens' assumed costs of**  
368 **methane (natural gas) are too optimistic; the actual cost of methane delivered to**  
369 **Puerto Rico, at \$12/MMBtu, is much higher. Do you accept this assertion?**

370 **A.** No, I do not. The Local Environmental Organizations seems to be making a wrong  
371 interpretation of the New Fortress Energy (NFE) Contract. When we asked how the  
372 \$12/MMBTU was determined, Dr. Irizarry indicated that it was determined using 115%  
373 Henry Hub plus \$ 8.5 / MBMTU plus an adjustment to cover a fixed cost of \$833,333  
374 per month. There are multiple issues with this interpretation of \$ 12/MMBTU being the  
375 price of natural gas delivered to Puerto Rico. The most important problem is that this  
376 price includes in addition to the delivered gas, the recovery of the investments for the  
377 docking and regasification facilities at San Juan and the cost of the conversion of SJ 5&6  
378 to gas (the \$833,333 per month). These regasification costs for other LNG terminals in  
379 the IRP, including the future land based terminal in San Juan, are modeled separately, thus  
380 the cost of delivered gas reported in the IRP is only the cost of the commodity plus

381 liquefaction plus transportation but not regasification as is the case of the NFE price.  
382 Finally, and for the record, the NFE contract was modeled in the IRP as agreed and also  
383 note that \$8.5 / MMBTU only applies to the first year and it drops to \$7.5 /MMBTU for  
384 the next year and \$6.5 /MMBTU for the balance of the contract.

385 **Q. Empire Gas asserts that switching from diesel to LPG could yield fuel cost savings of**  
386 **35%; even though LNG may be cheaper as of today, the cost of LPG/SNG in peaking**  
387 **applications “could be lower or come very close to LNG.” Please address this**  
388 **comment.**

389 **A.** The cost of LPG/SNG in comparison with LNG may be similar in terms of overall costs,  
390 insofar as peaking applications use relatively small quantities of fuel (given a typical  
391 capacity factor in the 5-10% range). However, on a per unit basis, our expectation is that  
392 LPG/SNG will be a more expensive fuel than LNG. Moreover, there are non-cost  
393 considerations for fuel selection, including environmental attributes. LNG (natural gas)  
394 burns more cleanly than other fossil fuels, emitting lower levels of carbon monoxide,  
395 carbon dioxide and nitrous oxides. While we do not dispute the potential cost savings by  
396 switching from diesel to LPG, it is not clear that switching to LPG would yield larger cost  
397 savings, environmental, and other benefits vs. switching to LNG.

398 **Q. Local Environmental Organizations witness Dr. Irizarry-Rivera states that “PREPA**  
399 **should reject any and all utility scale photovoltaic generation project [sic] through**  
400 **PPOA and instead should promote residential rooftop solar generation with net**  
401 **metering.” How do you respond to this recommendation?**

402 **A.** It would not be prudent, or even possible, for PREPA to turn its back on utility-scale  
403 photovoltaic generation, as Dr. Irizarry-Rivera urges. Among the major virtues of utility-



404 scale photovoltaic generation, particularly when coupled with battery energy storage, are  
405 that it can be integrated into a utility's long-term capacity plans with some confidence, and  
406 can readily be centrally dispatched, like other generation resources. As I have just noted,  
407 as a utility with an obligation to meet the energy needs of Puerto Rico energy consumers,  
408 PREPA cannot simply hope that adequate amounts of rooftop solar photovoltaic capacity  
409 and energy storage capacity will materialize and be available to meet the aggregate needs  
410 of the market. And PREPA certainly cannot compel action by the thousands of individuals  
411 and entities Dr. Irizarry-Rivera assumes will respond and commit to install, operate and  
412 maintain their own solar generation systems. If the "prosumer" response Dr. Irizarry-  
413 Rivera assumes is delayed, or does not materialize to the extent expected, PREPA and  
414 Puerto Rico will be short the necessary capacity, and PREPA will have to look elsewhere  
415 – probably to existing fossil generation resources – for the capacity and energy then needed.  
416 Moreover, even if the massive prosumer response Dr. Irizarry-Rivera assumes were to  
417 occur, the result would not necessarily be a resource mix that could be efficiently  
418 dispatched to meet the aggregate need of the grid for capacity, energy and ancillary  
419 services. With only a limited ability to dispatch rooftop solar and related storage resources,  
420 PREPA would need to look elsewhere to securely operate the system. Thus, even if rooftop  
421 solar plus storage installations proliferate in Puerto Rico, PREPA will nevertheless need to  
422 have resources available which it can dispatch as system needs and contingencies dictate.  
423 Utility-scale solar photovoltaic resources, coupled with battery energy storage systems,  
424 would qualify as such resources, as would gas-fired generating capacity. Because it will  
425 continue to need dispatchable resources to support grid operations and is obligated to do  
426 this with increasing amounts of renewable generation, PREPA has no choice but to seek to

427 procure increasing amounts of utility scale photovoltaic generation. Dr. Irizarry-Rivera's  
428 recommendation to the contrary should be dismissed.

429 **Q. WindMar in its testimony indicates that PREPA has considered storage only at the**  
430 **utility level; it has not considered the role that residential, commercial, industrial and**  
431 **vehicle-to grid batteries could play. How do you respond to this observation?**

432 **A.** Storage is a fundamental component for the secure and economic integration of the  
433 renewable generation and as the penetration increases the role of these resources in energy  
434 shifting and frequency regulation will become central. Hence it would be imprudent even  
435 if it were feasible for PREPA to depend on the hope that the resources will be installed in  
436 the amounts required and that third parties will provide the control of the storage as  
437 required for effective integration.

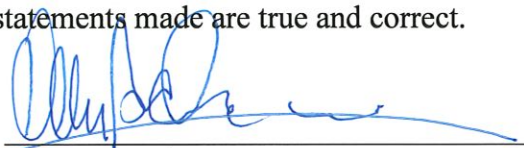
438 **II. CONCLUSION**

439 **Q. Does this complete your Rebuttal Testimony?**

440 **A.** Yes.

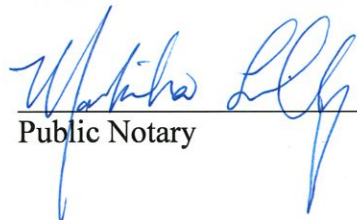
**ATTESTATION**

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

  
\_\_\_\_\_  
Nelson Bacalao

Affidavit No. \_\_\_\_\_

Acknowledged and subscribed before me by Dr. Nelson Bacalao, in his capacity as Senior Consulting Manager — Siemens Power Technologies International, who is personally known to me or whom I have identified by means of his driver's license number 16101472, in Houston, Texas, this 20<sup>th</sup> day of December 2019.

  
\_\_\_\_\_  
Public Notary

