

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

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

CASE NO.: CEPR-AP-2018-0001

SUBJECT: FINAL SUBSTANTIVE AND
LEGAL BRIEF OF WÄRTSILÄ NORTH
AMERICA, INC.

**FINAL SUBSTANTIVE AND LEGAL BRIEF OF
WÄRTSILÄ NORTH AMERICA, INC.**

TO THE HONORABLE PUERTO RICO ENERGY BUREAU:

COMES NOW Wärtsilä North America, Inc. (“Wärtsilä”), represented by appearing counsel, hereby respectfully submits its Final Substantive and Legal Brief (“Final Brief”) to the Puerto Rico Energy Bureau (the “Bureau”) pursuant to the procedural calendar set forth in the Bureau’s August 21, 2019 Resolution and Order, as amended in the February 28, 2020 Resolution, issued in these proceedings.

I. SUMMARY

The modeling performed by the Puerto Rico Electric Power Authority (“PREPA”) in its proposed integrated resource plan (“IRP”) is flawed. As demonstrated by the evidence presented at the Evidentiary Hearing, as well as the information contained in parties’ pre-filed testimony, PREPA’s choice of inaccurate software and use of inaccurate inputs in its modeling led to inaccurate results that do not properly give full consideration to all types of technology. Assuming the IRP is a roadmap developed to guide the configuration of Puerto Rico’s power grid and the location of new resources, the roadmap should be as accurate as possible and the Bureau should fully consider the effects of

inaccuracies demonstrated by Wärtsilä. Therefore, Wärtsilä respectfully requests that the Bureau ensure that the IRP is as accurate as possible to prevent any skewed results, and that any resulting request for proposal (“RFP”) should be as broad as possible given that the IRP serves only as a roadmap.

II. ARGUMENTS

A. The IRP’s Modeling is Flawed

Wärtsilä has shown that the modeling performed by PREPA in the IRP is flawed for two main reasons: (i) the use of the Aurora software to model Puerto Rico’s island grid; and (ii) the use of numerous inaccurate inputs. Wärtsilä also has demonstrated that both of these flaws led the IRP to have less accurate results that fail to fully and fairly consider all types of technology to create an optimized power grid.

1. PREPA Used Inaccurate Modeling Software

PREPA’s use of the Aurora modeling software in the IRP, rather than the more flexible and equally available Plexos modeling software, led to distorted results. *See* Wärtsilä Exhibits 2.01 and 2.02; Supplemental Written Testimony of Brian T. Fladger at 4:19-5:2, 8:1-12. Although PREPA’s witness Dr. Bacalao claimed in his rebuttal testimony that Aurora was suitable for the IRP’s modeling because it is widely used in the U.S. and has been used by Siemens Industry Inc., Power Technologies International (“Siemens”) for other IRP studies, *see* Rebuttal Testimony of Nelson Bacalao at 11:192-12:203, those general claims fail to take into account Puerto Rico’s status as an island and to address the specific issues identified by Wärtsilä’s witness Mr. Fladger. *See* Initial Pre-Filed Testimony of Brian T. Fladger at 2:17-3:1.¹

¹ Other limitations of the Aurora software were identified at the Evidentiary Hearing, such as Aurora’s difficulty modeling the correct amount of storage, which is discussed more fully below.

Wärtsilä's witness Mr. Fladger recommended using Plexos specifically for this IRP because Plexos is a more robust tool in the context of modeling island grids that seek to increase levels of renewable penetration and have no way of importing electricity because Plexos allows users to meticulously configure grid constraints. *See* Initial Pre-Filed Testimony of Brian T. Fladger at 4:18-5:8; Supplemental Written Testimony of Brian T. Fladger at 4:1-8. None of Dr. Bacalao's claims address these points. Further, Wärtsilä is not the only party that recognized the benefits of using Plexos for island grids. During Panel H of the Evidentiary Hearing, Local Environmental Organizations' witness Ms. Sommer stated that Plexos was part of the "paradigm" of capacity expansion modeling in Hawaii, another island grid.²

In fact, even PREPA acknowledged Aurora's limitations. In response to questions during Panel H of the Evidentiary Hearing, PREPA's witness Mr. Saenz admitted that Aurora has a hard time modeling the correct amount of storage and that PREPA had to develop a work around and rerun the model in order to manipulate it to try to find an optimal level of storage.³ Mr. Saenz later stated that he was not aware that Wärtsilä's modeling with Plexos was able to overcome that limitation.⁴ Thus, PREPA did not refute Wärtsilä's view that Plexos is the most accurate software to use in modeling Puerto Rico's island grid, and, as demonstrated more fully below, when Plexos is used to model Puerto Rico's grid, markedly different results are produced.

² Evidentiary Hearing Panel H, February 6, 2020, <https://www.youtube.com/watch?v=UGn8uAvm5NQ>, at 49:56.

³ Evidentiary Hearing Panel H, February 6, 2020, <https://www.youtube.com/watch?v=HO40ImpqKe8>, at 44:04.

⁴ Evidentiary Hearing Panel H, February 6, 2020, <https://www.youtube.com/watch?v=HO40ImpqKe8>, at 3:06:05.

2. PREPA Used Inaccurate Modeling Inputs

PREPA's use of inaccurate inputs in the IRP's modeling, including: (i) utilizing inaccurate cost inputs; (ii) the failure to include start-up costs; (iii) inaccurately modeling minimum downtime for reciprocating internal combustion engine ("RICE") technology; and (iv) inaccurately modeling variable operation and maintenance ("VOM") costs for the combined cycle gas turbine ("CCGT") all led to inaccurate results.

It is undisputed that if the inputs to a model are incorrect, the model will not produce accurate results or select the most accurate unit. PREPA's witness Dr. Bacalao recognized on multiple occasions the importance of modeling and utilizing accurate inputs. For example, Dr. Bacalao stated at the Initial Technical Hearing on September 5, 2019, that the modeling in the IRP is directly related to inputs and that the model selects units based on size and price.⁵ During Panel C of the Evidentiary Hearing, Dr. Bacalao reiterated that the model selects the unit, which he recognized, and the unit will sometimes be a RICE unit, a peaker, or a gas turbine.⁶ Dr. Bacalao also agreed at the Initial Technical Hearing on September 5, 2019, that incorrect inputs could have an effect on the outcome of the model, and that some inputs, such as the cost of renewables, would have more of an impact than others.⁷ Finally, during Panel H of the Evidentiary Hearing, Dr. Bacalao acknowledged the importance of modeling to determining the best hedge and agreed that the net present value of cash flows ("NPV") is generated by the modeling and, thus, to the extent that the inputs

⁵ Initial Technical Hearing, September 5, 2019, <https://www.youtube.com/watch?v=apDxg2FDt1k&feature=youtu.be>, at 1:48:38, 1:55:15.

⁶ Evidentiary Hearing Panel C, February 3, 2020, <https://www.youtube.com/watch?v=weJfs72YtvE>, at 3:26:47, 3:27:54.

⁷ Initial Technical Hearing, September 5, 2019, <https://www.youtube.com/watch?v=apDxg2FDt1k&feature=youtu.be>, at 1:55:27.

to the modeling vary, the NPV will vary.⁸ The importance of accurate inputs cannot be overstated.

The Bureau should carefully review those inputs shown to be inaccurate. First, PREPA failed to utilize accurate cost inputs in the IRP. Dr. Bacalao specifically agreed during Panel C of the Evidentiary Hearing, that cost inputs were important.⁹ However, inexplicably, Dr. Bacalao relied on out of date cost information obtained from Wärtsilä several years ago, which Siemens adjusted based on its own unsupported escalator to arrive at a “range of costs”¹⁰ that forms the basis for Dr. Bacalao’s claim that PREPA used accurate cost inputs. Utilizing escalated outdated cost information as the basis for inputs that are admittedly important defies logic.

For example, Dr. Bacalao alleged that inaccurate cost inputs were not used in the IRP because the cost values that were used included all costs for the installation in Puerto Rico, of which “Wartsila may not be aware,” and that a premium is added to reflect the costs of executing projects in Puerto Rico versus the U.S. mainland. *See* Rebuttal Testimony of Nelson Bacalao at 10:169-11:176. This bald claim is nonsensical. There is no support for the claim that Wärtsilä is not aware of installation costs. Wärtsilä, as the vendor, is in the best position to know its own costs, particularly when those costs were submitted to PREPA in the context of an Expression of Interest. *See* Initial Pre-Filed Testimony of Brian T. Fladger at 6:5-8. Further, once Wärtsilä objected to the pricing information in the IRP, Dr.

⁸ Evidentiary Hearing Panel H, February 6, 2020, <https://www.youtube.com/watch?v=HO40ImpqKe8>, at 1:43:48, 3:05:07.

⁹ Evidentiary Hearing Panel C, February 3, 2020, <https://www.youtube.com/watch?v=weJfs72YtvE>, at 2:57:21, 3:26:12.

¹⁰ Evidentiary Hearing Panel C, February 3, 2020, <https://www.youtube.com/watch?v=weJfs72YtvE>, at 2:57:24.

Bacalao of Siemens should have simply acknowledged and accepted this pricing information. Wärtsilä's witness Mr. Fladger provided the current RICE pricing in Puerto Rico as of October 2019 in his Initial Pre-Filed Testimony, which PREPA did not contradict. *See* Initial Pre-Filed Testimony of Brian T. Fladger at 6:17-7:2. Nor could it because there is no reason whatsoever to believe that Wärtsilä had not provided the accurate pricing.

Rather than conceding that vendors' pricing information, such as Wärtsilä's, is the best pricing information available, PREPA chose to rely on inaccurate, outdated cost information. In fact, PREPA admitted that no vendors were contacted to obtain the most accurate cost information for the IRP. *See* PREPA's response to Wärtsilä-PREPA-02-01. Thus, PREPA failed to utilize accurate cost inputs in the IRP, which resulted in overstated selection of CCGT at the expense of RICE and renewable technology, as discussed below.

Furthermore, PREPA obtained the RICE technology pricing it used in the IRP from Wärtsilä in 2015 and then "escalated" that 2015 cost information to current dollars. *See* PREPA's response to Wärtsilä-PREPA-01-02. PREPA's use of the 2015 pricing information is an admission that the best information is from the source, in this case Wärtsilä. The Bureau should reject PREPA's attempt to claim that it is appropriate to rely on outdated information obtained from Wärtsilä in another context that then must be escalated, and at the same time somehow claim, without any basis, that Wärtsilä's 2019 cost data submitted in this very IRP proceeding is not accurate for Puerto Rico. PREPA cannot have it both ways. Moreover, Dr. Bacalao's position is also inconsistent with his insistence, discussed more fully below, that the RFP process is the only time that accurate costs can be obtained because the costs are provided at the time by the vendor.

Second, PREPA failed to include start-up costs in the IRP. Dr. Bacalao stated during Panel C of the Evidentiary Hearing, that start-up costs were not included in the IRP and agreed that they should have been included.¹¹ The failure to include start-up costs in the IRP means that the IRP does not reflect the true cost of turning on the generation, which skews the IRP's selection toward combined cycle units instead of flexible units. At the Initial Technical Hearing on September 5, 2019, Dr. Bacalao agreed that RICE technology allows for better flexibility to integrate renewables and stated that RICE is one of the most flexible units.¹² Thus, failing to include start-up costs in the IRP impacts unit commitment dispatch optimization and the choices selected in the model, such as RICE technology.¹³ *See* Initial Pre-Filed Testimony of Brian T. Fladger at 9:9-15.

Finally, PREPA inaccurately modeled minimum downtime for RICE technology. In his rebuttal testimony, Dr. Bacalao confirmed that the IRP modeled minimum downtime for RICE technology at two hours. *See* Rebuttal Testimony of Nelson Bacalao at 11:176-180. The minimum downtime for RICE technology, however, is only five minutes. Dr. Bacalao claimed that Siemens input minimum downtime at two hours because the maximum resolution of the Long-Term Capacity Expansion ("LTCE") is two hours, so all units with short uptimes and downtimes were modeled at two hours and that properly modeling the downtime at five minutes would not have made a difference in the selection of the technologies. *Id.* However, this claim is disproven because this limitation of PREPA's

¹¹ Evidentiary Hearing Panel C, February 3, 2020, <https://www.youtube.com/watch?v=weJfs72YtvE>, at 3:20:38.

¹² Initial Technical Hearing, September 5, 2019, <https://www.youtube.com/watch?v=apDxg2FDt1k&feature=youtu.be>, at 2:04:50.

¹³ Additionally, PREPA's failure to include start-up costs increases the overall cost of generation because the model runs the units when not necessary, which increases fuel costs and reduces the amount of renewables selected.

modeling favors certain technologies over others.¹⁴ During Panel H of the Evidentiary Hearing, Dr. Bacalao stated that you want flexibility in the model to integrate renewables because once you turn them on they have to stay on for a long time and they have a high minimum load.¹⁵ This is true of CCGT but not of RICE technology. The effect is twofold. Modeling downtimes at a standard two hours fails to disclose the drawbacks of CCGT while also failing to highlight this additional benefit of RICE technology.

Contrary to PREPA's claims, properly modeling the correct downtimes for relevant technologies, as well as using other accurate inputs in the modeling, does make a difference in the selection of technologies, as shown by the modeling done by Wärtsilä's witness Mr. Fladger in his Supplemental Written Testimony.

B. Markedly Different Results Are Produced With Proper Modeling

Markedly different results are produced when proper modeling is done using relevant and accurate inputs and software. In his Supplemental Written Testimony, Wärtsilä's witness Mr. Fladger used Plexos to model the same inputs Siemens used on behalf of PREPA at hourly granularity (as compared to the Energy System Modernization ("ESM") plan, which was run every other hour) to generate the graph in Wärtsilä Exhibit 2.01 labeled "Siemens Inputs Optimized." Using Plexos and the hourly chronology generated noticeably different results, including the addition of 416 MW of RICE

¹⁴ The Bureau should guard against PREPA's use of the IRP to favor its consultants, not only in the selection of certain technology but also in the transparency of RFP processes. For example, during Panel A of the Evidentiary Hearing, PREPA's Director of Generation, Mr. Hernandez Morales, stated that PREPA had been in contact with various suppliers and vendors regarding their ability to have temporary generation available to cover generation lost during recent earthquakes, including Siemens, AES-Puerto Rico, L.P., and APR Energy. Evidentiary Hearing Panel A, February 3, 2020, <https://www.youtube.com/watch?v=TUOgYQNFCaE>, at 2:47:16. Wärtsilä is not one of the vendors. Safeguards should be used to ensure transparency in the RFP process and prevent potential favoritism.

¹⁵ Evidentiary Hearing Panel H, February 6, 2020, <https://www.youtube.com/watch?v=HO40ImpqKe8>, at 16:16.

technology, and renewables, including battery storage. *See* Wärtsilä Exhibit 2.01; Supplemental Written Testimony of Brian T. Fladger at 4:19-5:2.

Additionally, Mr. Fladger used Plexos to run the “Puerto Rico Optimized” model, in which he used the current pricing for RICE technology in Puerto Rico, correct start-up costs, including accurate VOM, correct minimum downtime for RICE technology, and the use of batteries to provide spinning reserves. The graph in Wärtsilä Exhibit 2.02 labeled “Puerto Rico Optimized” shows the noticeable difference in results when the correct software and inputs are used, including: (i) 314 MW more solar; (ii) 595 MW more battery storage; (iii) 530 MW more RICE; and (iv) 604 MW and 464 MW less CCGT and open cycle gas turbine (“OCGT”), respectively. *See* Wärtsilä Exhibit 2.02; Supplemental Written Testimony of Brian T. Fladger at 8:1-12.

PREPA failed to address or refute either the Siemens Inputs Optimized model or the Puerto Rico Optimized model in its rebuttal testimony or at the Evidentiary Hearing. These models reflect very different power systems for Puerto Rico that more accurately take into account the flexibility of different types of technology. For example, during Panel H of the Evidentiary Hearing, Wärtsilä’s witness Mr. Fladger agreed that RICE units tend to replace gas turbines and combined cycle units, and that in the Puerto Rico Optimized model there was no new build CCGT.¹⁶ As a result, Mr. Fladger confirmed that in the Puerto Rico Optimized model, more batteries and solar are integrated than in the ESM case and RICE units are playing the role of supplying both bulk energy and flexible capacity.¹⁷

¹⁶ Evidentiary Hearing Panel H, February 6, 2020, <https://www.youtube.com/watch?v=HO40ImpqKe8>, at 2:12:12.

¹⁷ Evidentiary Hearing Panel H, February 6, 2020, <https://www.youtube.com/watch?v=HO40ImpqKe8>, at 2:12:53.

He stated that in the Puerto Rico Optimized model, the capacity factor of the RICE units would range from 35% to 65%, so that at some points they are operating as bulk delivery systems and at other points are providing more of a peaking or balancing capacity.¹⁸ Mr. Fladger also pointed out the flexibility of RICE units, stating that they can be built in one location or spread out across the island depending on the application and the type of capacity being replaced.¹⁹ The IRP's flawed modeling fails to fully take into account these important flexibility benefits.

The markedly different results obtained when using the proper software and inputs demonstrate that the IRP's modeling approach leads to inaccurate results that do not properly give full consideration to all types of technology. Therefore, the Bureau should fully consider that the results of the IRP should be adjusted to allow for modeling with accurate inputs, as shown below, and in addition provide additional safeguards for the RFP process to afford all technologies the opportunity to be considered.

C. The IRP is a Roadmap and Should be as Accurate as Possible

The focus of the Evidentiary Hearing is the IRP, which, as a roadmap for Puerto Rico's future power system, needs to be as accurate as possible. During Panel I of the Evidentiary Hearing, Commissioner Rivera stated that the purpose of the IRP is to identify the least cost resource mix to meet demand needs.²⁰ This purpose cannot be accurately met when the IRP's modeling approach is based on inaccurate inputs,

¹⁸ Evidentiary Hearing Panel H, February 6, 2020, <https://www.youtube.com/watch?v=HO40ImpqKe8>, at 2:13:48.

¹⁹ Evidentiary Hearing Panel H, February 6, 2020, <https://www.youtube.com/watch?v=HO40ImpqKe8>, at 2:14:36.

²⁰ Evidentiary Hearing Panel I, February 7, 2020, <https://www.youtube.com/watch?v=zKGmsj6OTs>, at 2:36:38.

including cost inputs, that lead to inaccurate results that do not give full consideration to all types of technology. Moreover, contrary to PREPA's view, because the IRP is meant to identify the least cost resource mix to meet demand needs it is the IRP, not the resulting RFP process, that determines the best technology to meet demand needs.

During Panel C of the Evidentiary Hearing, PREPA's witness Dr. Bacalao claimed that the IRP only finds the need, and that the RFP process should be the one that selects the best technology to fill that need.²¹ Dr. Bacalao stated that RFPs would, therefore, be open to multiple types of technology.²² Dr. Bacalao, however, does not work on the RFP side of the process. During a discussion at the Initial Technical Hearing on September 4, 2019, regarding the procedures Siemens has in place to prevent conflicts of interest between its planning and developing groups, Dr. Bacalao stated that he is not involved in the actual RFP process.²³

Moreover, Dr. Bacalao's view is directly contradicted by the specific models and types of generation listed in Section 6 of the IRP, as well as Wärtsilä Exhibits 2.01 and 2.02, which show that modeling does select the types of generation, including renewables. It is also contradicted by Dr. Bacalao himself. In response to PREB-PREPA-09-02(a) regarding the retirement of certain older gas turbines, Dr. Bacalao stated that the Aurora optimization retired the units, which PREPA's witness Mr. Saenz also agreed to during

²¹ Evidentiary Hearing Panel C, February 3, 2020, <https://www.youtube.com/watch?v=weJfs72YtvE>, at 3:27:42, 3:28:19.

²² Evidentiary Hearing Panel C, February 3, 2020, <https://www.youtube.com/watch?v=weJfs72YtvE>, at 3:28:35.

²³ Initial Technical Hearing, September 4, 2019, <https://www.youtube.com/watch?v=FKBdmx7IkIY&feature=youtu.be>, at 47:53.

Panel H of the Evidentiary Hearing, confirming that it was an output of the model.²⁴ Thus, Dr. Bacalao acknowledged that the model selects specific units and not just a generic amount of capacity. The Bureau should reject Dr. Bacalao's effort to have it both ways: to create an IRP based on inaccurate modeling that selects CCGT rather than accurate modeling that supports greater integration of renewables, while at the same time claiming that all issues with the IRP will be resolved by the RFP process when in fact, the RFP process is typically limited by the results of the IRP. Dr. Bacalao's position allows him to ignore the inaccuracies and inconsistencies in the IRP that benefit CCGT while also promising corrections that are unlikely to occur in the typical RFP process.

The focus following the Evidentiary Hearing should be to analyze and approve the best possible IRP. The IRP needs to be as accurate as possible on its own, without relying on the potential RFP process to attempt to correct any inaccuracies, because, as demonstrated above by the modeling performed by Wärtsilä's witness Mr. Fladger and as agreed to by Dr. Bacalao, the inputs drive the results.

In fact, as Mr. Fladger stated during Panel C of the Evidentiary Hearing, it is very important to know pricing assumptions to a high degree of precision before the modeling occurs because the pricing assumptions would be used as an input that would ultimately determine what capacity is needed.²⁵ Mr. Fladger stated that even before an RFP is issued, "you parameterize those different generating technologies and let the model select

²⁴ Evidentiary Hearing Panel H, February 6, 2020, <https://www.youtube.com/watch?v=HO40ImpqKe8>, at 20:22.

²⁵ Evidentiary Hearing Panel C, February 3, 2020, <https://www.youtube.com/watch?v=weJfs72YtvE>, at 2:56:01.

which is the best piece of equipment to install.”²⁶ Therefore, Mr. Fladger agreed that the IRP identifies which type of technology is the better approach, and then an RFP is issued for that type of technology rather than having different types of technologies compete against each other in the RFP,²⁷ as Dr. Bacalao suggested. As Mr. Fladger explained, modeling inputs are critical to obtain accurate and valid outputs, not just in terms of how much capacity needs to be installed but also as to the types of generating technologies and the quantities of such generating technologies, which will then lead to the content for the resulting RFP. This is why it is important to make the IRP as accurate as possible.

III. CONCLUSION

Wärtsilä’s Puerto Rico Optimized graph demonstrates that the issues Wärtsilä has raised regarding the inaccurate inputs and modeling approach used by PREPA in the IRP have significant consequences for unit commitment for the next twenty years. The fact that using more accurate inputs and software resulted in noticeably different modeling results demonstrates that the IRP is not as accurate as possible. PREPA did not refute Wärtsilä’s evidence in this regard. Thus, Wärtsilä respectfully requests that the Bureau take into consideration the arguments set forth in this Final Brief and ensure: (i) that the IRP is as accurate as possible before its final approval so that full and fair consideration can be given to all types of technology; and (ii) that the resulting RFP process is as broad as possible because the IRP is only a roadmap.

²⁶ Evidentiary Hearing Panel C, February 3, 2020, <https://www.youtube.com/watch?v=weJfs72YtvE>, at 2:54:04.

²⁷ Evidentiary Hearing Panel C, February 3, 2020, <https://www.youtube.com/watch?v=weJfs72YtvE>, at 2:54:25.

RESPECTFULLY SUBMITTED,

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CERTIFICATE OF SERVICE

I hereby certify that on March 6, 2020, I have sent the Final Substantive and Legal Brief of Wärtsilä North America, Inc. via email to the Energy Bureau, PREPA, and the intervenors:

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