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

IN RE: IMPLEMENTATION OF THE PUERTO RICO ELECTRIC POWER AUTHORITY INTEGRATED RESOURCE PLAN AND MODIFIED ACTION PLAN	**CASE NO. NEPR-MI-2020-0012** **SUBJECT: Motion in Compliance with December 19th Order with Respect to Status of Interconnection Studies for Six Approved BESS Projects and Modeling Description for such Studies**

MOTION IN COMPLIANCE WITH DECEMBER 19TH ORDER WITH RESPECT TO STATUS OF INTERCONNECTION STUDIES FOR SIX APPROVED BESS PROJECTS AND MODELING DESCRIPTION FOR SUCH STUDIES

TO THE PUERTO RICO ENERGY BUREAU:

COME NOW LUMA Energy ServCo, LLC and **LUMA Energy, LLC** (collectively "LUMA"), through the undersigned legal counsel, and respectfully submit the following:

I. Procedural Background

1. On December 19, 2022, the Energy Bureau issued a Resolution and Order ("December 19th Order") in which, in pertinent part, it ordered LUMA to file, no later than 10 business days from the notification of such order, a "status update on the updated interconnection studies" of six Battery Energy Storage System ("BESS") projects. *See* December 19th Order at page 5. These six BESS projects ("Six Approved BESS Projects") are part of group of nine BESS projects of the Tranche 1 procurement[1] that had been approved by the Energy Bureau by

[1] Tranche 1 refers to the first of six procurement tranches for renewable energy resources to be conducted by the Puerto Rico Electric Power Authority ("PREPA") required under the Final Resolution and Order on the Puerto Rico Electric Power Authority's Integrated Resource Plan, *In re: Review of the Integrated Resource Plan of the Puerto Rico Electric Power Authority*, Case No. CEPR-AP-2018-0001, of August 24, 2020.

Resolution and Order of June 13, 2022 ("June 13th Resolution"), corresponding to six of these BESS projects for which interconnection studies had not been conducted as of the date of that Resolution. *See* December 19th Order at page 3; *see also*, LUMA's *Informative Motion Relating to Energy Bureau's Approval of Nine Tranche 1 BESS Projects* filed on July 13, 2022 at pages 3-5.

2. In the December 19th Order, the Energy Bureau also ordered LUMA to provide as part of the status update "a simplified description of how [these studies] [model] the output of any battery energy storage resources during midday (l0 AM to 2 PM) periods coinciding with roughly maximal levels of output of utility-scale or distributed scale solar PV resources in Puerto Rico, and an explanation of its reasoning for making such assumptions" (the "Modeling Description"). *Id*. The Energy Bureau also indicated that it "anticipate[d] receiving detailed explanations in the interconnection studies themselves of both the modeling approach, and LUMA's intended operational approach, to maximize the value of flexible battery energy storage resources once installed across the Puerto Rico grid". *Id*.[2]

3. In attention to the December 19th Order, on December 22, 2022, LUMA informed this Energy Bureau that LUMA had completed the interconnection studies for the Six Approved BESS Projects and had submitted the reports of these studies (referred to as "Final Interconnection Study Reports") to PREPA on November 10, 2022. *See* December 22nd Motion at page 5. LUMA also submitted to the Energy Bureau, as an Exhibit 1, copy of these Final Interconnection Study

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[2] As per LUMA's subsequent *Informative Motion Regarding Interconnection Studies for Tranche 1 Approved BESS Projects and Request for Confidential Treatment* of that date ("December 22nd Motion"), LUMA interpreted that the latter information forms part of the Modeling Description. *See* December 22nd Motion at page 5.

Reports, with a request for confidential treatment. *See id*. at pages 5-10 and Exhibit 1. As part of Exhibit 1 to the December 22nd Motion, LUMA also submitted an update of the System Impact & Facility Study originally submitted by LUMA to the Energy Bureau on May 31, 2022[3] to account for the Six Approved BESS Projects, containing updated cost estimates for required transmission system network upgrades for the Tranche 1 resources. *See id*. at pages 3 and 5 and Exhibit 1.

4. LUMA further informed in the December 22nd Motion that LUMA would be conducting the necessary assessments to address the Modeling Description and be submitting this information to this Energy Bureau on or before January 9, 2023, in compliance with the December 19th Order. *See id*. at page 6.

II. Modeling Description Information in Compliance with December 19th Order

5. LUMA hereby submits the information on the Modeling Description relating to the interconnection studies of all approved Tranche 1 projects, including the Six Approved BESS Projects as required in the December 19th Order. *See* Exhibit 1. Exhibit 1 provides a description of the methodology and technical assumptions used for the preparation of the Tranche 1 final interconnections study reports, including, among others, day peak and night peak cases, contingency analysis and MTR compliance analysis; modeling of the output of BESS resources throughout the day, including the 10:00 a.m. to 2:00 pm time period; and a description on the modeling and operational approach for the BESS resources to maximize the value of flexible BESS resources. LUMA respectfully informs that the description on the modeling and operational

[3] This study was submitted by LUMA with its *Motion Submitting Final Technical Interconnection Studies for Eighteen Tranche 1 Projects Required Under Energy Bureau's Resolution and Order of April 27, 2022, and Request for Confidential Treatment* filed on May 31, 2022 ("May 31st Motion") and covered eighteen photovoltaic energy project and three BESS projects of the Tranche 1 procurement. *See* December 19th Motion at pages 1-2; *see* also May 31st Motion at page 3 and Exhibit 1.

approaches to maximize the value of flexible BESS resources described in Exhibit 1 is outside the scope of the Final Interconnection Study Reports for the Six Approved BESS Projects, which reports had been finalized and submitted to PREPA before the December 19th Order requiring such information. In addition, LUMA respectfully submits that this type of information is typically not included in an interconnection study. LUMA has made the separate assessment based on resource adequacy and operational considerations, consistent with industry practice. This information is presented herein in a separate document (in the form of Exhibit 1).

WHEREFORE, LUMA respectfully requests the Energy Bureau to **take notice** of the aforementioned, **accept** Exhibit 1 included in this Motion, and deem LUMA in compliance with the December 19th Order.

RESPECTFULLY SUBMITTED.

In San Juan, Puerto Rico, this 9th day of January2023.

We hereby certify that we filed this motion using the electronic filing system of this Puerto Rico Energy Bureau and that copy of this motion was notified to PREPA counsel mvazquez@diazvaz.law and kbolanos@diazvaz.law.

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Exhibit 1

BESS Interconnection Studies and Modeling

Informative Motion

January 9, 2023

Contents

A summary of the methodology and technical assumptions used in the updated System Impact and Facility Studies (System Impact & Facility Studies or SI&FS) for all 27 Tranche 1 projects approved by the Energy Bureau ("Tranche 1 SIS") is provided below. These approved Tranche 1 projects are comprised of 18 solar photovoltaic projects (Tranche 1 Phase III Solar PV Projects) and 9 Battery Energy Storage System (BESS) projects (the Tranche 1 BESS projects) (the former and the latter, collectively the Tranche 1 Projects). The methodology used in the Tranche 1 SI&FS is consistent with the methodology used for the interconnection studies and SI&FS of the original 21 projects studied and filed with the Energy Bureau on May 31, 2022.

I. SUMMARY OF ASSUMPTIONS

The System Impact Studies (SIS) were presented in a report dated May 25, 2022 (the Original Report) which was submitted to the Energy Bureau on May 31, 2022 and covered the Tranche 1 Phase III Solar PV Projects and three of the nine Tranche 1 BESS Projects. It was thereafter updated as described in this report to include the remaining six BESS Projects (the SIX BESS Projects). In the Tranche 1 System Impact Studies (SIS), LUMA studied day peak and night peak cases, including steady state thermal analysis, contingency analysis, short circuit analysis, short circuit ratio analysis, and MTR compliance analysis. Based on the results of the analysis, transmission system overloads were evaluated, and network upgrades were identified that would resolve the overloads. A summary of the SIS assumptions is provided below:

- *Existing renewable energy projects and shovel-ready solar PV projects that are expected to be operating and in service before Tranche 1 projects are included in the day peak and night peak cases. The existing wind power projects that are in service (or expected to be returned to service, in the case of Punta Lima) are dispatched in the interconnection studies based on historical data. Existing and shovel-ready solar PV projects are at 0 MW in the night peak case.*
- *Day peak cases have all Tranche 1 Phase III Solar PV Projects modeled with 100% MW output and the Tranche 1 BESS projects at 0% MW output (simulating the solar projects at full output with the battery systems fully charged).*
- *Night peak cases have all Tranche 1 Phase III Solar PV Projects modeled with 0 MW output and Tranche 1 BESS projects at 100% MW output (simulating the evening peak in Puerto Rico—after sunset—with the battery systems discharging at full output).*
- *For PV projects, a BESS for minimum technical requirement (MTR) compliance was modeled but is not charging or discharging in the power flow cases.*
- *The PSS/E model of each of the Tranche 1 Phase III Solar PV Projects or Tranche 1 BESS Projects submitted by the proponents was used for the Tranche 1 SIS.*
- *The Tranche 1 Projects are studied together in a cluster study, considering a day peak case and a night peak case. All Tranche 1 Phase III Solar PV Projects are studied at 100% of their output in the day peak case and all Tranche 1 BESS Projects are studied discharging at 100% capacity in the night peak case.*

II. TRANCHE 1 SYSTEM IMPACT STUDY

A. Day Peak Re-Dispatch

The day peak post-project case includes all proposed Tranche 1 Phase III Solar PV Projects at full output and assumes that all Tranche 1 BESS Projects are fully charged (they are modeled as "off" – not charging or discharging – in the day peak post-project case). Since the Tranche 1 BESS Projects were modeled as "off" in the day peak case, the addition of the Six BESS Projects did not alter the day peak re-dispatch from the results given in the Original Report. Currently used minimum generation levels and new study case *minimum generation levels for existing generating units are included in Table 4-4 of the Original Report. As mentioned at the beginning of Section 4.2.5 of this same report, these minimum generation levels were identified by LUMA for interconnection study purposes only.*

B. Night Peak Re-Dispatch

The total capacity of the Six BESS Projects is 270 MW. Power generation units are re-dispatched in the study model at Aguirre 1, Aguirre 2, Palo Seco 3 and Palo Seco 4 in the SIS to accommodate the Six BESS projects. The Tranche 1 BESS Projects were dispatched to meet desired generation at the POI.

III. FACILITY STUDIES

Facility Studies were performed for the Six BESS projects. These are engineering studies to determine the conceptual, expected additions or modifications to the power grid system, including the estimated costs for such additions or modifications required to connect the Tranche 1 Projects to the power grid and deliver the power from these projects under certain scenarios. The Facility Studies consist of two scopes: (1) a point of interconnection (POI) study to identify the major equipment required at the defined demarcation point between the project and the utility/grid system, and (2) a network upgrade study to identify upgrades needed that are triggered by the additional renewable energy generation and/or BESS (that is, the Tranche 1 Projects) from the system impact studies.

The POI facility study cost estimates were developed in general accordance with an AACE (Association for the Advancement of Cost Engineering) Class 3 level. The network upgrade cost estimates were developed in general accordance with an AACE Class 5 level. The network upgrade cost allocations were performed using industry standard methods. As part of each network upgrade facility study, LUMA evaluated whether any planned FEMA-funded projects could be leveraged to provide benefits to the Tranche 1 network upgrade projects.

IV. LUMA APPROACH TO MODELING BESS

Appendix 24 and 25 of the Generation Resource Adequacy Report prepared by LUMA dated August 30, 2022 and presented by LUMA to the Energy Bureau on that same date (found in docket (NEPR-MI-2022-0002) (the 2022 Resource Adequacy Report) provide an overview of how LUMA models BESS and quantifies the impact and benefits of this resource to the bulk power system. While BESS can provide many different benefits to the grid in terms such as frequency and voltage regulation, the primary benefit to the current bulk power system is its role in improving system reliability which we quantify as the contribution to reducing loss of load expectation (LOLE) and loss of load hours (LOLH).

For the 2022 Resource Adequacy Report's analysis, two sensitivity scenarios were performed to investigate the impact to system resource adequacy of having both standalone BESS and BESS paired with solar PV. These sensitivity scenarios were specifically defined as follows:

- *Appendix 24: New standalone BESS resources: Two cases with varying amounts of new BESS resources were performed under this scenario. The first case added 100 MW of 4-hour duration BESS (400 MWh total). The second case doubled this amount to 200 MW of 4-hour duration BESS (800 MWh total). In this sensitivity, the BESS was modeled as being allowed to charge from the grid at any time. The round-trip efficiency of the BESS resources was modeled at 85%.*

- *Appendix 25: New BESS paired with solar PV resources: Two cases with varying amounts of new generating resources were performed under the BESS scenario. The first case added 420*

MW of solar PV paired with 100 MW of 4-hour duration BESS (400 MWh total). The second case doubled these amounts for a total of 845 MW of solar PV paired with 200 MW of 4-hour duration BESS (800 MWh total). In this sensitivity, the BESS was modeled as only being allowed to charge from the solar PV generation. The analyzed new solar PV and BESS sizes were chosen to represent one-half and the full addition of the proposed Tranche 1 projects. The round-trip efficiency of the BESS resources was modeled at 85%.

For both the standalone BESS and solar PV paired BESS scenarios, BESS operation is modeled by considering the following two unique operating modes:

- *Typical dispatch*
- *Emergency dispatch*

Under normal system conditions, the modeled BESS resources operate under typical dispatch mode. Under this mode, the BESS resources either charge in the early morning from the grid (for the standalone BESS scenario) or charge during the day from the solar PV generation (for the solar PV paired BESS scenario). The BESS resources then discharge throughout the evening to help meet peak system load. By injecting their stored energy during the evening peak, the BESS resources help reduce the need for the island's expensive peaking generators to operate during the evening. After discharging throughout the evening, the BESS resources are typically fully depleted by midnight, after which they begin to charge again in the morning.

Whenever the total system load is greater than the total available system capacity, there is the potential for a load shed event. During these time periods, the BESS resources switch to emergency dispatch mode. When operating in this mode, the BESS resources are modeled such that their sole objective is to help stop the potential load shed event. As such, the BESS resources inject any of their available energy into the system during emergency dispatch mode. Depending on how much greater system load is than the total available system capacity, the energy injected from the BESS resources may not be high enough to fully prevent the load shed event from occurring. In these cases, the BESS resources inject what they can to minimize the MW shortfall – the load shed event still occurs, but its severity is diminished due to the BESS resources' energy injection. Note that during emergency dispatch mode, the BESS resources are unable to charge since system load is already higher than the available system capacity. Any charging of the BESS resources during this time would only increase system load, further amplifying the load shed event.

For reference, the loss of load expectation (LOLE) and loss of load hours (LOLH) results from the resource adequacy analysis in the 2022 Resource Adequacy Report are provided in the following table. Included in the table are all the scenarios that were run for the resource adequacy analysis. The standalone and solar paired BESS scenarios are highlighted in yellow.

	Scenario	**Loss of Load Expectation (LOLE), Days / Year**	**Loss of Load Hours (LOLH), Hours / Year**
	Baseline Scenario	**8.81**	**40.77**
	Baseline Scenario Without Costa Sur Unit 5	*28.08*	*155.06*
Bas elin	*675 MW of 'Perfect Capacity'*	*0.1*	*0.36*

Scenario		Loss of Load Expectation (LOLE), Days / Year	Loss of Load Hours (LOLH), Hours / Year
	420 MW of Solar PV	*8.29*	*30.58*
	845 MW of Solar PV	*8.17*	*28.43*
	100 MW Standalone BESS (4 Hour)	*5.79*	*27.71*
	200 MW Standalone BESS (4 Hour)	*3.87*	*19.21*
	420 MW Solar PV + 100 MW Solar-Paired BESS (4 Hour)	*5.01*	*20.22*
	845 MW Solar PV + 200 MW Solar-Paired BESS (4 Hour)	*3.12*	*12.40*
	100 MW Flexible Thermal Resource	*5.15*	*22.56*
	200 MW Flexible Thermal Resource	*3.01*	*12.55*
	25 MW Demand Response (8 Hour)	*7.77*	*35.75*
	50 MW Demand Response (8 Hour)	*6.62*	*30.17*
	0.25% Energy Efficiency (Load Reduction)	*8.56*	*39.77*
	0.50% Energy Efficiency (Load Reduction)	*8.16*	*37.36*
Industry Benchmark Target		**0.1**	**—**

For reference, Appendix 24 and Appendix 25 from the 2022 Resource Adequacy Report, with some revisions/update, are included in the following pages.

A. Appendix 24 Sensitivity Analysis

– *Additional Standalone BESS Results*

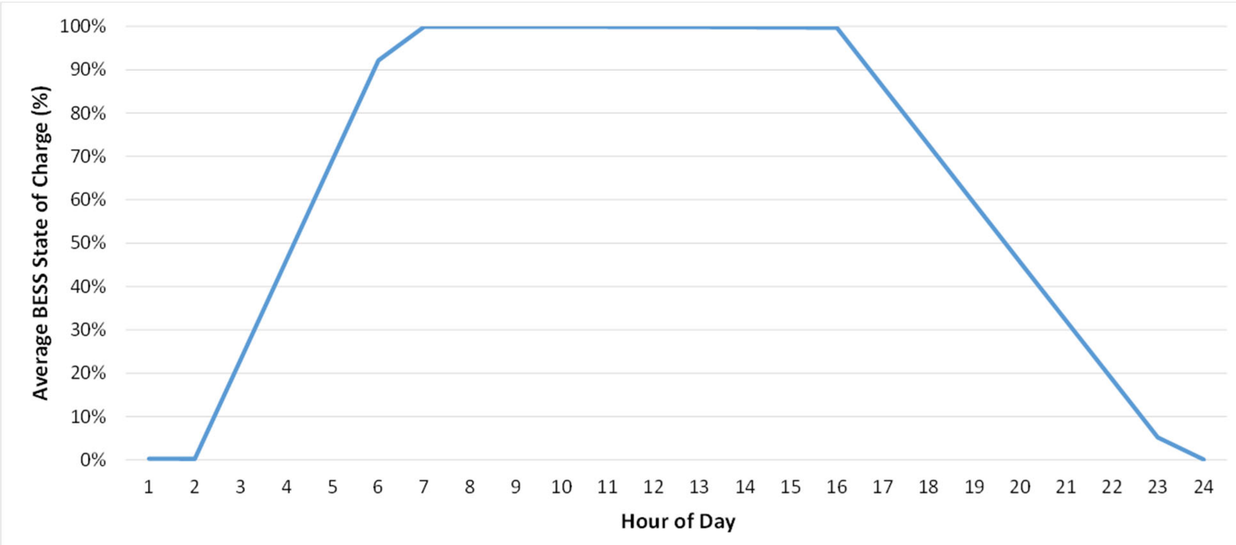
This sensitivity evaluates the impact of adding standalone BESS to the current system. For this sensitivity, no additional solar is added to the current system. Two sensitivity scenarios with varying amounts of standalone BESS were performed. The first scenario adds 100 MW of standalone 4-hour duration BESS (400 MWh total), while the second scenario doubles that amount for a total of 200 MW of standalone 4-hour duration BESS (800 MWh total).

For this scenario, the round-trip efficiency of the BESS is assumed to be 85%. Typical hourly dispatch of the BESS is modeled such that discharge occurs throughout the evening to help meet peak load, with the BESS modeled as being depleted around midnight. Charging of the BESS primarily takes place during the early morning hours, when system load is lowest. Whenever there is an emergency situation, defined as a period where load is greater than available capacity, the model forces BESS resources to inject available energy to meet load demand. If the shortfall in available system capacity is greater than what the BESS is able to inject at that hour, or if the BESS does not have sufficient charge, the BESS resources inject what they are able to in order to minimize the MW shortfall.

In contrast to solar-paired BESS, standalone BESS has the benefit of being able to charge from the grid at any time during the day, capturing surplus energy during times when available capacity is high and energy demand is low (i.e., nighttime in Puerto Rico). Since it can be fully charged earlier in the day than solar-paired BESS, it can be dispatched to help mitigate emergency MW shortfall situations that occur earlier in the day, when a solar-paired BESS might otherwise not yet be fully charged. In contrast, because standalone BESS charges from energy from the generating resources that are operating at that time, if standalone BESS is charging during the early morning, it is primarily charging from thermal generators, not renewable generators. Additionally, if standalone BESS is mostly charged before the sun rises, then it could not be used as a tool to help mitigate potential solar power plant curtailment. We recommend both standalone and solar-paired BESS be considered as potential candidate resources for further analysis in the future IRP process.

The figure below shows the average state of charge by hour of the day for the standalone BESS over all simulations performed. As shown, the BESS is primarily charging overnight between 2 and 7 a.m. On average, BESS are not utilized during most daytime hours (unless an emergency situation occurs during this time) and start discharging at 4 p.m. to help the system during the evening peak.

Figure A56: Standalone BESS Average State of Charge by Hour (100 MW and 200 MW BESS)



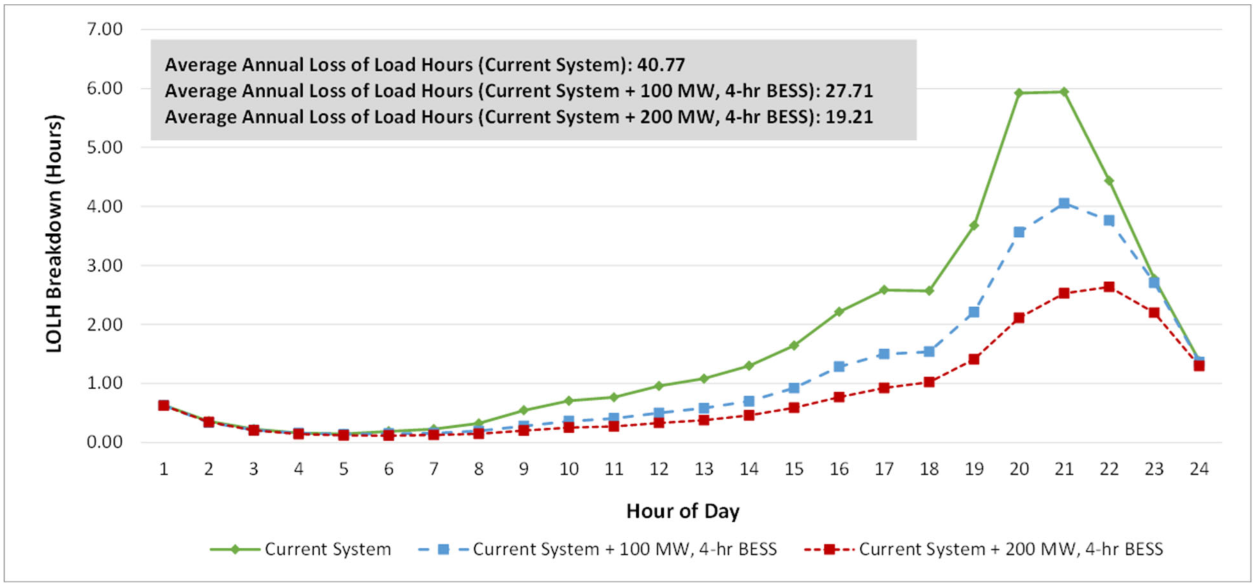
The table below shows the results of these two sensitivity cases along with the current system results for comparison. As compared to the current system, the addition of 100 MW of standalone BESS reduces both LOLE and LOLH by approximately 34%; the addition of 200 MW of standalone BESS reduces both LOLE and LOLH by approximately 56%.

Table A29: Calculated Resource Adequacy Risk Measures – Standalone BESS Addition

Scenario	Loss of Load Expectation (LOLE)	Loss of Load Hours (LOLH)
Current System	*8.81 Days / Year*	*40.77 Hours / Year*
Current System + 100 MW Standalone BESS (4 Hour Duration)	*5.79 Days / Year*	*27.71 Hours / Year*
Current System + 200 MW Standalone BESS (4 Hour Duration)	*3.87 Days / Year*	*19.21 Hours / Year*
Industry Benchmark Target	*0.1 Days / Year*	—

The addition of standalone BESS results in nearly the same improvement to both LOLE and LOLH for a given scenario. This is because standalone BESS can contribute to system capacity nearly all times of the day, with the only limitations being the state of charge and its one cycle per day limit. Given that 55% of the observed LOLH in the current system scenario occurred between 7 p.m. and 11 p.m., standalone BESS has a positive impact on system resource adequacy due to its ability to support the system at night. The figure below shows the average LOLH for all the simulations for the three scenarios. As shown, the standalone BESS help reduce the incidence of LOLH during the day and nighttime hours.

Figure A57: Comparison of Loss of Load Hours by Hour – Standalone BESS Addition



B. Appendix 25 Sensitivity Analysis

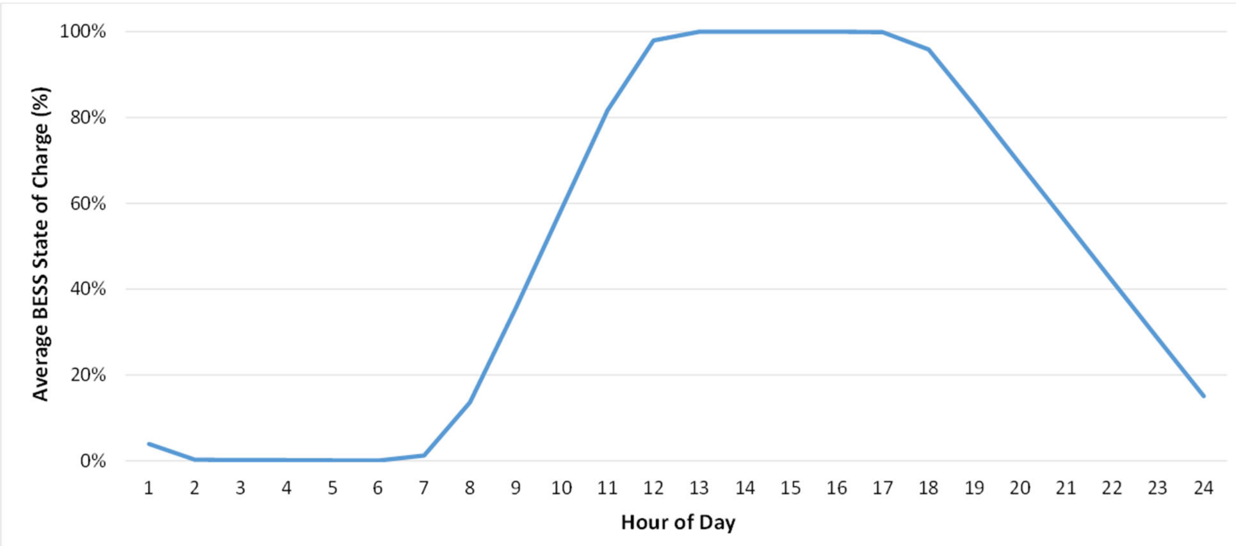
Additional Solar and Paired BESS Results

This sensitivity evaluates the impact of combining both solar PV and BESS. In this sensitivity, the BESS is modeled as paired with the solar PV, meaning that it is only allowed to charge from the solar generation. Two sensitivity scenarios with varying amounts of new generating resources were performed. The first scenario adds 420 MW of solar PV paired with 100 MW of 4-hour duration BESS (400 MWh total). The second scenario doubles these amounts for a total of 845 MW of solar PV paired with 200 MW of 4-hour duration BESS (800 MWh total). Note that these two scenarios represent half and the full addition of new generating resources as planned under PREPA's renewable Tranche 1 projects.[32]

For this scenario, the round-trip efficiency of the BESS is assumed to be 85%. Typical hourly dispatch of the BESS is modeled such that discharge occurs throughout the evening to help meet peak load, with the BESS modeled as being depleted around or shortly after midnight. Charging of the BESS is from the solar power plants; thus, charging only occurs during the day. Whenever there is an emergency situation, defined as a period where load is greater than available capacity, the model forces BESS resources to inject available energy to meet load demand. If the shortfall in available system capacity is greater than what the BESS can inject at that hour, or if the BESS does not have sufficient charge, the BESS resources inject what they are able to in order to minimize the MW shortfall.

In contrast to standalone BESS, solar-paired BESS can only charge from the solar resources. This constraint is largely a result of tax credit requirements that existed prior to the Inflation Reduction Act passed in 2022. Because of this, any generation from these BESS would be considered renewable generation and would contribute towards Puerto Rico's renewable portfolio standards. The figure below shows the average state of charge by hour of the day for the solar-paired BESS. As shown, the BESS begin to charge as the sun rises and are typically fully charged in the model by noon. BESS then start discharging at 6 p.m. after the sun sets to support the electrical system during the evening peak. This differs from the stand-alone storage assets which could be used to reduce LOLH at any hour of the day, even though "on average" they started discharging at 4 pm due to when the model determined they were needed.

Figure A58: Solar-Paired BESS Average State of Charge by Hour (100 MW and 200 MW BESS)



The table below shows the results of the two sensitivity scenarios, along with the current system results for comparison. As compared to the current system, the addition of 420 MW of solar PV paired with 100 MW of BESS reduces LOLE by 43% and LOLH by 50%, while 845 MW of solar PV paired with 200 MW of BESS reduces LOLE by 65% and LOLH by 70%. Similar to what was observed in the solar-only sensitivity scenario (see Appendix 23), the combination of new resources has a greater impact on LOLH versus LOLE because of the contributions of the solar resources (which only generate while the sun is shining). The solar resources support the system during daytime and help to reduce LOLH but are unable to contribute to reducing LOLH at night – this can only be accomplished by the BESS. As a result, there is a higher reduction in LOLH than LOLE.

Table A30: Calculated Resource Adequacy Risk Measures – Solar PV + BESS Addition

Scenario	Loss of Load Expectation (LOLE)	Loss of Load Hours (LOLH)
Current System	*8.81 Days / Year*	*40.77 Hours / Year*
Current System + 420 MW Solar PV + 100 MW Solar-Paired BESS (4 Hour Duration)	*5.01 Days / Year*	*20.22 Hours / Year*
Current System + 845 MW Solar PV + 200 MW Solar-Paired BESS (4 Hour Duration)	*3.12 Days / Year*	*12.40 Hours / Year*
Industry Benchmark Target	*0.1 Days / Year*	—

The figure below shows the average LOLH averaged over the 2,000 simulations performed. As shown, the combination of solar PV and BESS nearly eliminates LOLH during the daytime while the sun is shining and reduces LOLH during the nighttime during BESS injection. Note that there are diminishing returns for doubling the size of the additional generation resources. This is expected given that resource adequacy improvements per MWs added of similar generation types reduce with subsequent additions.

Figure A59: Comparison of Loss of Load Hours by Hour – Solar PV + BESS Addition