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

IN RE: INTERCONNECTION REGULATIONS	**CASE NO. NEPR-MI-2019-0009** **SUBJECT: Motion to Submit Presentation Shown at Technical Conference/Stakeholder Workshop Held on June 18, 2024, with Correction and Revised Technical Bulletin**

MOTION TO SUBMIT PRESENTATION SHOWN AT TECHNICAL CONFERENCE/STAKEHOLDER WORKSHOP HELD ON JUNE 18, 2024, WITH CORRECTION AND REVISED TECHNICAL BULLETIN

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 state and request the following:

1. On June 17, 2024, LUMA filed with this Puerto Rico Energy Bureau of the Public Service Regulatory Board ("Energy Bureau") a motion submitting as *Exhibit 1* thereto a pdf file with the presentation prepared by LUMA to be provided during the Technical Conference/Stakeholder Workshop scheduled by the Energy Bureau for June 18, 2024 in this proceeding (the "June 18th Presentation"). *See Motion to Submit Presentation for Technical Conference/Stakeholder Workshop Scheduled for June 18, 2024,* filed on June 17, 2024. The June 18th Technical Conference/Workshop ("June 18th TC/Workshop") had the purpose of discussing the suitability of the requirement that a supplemental study be required for distributed generators ("DGs") interconnecting to a feeder exceeding 15% of its annual peak load or in the alternative any other less onerous but safe criteria, to require a supplemental study to DG proponents "and the measures proposed by LUMA, in the [Manual of Technical Requirements for Interconnection

submitted by LUMA in this proceeding[1]] and/or the [Technical Bulletin regarding Smart Inverter Settings Sheets published by LUMA on April 1, 2024[2] ("Technical Bulletin")], to reduce or manage the operational challenges of the high penetration of DGs and avoid or postpone having to make improvements in the distribution network". *See* Energy Bureau's Resolution and Order of April 15, 2024, on pages 2-3 (footnotes added; translation ours). It also had the purpose of discussing "how to best implement the grid support functionality of smart inverters and what equipment requirements are needed to orderly provide this capability to the electric grid". *See* Energy Bureau Resolution and Order of June 12, 2024, on page 2.

2. On June 18, 2024, the June 18th TC/Workshop was held. LUMA representatives discussed the June 18th Presentation. During this presentation, LUMA indicated that a sentence on slide number 3 of the June 18th Presentation where it was stated that "around 25 jurisdictions in the United States adopted completely the IEEE 1547-2018 Standard" needed to be corrected to reflect that these jurisdictions had "partially or completely" adopted such standard. LUMA also indicated that the Presentation was supposed to include a link to the Technical Bulletin, with some redlined revisions made by LUMA in attention to stakeholder comments, but this link did not work in the version of the June 18th Presentation submitted. LUMA requested it be allowed to present this revised Technical Bulletin after the June 18th TC/Workshop, which request was granted. LUMA also requested leave to submit the Presentation with the correction in slide 3 and the revised Technical Bulletin that was supposed to be included in a link, which the Energy Bureau commissioners present granted.

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[1] This refers to a manual proposed by LUMA in this proceeding, the most recent version of which was submitted on May 19, 2022. See LUMA's *Motion Submitting Complete Version of Technical Interconnection Requirements Document* filed on that date.
[2] *See* LUMA's *Response to Urgent Request Filed by SESA on April 4, 2024* filed on April 22, 2024.

3. LUMA submits herein the corrected version of June 18th Presentation. *See Exhibit 1*. This presentation corrects the statement in slide number 3 regarding the number of jurisdictions that adopted the IEEE 1547-2018 Standard to indicate as follows: "Currently, though the specifics of adoption vary across states, around 25 states or regions in the in the US and Canada adopted the IEEE 1547-2018 Standard". In addition, instead of including an activated link to the revised Technical Bulletin in slide 6, for ease of access and review, LUMA submits herein separately the revised Technical Bulletin that was shown and discussed during the June 18th TC/Workshop as part of the June 18th Presentation. *See Exhibit 2*.

4. LUMA also herein informs that, following the June 18th TC/Workshop, LUMA made an additional revision to the Technical Bulletin to address comments received during the June 18th TC/Workshop and wishes to submit herein this revised version. *See Exhibit 3*. This revised version in Exhibit 3 includes a change to clarify that, in the case of the expansion of distributed energy resources ("DER") facility, only the additional DER installed on or after July 1, 2024, must meet the Technical Bulletin's default setting requirements. LUMA looks forward to discussing the Technical Bulletin with SESA and resolving any pending questions so that it can be expeditiously implemented in order to improve system stability and operations under the current high DG penetration.

WHEREFORE, LUMA respectfully requests this Honorable Energy Bureau to **take notice** of the above; **accept** LUMA's corrected Presentation given during the June 18th TC/Workshop and the revised Technical Bulletin shown during such Presentation in *Exhibits 1* and *2* hereto, respectively; and accept the revised version of the Technical Bulletin prepared by LUMA in attention to comments received during such TC/Workshop, included in *Exhibit 3* hereto.

RESPECTFULLY SUBMITTED.

In San Juan, Puerto Rico, this 21st day of June 2024.

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 hrivera@jrsp.pr.gov; arivera@gmlex.net; mvalle@gmlex.net; agustin.irizarry@upr.edu; javrua@sesapr.org; contratistas@jrsp.pr.gov; aconer.pr@gmail.com; john.jordan@nationalpfg.com; cfl@mcvpr.com; and mqs@mcvpr.com.

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Exhibit 1

LUMA’s Corrected Presentation for June 18th Technical Conference/Stakeholder Workshop

Interconnection Regulations

NEPR-MI-2019-0009

JUNE 18, 2024

Introduction

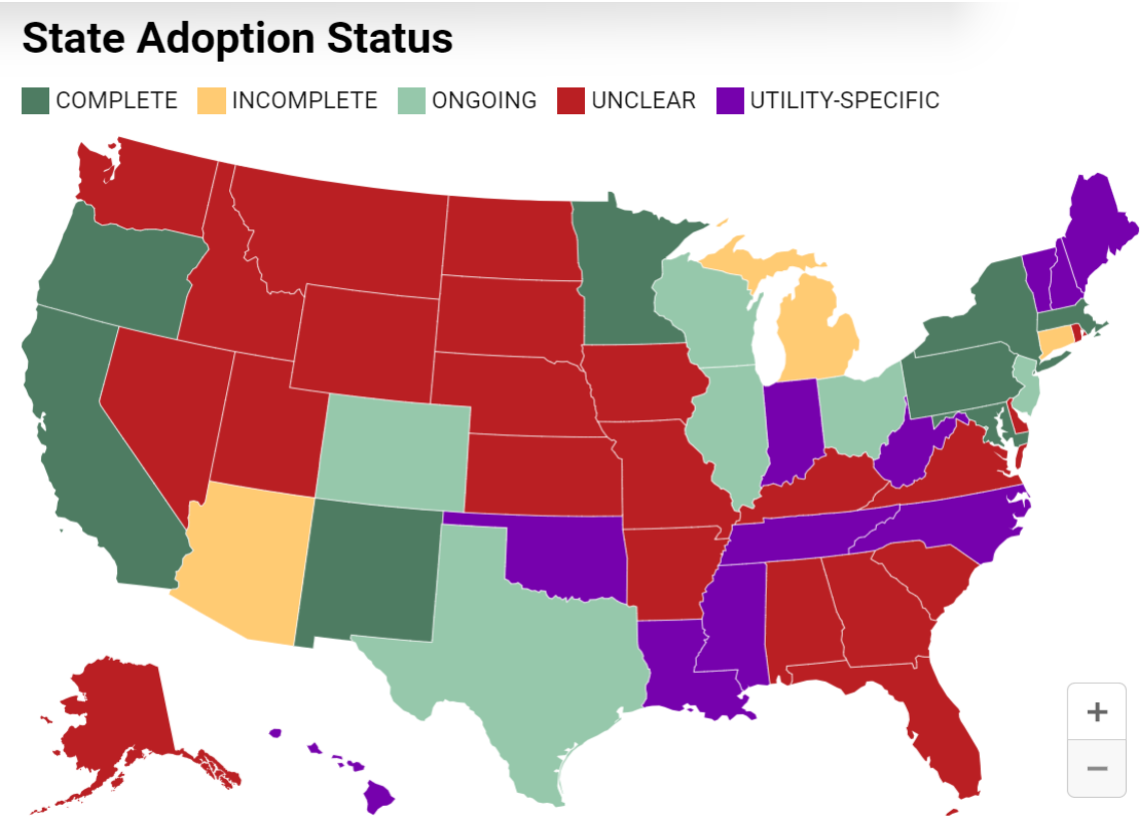
- LUMA is dedicated to accelerating Puerto Rico's transition to clean energy and actively promotes the integration and expanded use of renewable energy across the island. LUMA has made significant strides in advancing renewables, having interconnected more than 91,000 Distributed Generation (DG) systems with 585 MW generating capacity by March 2023.
- The distributed generation customer is responsible for ensuring that the Distributed Generation complies with the electrical signal quality requirements specified in IEEE 1547 and other applicable standards, as set forth in Regulation 8915, Section VI, Article C. Other provisions of Regulation 8915 refer to IEE 1547 standard in effect as applicable to the DG customer. (See Section IV, Article B and notes in Tables 3 and 4). In sum, Regulation 8915 provides for the application of the IEEE 1547 Standard, as that standard may be updated over time, to DG customers.
- LUMA issued Technical Bulletin 2024-001, effective July 1, 2024, to provide supporting technical information to Regulation 8915 by applying the IEEE 1547-2018 standard for smart distributed energy resources as provided in Regulation 8915.
- The main purpose of the Technical Bulletin is improving system stability and operations under high DER penetration.

Background

IEEE 1547™-2018 Standard's contribution is significant. It establishes crucial guidelines for distributed energy resources (DERs) interconnection to the grid. It defines particularly smart inverter settings to help the grid accommodate higher levels of distributed generation.

This standard plays a vital role in enhancing grid reliability and supporting integration of renewable energy resources.

Currently, though the specifics of adoption vary across states, around 25 states or regions in the US and Canada adopted the IEEE 1547-2018 Standard. The widespread adoption of these standards among inverters installed by Net Energy Metering customers underscores their importance in modern grid infrastructure.



Reference: IREC's IEEE 1547™-2018 Adoption Tracker

Required Smart Inverter Functions

Per the Technical Bulletin Smart Inverters must be:

(a) set to conform to the default setting requirements and,

(b) capable of performing the default functions, both provided in the technical bulletin, Smart Inverter Settings Sheets, as applicable.

- Customers must comply with the requirements set forth in the Smart Inverter Settings Sheets or, any alternative Smart Invert settings and functions that may be defined in the interconnection agreement.
- Any alternative settings and functions defined in the interconnection agreement will take precedent and override the default settings requirements and functions provided in the technical bulletin.
- Notwithstanding the preceding provisions of this Smart Inverter Settings Sheets, customer's Smart Inverter(s) shall conform with the requirements and functions required pursuant to the interconnection agreement.

Impact of Smart Inverter Grid Support

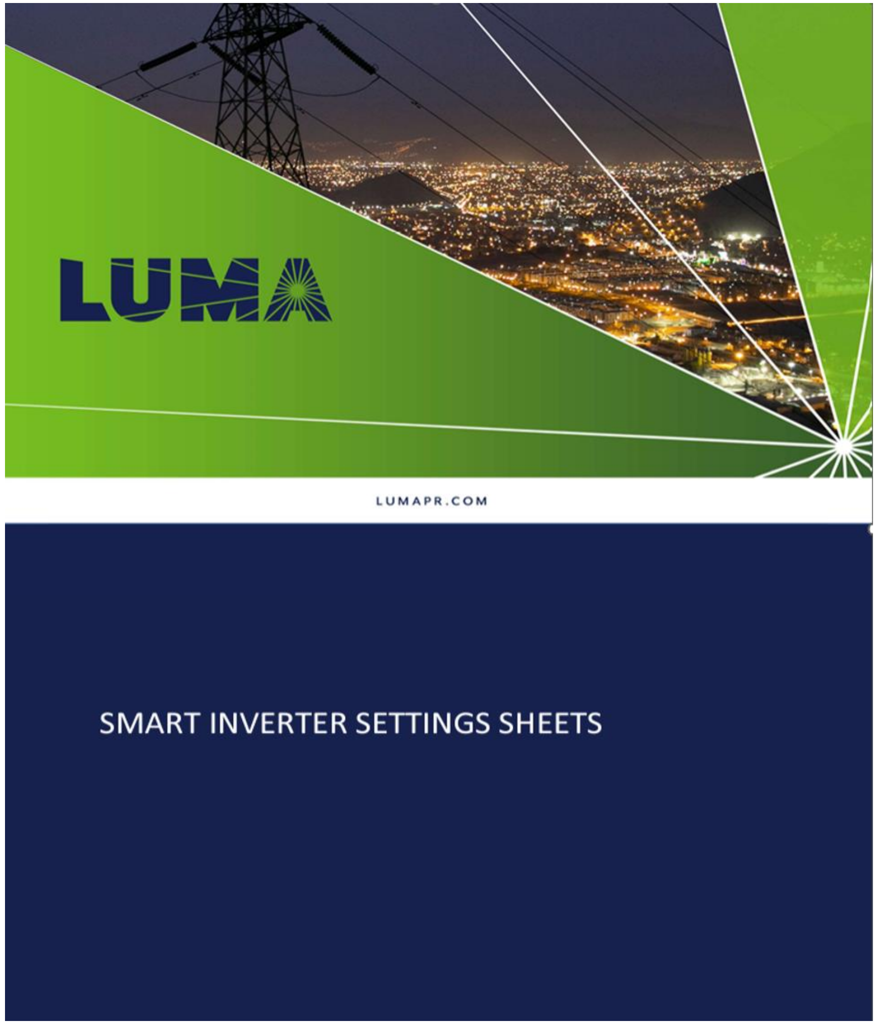
Regulation 8915*- Section VI, Article B: Requires certified inverter equipment to comply with IEEE 1547 and UL1741.

IEEE 1547 -2018 requires, among other things:

- **Voltage Regulation**:
  - Ability to support voltage stability by absorbing or injecting reactive power.
  - Reduces voltage fluctuations and improves overall grid reliability.
- **Frequency Regulation:**
  - Contributes to frequency stability by adjusting power output in response to frequency deviations.
  - Helps maintain the balance between supply and demand.
- **Ride-Through Capabilities:**
  - Enables inverters to remain connected and operational during short-term voltage and frequency disturbances.
  - Enhances grid resilience and reduces the risk of widespread outages.
- **Communication and Control:**
  - Supports remote monitoring and control, allowing utilities to optimize grid performance.
  - Facilitates integration with advanced grid management systems.

*See *"Reglamento para Interconectar Generadores con el Sistema de Distribución Eléctrica de la Autoridad de Energía Eléctrica y Participar en los Programas de Medición Neta"*: 8915.pdf (gobierno.pr)

Technical Bulletin IEEE 1547-2018



Reasonableness of the 15% threshold

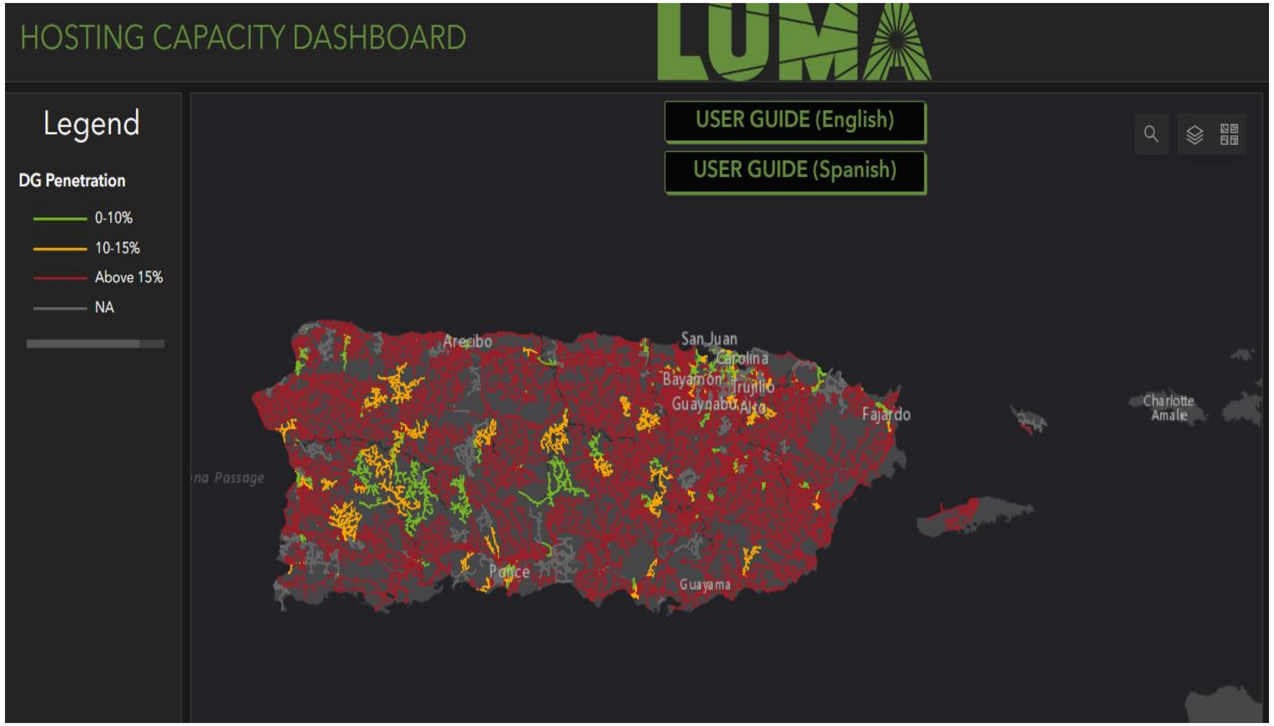
Regulation 8915- Section IV, Article D, 3(g):

The aggregate capacity of all DERs, interconnected in the same feeder, including the proposed one, may not exceed 15% of the annual peak demand of the feeder. This demand will be determined at the output of the feeder at the substation and will correspond to the maximum demand recorded at the feeder during the twelve months prior to the date on which the evaluation request is received.

- If the feeder DER penetration is above the 15%, the DER application requires a supplemental study:
  - Voltage Regulation
  - Thermal violations (conductor ampacity)
  - Short Circuit Ratio
  - Reverse power flow

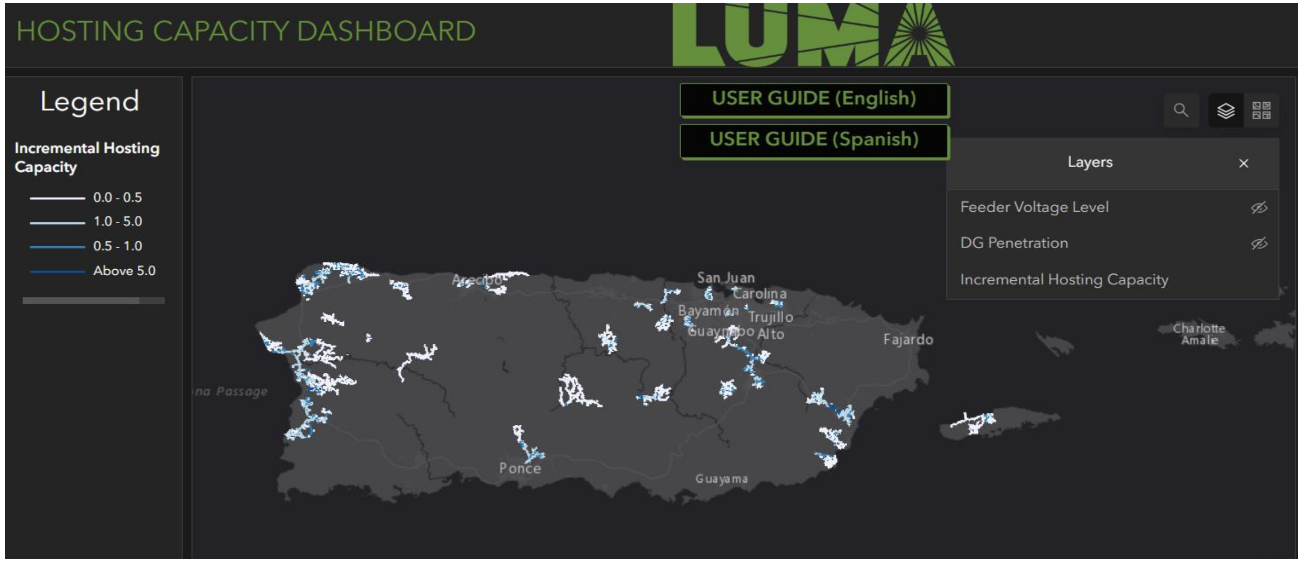
Reasonableness of the 15% threshold (Cont.)

- Currently, about 51% of feeders are over the 15% threshold.
- Considerations to increasing the 15% threshold:
    - Results of cluster studies show that it is possible to increase the threshold to 30% without overlooking network violations.
    - A 30% threshold will allow the detection of system violations in a timely manner, before they become significant system issues.
    - As penetration levels increase, these levels need to be revised based on operational conditions and reliability considerations.



Functionality of Hosting Capacity

- Hosting capacity is the amount of DERs that can be added to the distribution system before control changes or system upgrades are required to safely and reliably integrate additional DERs.
- From the perspective of a DER developer (customer), hosting capacity is useful because it:
  - **Assessment**: Helps determine the maximum amount of DER that can be integrated without requiring grid upgrades.
  - **Cost Efficiency**: Identifies cost-effective locations for DER deployment by highlighting areas with higher hosting capacity.
  - **Project Planning**: Aids in strategic planning and decision-making by understanding grid limitations and potential impacts.
- Hosting capacity is not a hard limit on the amount of DERs, nor is it a detailed evaluation of a specific DER.
- LUMA offers **Incremental Hosting Capacity** information on field verified feeders.



Thank You!

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Exhibit 2

Revised Technical Bulletin Shown During June 18th TC/Workshop

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SMART INVERTER SETTINGS SHEETS

January 3, 2024

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~~VERSION HISTORY:~~

~~Version~~	~~Date~~	~~Description~~
~~1~~	~~06/20/2022~~	~~Initial Draft~~
~~2~~	~~10/25/2022~~	~~Revised based on LUMA comments~~
~~3~~	~~01/03/2024~~	~~Final document~~

LUMA Energy publishes the Technical Bulletin 2024-001 to provide supporting technical information to the current regulation, *Regulation for the Interconnection of Generators with the Distribution System of the Puerto Rico Electric Power Authority and to Participate in Net Metering Programs*, Regulation No. 8915, February 6, 2017. This bulletin seeks to apply the IEEE 1547-2018 standard for smart distributed energy resources (DERs) settings. Regulation 8915 in its Article of Control and Protection, #2 indicates that "In addition to the requirements contained in this Section, the customer's DG must comply with applicable standards, including, but not limited to, IEEE 1547, IEEE 519 and IEEE/ANSI C37.90 (Standard for Relays and Relay Systems Associated with Electric Power Apparatus)".

The main purpose of adopting the requirements in this bulletin is to improve the system stability and operations under high penetration of DERs. Starting **July~~April~~ 1, 2024**, all DER applications must meet the default setting requirements that are specified in this bulletin.

Table of Contents

List of Tables

List of Figures

1. Required Smart Inverter Functions

Smart Inverters must be (a) set to conform to the default setting requirements and (b) capable of performing the default functions, both provided in this document, "Smart Inverter Settings Sheets", as applicable.

Customers must comply with the requirements set forth in this "Smart Inverter Settings Sheets" or, any alternative Smart Invert settings and functions that may be defined in the interconnection agreement. Any alternative settings and functions defined in the interconnection agreement will take precedent and override the default settings requirements and functions provided in this document. Notwithstanding the preceding provisions of this "Smart Inverter Settings Sheets", customer's Smart Inverter(s) shall conform with the requirements and functions required pursuant to interconnection agreement.

1.1. Communication Requirements

Table 1-1~~Table 1-1~~ lists minimum communication requirements for Smart Inverters connected to the distribution system.

Table 1-1- Minimum Requirements for Communication and Interface

Protocol	Transport	Physical Interface/Layer
IEEE 1815 (DNP3)/ SunSpec Modbus/ IEEE 2030.5 (Sep 2.0)	TCP/IP	Ethernet/ RS 485

1.2. Control Modes

Table 1-1~~Table 1-1~~ lists control modes that must be supported by Smart Inverters as well as default status of each control mode.

Table 1-2- Smart Inverter Control Modes

Applicable to Retail Customers Interconnected

Mode of Operation	Required/Optional	Description	Default Activation Status
Anti-Islanding	Required	Refers to the ability to detect loss of utility source and cease to energize	Activated
Adjustable constant power factor	Required	Refers to Power Factor set to a fixed value.	Deactivated
Adjustable Constant Reactive Power	Required ~~(If available)~~	Refers to Reactive Power set to a fixed value	~~If capable,~~ ~~d~~Deactivated
Voltage Ride through	Required	Refers to ability of Smart Inverter to ride through a certain range of voltages before tripping off	Activated
Frequency Ride through	Required	Refers to ability of Smart Inverter to ride through a certain range of frequencies before tripping off	Activated
Voltage – Reactive (Volt/Var)	Required	Refers to control of reactive power output as a function of voltage	Activated
Voltage – Active Power (Volt/Watt)	Required ~~(If available)~~	Refers to control of real power output as a function of voltage	Activated
Frequency - Watt	Required ~~(If available)~~	Refers to control of real power as a function of frequency	~~If capable,~~ ~~d~~Ae~~a~~ctivated
Normal Ramp-up Rates	~~Required~~ Optional	~~Refers to ability to have an adjustable entry service ramp rate when a DER restores output of active power or changes output levels over the normal course of operation.~~ Refers to ability to transition between energy output levels over the normal course of operation	Activated, if available
Connect/Reconnect Ramp-up rate	Required	Refers to ability to have an adjustable entry service ramp rate when a DER restores output of active power	

2. Smart Inverter Function Settings

This section lists the required settings for smart inverter functions.

2.1. Anti-Islanding Settings

Smart Inverters shall detect the unintentional island and trip as specified in Table 2-1.

Table 2-1- Responses to Islanding and Open Phase Conditions - ACTIVATED

Applicable to Retail Customers Interconnected	
Condition	Maximum Trip Time (s)
Islanding/Open Phase	2

2.2. Voltage Settings

2.2.1. Voltage Trip Settings

Smart Inverters shall meet the abnormal voltage response requirements, as specified in Table 2-2.

Table 2-2- Smart Inverter Response to Abnormal Voltage

Voltage Trip Settings	Default Voltage (pu)	Adjustable Range for Voltage (pu)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Voltage 2 (OV2)	V ≥ 1.2	0.16	Fixed at 1.2	Fixed at 0.16
Over Voltage 1 (OV1)	V ≥ 1.1	1.1 - 1.2	13	1 - 13
Under Voltage 1 (UV1)	V ≤ 0.88	0 - 0.88	21	11 - 50
Under Voltage 2 (UV2)	V ≤ 0.5	0 - 0.5	2	2 - 21

2.2.2. Voltage Ride-Through Settings

Smart Inverters shall meet the Low/High Voltage Ride-Through requirements, as specified in Table 2-3.

Table 2-3- Low/High Voltage Ride-Through Minimum Requirement – ACTIVATED

Voltage Range~~ide-Through Settings~~	Voltage Range (pu)	~~Smart Inverter Response (~~Operating Mode~~)~~/Response	Maximum Ride Through ~~Response~~ Time (s) (design criteria)	Minimum Ride Through Time (s) (Design Criteria)
High Voltage 2 (HV2)	V ≥ 1.2	Cease to Energize	0.16	N/A
High Voltage 1 (HV1)	1.1 ≤ V ≤ 1.2	Momentary Cessation	0.083	12
Near Normal Voltage (NNV)	0.88 ≤ V ≤ 1.1	Continuous Operation	N/A	Infinite
Low Voltage 1 (LV1)	0.7 ≤ V ≤ 0.88	Mandatory Operation	N/A	20
Low Voltage 2 (LV2)	0.5 ≤ V ≤ 0.7	Mandatory Operation	N/A	10
Low Voltage 3 (LV3)	V ≤ 0.5	Momentary Cessation	0.083	1

2.3. Frequency Settings

2.3.1. Frequency Trip Settings

Smart Inverters shall meet the abnormal frequency response requirements, as specified in Table 2-4.

Table 2-4- Smart Inverter Response to Abnormal Frequency

Frequency Trip Settings	Default Frequency (Hz)	Adjustable Range for OF1 (Hz)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Frequency 2 (OF2)	f ≥ 62	61.8 - 66	0.16	0.16 - 1000
Over Frequency 1 (OF1)	f ≥ 61.2	61.2 - 66	300	21 - 1000
Under Frequency 1 (UF1)	f ≤ 58.5	50 - 58.8	300	21 - 1000
Under Frequency 2 (UF2)	f ≤ 57	50 - 57	0.16	0.16 - 1000

2.3.2. Frequency Ride-Through Settings

Smart Inverters shall meet the Low/High Frequency Ride-Through requirements, as specified in Table 2-5.

Table 2-5- Low/High Frequency Ride-Through Minimum Requirement – ACTIVATED

Frequency Ride-Through Settings	High Frequency Range (Hz)	High Smart Inverter Response (Operating Mode)	Minimum Ride Through Time (s)
High Frequency 2 (HF2)	f ≥ 62	N/A	N/A
High Frequency 1 (HF1)	61.2 ≤ f ≤ 62	Mandatory Operation	299
Near Normal Frequency (NNF)	58.8 ≤ f ≤ 61.2	Continuous Operation	Infinite
Low Frequency 1 (LF1)	57 ≤ f ≤ 58.8	Mandatory Operation	299
Low Frequency 2 (LF2)	f ≤ 57	N/A	N/A

2.4. Voltage-Reactive Power Control Mode Settings

An example Volt-Var characteristic is shown in Figure 2-1~~Figure 2-1~~. The voltage-reactive power characteristic shall be configured in accordance with the default parameter values specified in Table 2-6~~Table 2-6~~.

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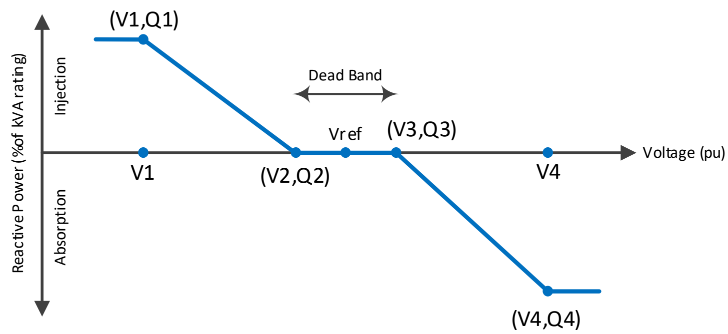

Figure 2-1. Example Volt-Var characteristic

Table 2-6- Volt-Var Settings – ACTIVATED

Volt-Var Parameters	Definitions	Default Values (% of nominal rating)	Allowable Range	
			Minimum	Maximum
Vref	Dead band center	VN	95% VN	105% VN
V2	Dead band lower voltage limit	98% VN	Vref – 3%VN	Vref
Q2	Reactive power injection or absorption at voltage V2	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V3	Dead band upper voltage limit	102% VN	Vref	Vref + 3%VN
Q3	Reactive power injection or absorption at voltage V3	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V1	Voltage at which DER shall inject Q1 reactive power	92% VN	Vref – 18%VN	V2 – 2%VN
Q1(1)	Reactive power injection at voltage V1	44%	0	maximum reactive power capability, injection
V4	Voltage at which DER shall absorb Q4 reactive power	108% VN	V3 + 2%VN	Vref + 18%VN
Q4(1)	Reactive power absorption at voltage V4	44%	maximum reactive power capability, absorption	0
Open loop response time	Time to 90% of the reactive power change in response to the change in voltage	5 sec	1 sec	90 sec

(1) This requires that the Smart Inverter operates with a reactive power priority and generate/absorb reactive power to the ranges specified in this table irrespective of active power production.

2.5. Voltage-Active Power Control Mode Settings

Two examples of these characteristics are shown in Figure 2-2~~Figure 2-2~~. The characteristic shall be configured in accordance with the default parameter values specified in Table 2-7.

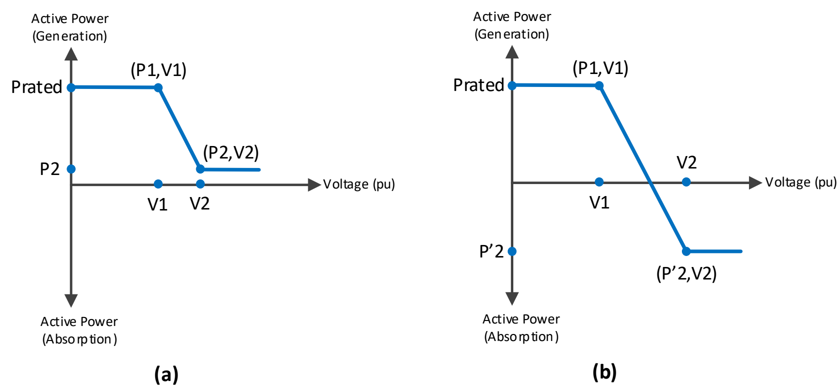

Figure 2-2. Example Volt-Watt characteristics

Table 2-7- Volt-Watt Settings – ACTIVATED

Voltage-active power parameters	Default Settings	Ranges of allowable settings	
		Minimum	Maximum
V1	106% VN	105% VN	109% VN
P1	P_{RATED}	NA	NA
V2	110% VN	V1 + 1% VN	110% VN
P2 (applicable to DER that can only generate active power)	The lesser of 0.2 P_{RATED} or P_{MIN}[(1)]	P_{MIN}	P_{RATED}
P'2 (applicable to DER that can generate and absorb active power)	0	0	P'_{RATED}[(2)]
Open-loop response time	10 sec	0.5 sec	60 sec

[(1)] P_{MIN} is the minimum active power output in p.u. of the DER rating (i.e., 1.0 p.u.).
[(2)] P'_{RATED} is the maximum amount of active power that can be absorbed by the DER.

2.6. Ramp Rate Settings

The following is the ramp-rate requirement during normal and reconnection operation of Smart Inverters:

- Normal ramp-up rate (Optional): For transitions between energy output levels over the normal course of operation, the default value is 100% of maximum current output per second with a range of adjustment between 1% to 100%.
- Connect/Reconnect Ramp-up rate: Upon starting power into the grid, following a period of inactivity or a disconnection, the inverter shall wait for 300 seconds before reconnecting and shall be able to control its rate of increase of power from 1 to 100% maximum current per second. The default value is 2% of maximum current output per second. The maximum active power step during restoring output is 20%

Exhibit 3

Revised Technical Bulletin (Post- June 18th TC/Workshop)

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SMART INVERTER SETTINGS SHEETS

January 3, 2024

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~~**VERSION HISTORY:**~~

~~Version~~	~~Date~~	~~Description~~
~~1~~	~~06/20/2022~~	~~Initial Draft~~
~~2~~	~~10/25/2022~~	~~Revised based on LUMA comments~~
~~3~~	~~01/03/2024~~	~~Final document~~

LUMA Energy publishes the Technical Bulletin 2024-001 to provide supporting technical information to the current regulation, *Regulation for the Interconnection of Generators with the Distribution System of the Puerto Rico Electric Power Authority and to Participate in Net Metering Programs*, Regulation No. 8915, February 6, 2017. This bulletin seeks to apply the IEEE 1547-2018 standard for smart distributed energy resources (DERs) settings. Regulation 8915 in its Article of Control and Protection, #2 indicates that "In addition to the requirements contained in this Section, the customer's DG must comply with applicable standards, including, but not limited to, IEEE 1547, IEEE 519 and IEEE/ANSI C37.90 (Standard for Relays and Relay Systems Associated with Electric Power Apparatus)".

The main purpose of adopting the requirements in this bulletin is to improve the system stability and operations under high penetration of DERs. ~~Starting~~ ~~**April 1, 2024**~~~~, all~~ All DER applications that are submitted on or after July 1, 2024 must meet the default setting requirements that are specified in this bulletin. For the DER facility expansions, only the additional DER must meet the requirements in the bulletin.

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1.1. Communication Requirements

Table 1-1~~Table 1-1~~ lists minimum communication requirements for Smart Inverters connected to the distribution system.

Table 1-1- Minimum Requirements for Communication and Interface

Protocol	Transport	Physical Interface/Layer
IEEE 1815 (DNP3)/ SunSpec Modbus/ IEEE 2030.5 (Sep 2.0)	TCP/IP	Ethernet/ RS 485

1.2. Control Modes

Table 1-1~~Table 1-1~~ lists control modes that must be supported by Smart Inverters as well as default status of each control mode.

Table 1-2- Smart Inverter Control Modes

Applicable to Retail Customers Interconnected

Mode of Operation	Required/Optional	Description	Default Activation Status
Anti-Islanding	Required	Refers to the ability to detect loss of utility source and cease to energize	Activated
Adjustable constant power factor	Required	Refers to Power Factor set to a fixed value.	Deactivated
Adjustable Constant Reactive Power	Required ~~(If available)~~	Refers to Reactive Power set to a fixed value	~~If capable,~~ ~~d~~Deactivated
Voltage Ride through	Required	Refers to ability of Smart Inverter to ride through a certain range of voltages before tripping off	Activated
Frequency Ride through	Required	Refers to ability of Smart Inverter to ride through a certain range of frequencies before tripping off	Activated
Voltage – Reactive (Volt/Var)	Required	Refers to control of reactive power output as a function of voltage	Activated
Voltage – Active Power (Volt/Watt)	Required ~~(If available)~~	Refers to control of real power output as a function of voltage	Activated
Frequency - Watt	Required ~~(If available)~~	Refers to control of real power as a function of frequency	~~If capable,~~ ~~d~~A~~ea~~ctivated
Normal Ramp-up Rates	~~Required~~ Optional	~~Refers to ability to have an adjustable entry service ramp rate when a DER restores output of active power or changes output levels over the normal course of operation.~~ Refers to ability to transition between energy output levels over the normal course of operation	Activated, if available
Connect/Reconnect Ramp-up rate	Required	Refers to ability to have an adjustable entry service ramp rate when a DER restores output of active power	

2. Smart Inverter Function Settings

This section lists the required settings for smart inverter functions.

2.1. Anti-Islanding Settings

Smart Inverters shall detect the unintentional island and trip as specified in Table 2-1.

Table 2-1- Responses to Islanding and Open Phase Conditions - ACTIVATED

Applicable to Retail Customers Interconnected	
Condition	**Maximum Trip Time (s)**
Islanding/Open Phase	2

2.2. Voltage Settings

2.2.1. Voltage Trip Settings

Smart Inverters shall meet the abnormal voltage response requirements, as specified in Table 2-2.

Table 2-2- Smart Inverter Response to Abnormal Voltage

Voltage Trip Settings	Default Voltage (pu)	Adjustable Range for Voltage (pu)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Voltage 2 (OV2)	V ≥ 1.2	0.16	Fixed at 1.2	Fixed at 0.16
Over Voltage 1 (OV1)	V ≥ 1.1	1.1 - 1.2	13	1 - 13
Under Voltage 1 (UV1)	V ≤ 0.88	0 - 0.88	21	11 - 50
Under Voltage 2 (UV2)	V ≤ 0.5	0 - 0.5	2	2 - 21

2.2.2. Voltage Ride-Through Settings

Smart Inverters shall meet the Low/High Voltage Ride-Through requirements, as specified in Table 2-3.

Table 2-3- Low/High Voltage Ride-Through Minimum Requirement – ACTIVATED

Voltage Range~~ide-Through Settings~~	Voltage Range (pu)	~~Smart Inverter Response (~~Operating Mode~~)~~/Response	Maximum Ride Through ~~Response~~ Time (s) (design criteria)	Minimum Ride Through Time (s) (Design Criteria)
High Voltage 2 (HV2)	V ≥ 1.2	Cease to Energize	0.16	N/A
High Voltage 1 (HV1)	1.1 ≤ V ≤ 1.2	Momentary Cessation	0.083	12
Near Normal Voltage (NNV)	0.88 ≤ V ≤ 1.1	Continuous Operation	N/A	Infinite
Low Voltage 1 (LV1)	0.7 ≤ V ≤ 0.88	Mandatory Operation	N/A	20
Low Voltage 2 (LV2)	0.5 ≤ V ≤ 0.7	Mandatory Operation	N/A	10
Low Voltage 3 (LV3)	V ≤ 0.5	Momentary Cessation	0.083	1

2.3. Frequency Settings

2.3.1. Frequency Trip Settings

Smart Inverters shall meet the abnormal frequency response requirements, as specified in Table 2-4.

Table 2-4- Smart Inverter Response to Abnormal Frequency

Frequency Trip Settings	Default Frequency (Hz)	Adjustable Range for OF1 (Hz)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Frequency 2 (OF2)	f ≥ 62	61.8 - 66	0.16	0.16 - 1000
Over Frequency 1 (OF1)	f ≥ 61.2	61.2 - 66	300	21 - 1000
Under Frequency 1 (UF1)	f ≤ 58.5	50 - 58.8	300	21 - 1000
Under Frequency 2 (UF2)	f ≤ 57	50 - 57	0.16	0.16 - 1000

2.3.2. Frequency Ride-Through Settings

Smart Inverters shall meet the Low/High Frequency Ride-Through requirements, as specified in Table 2-5.

Table 2-5- Low/High Frequency Ride-Through Minimum Requirement – ACTIVATED

Frequency Ride-Through Settings	High Frequency Range (Hz)	High Smart Inverter Response (Operating Mode)	Minimum Ride Through Time (s)
High Frequency 2 (HF2)	f ≥ 62	N/A	N/A
High Frequency 1 (HF1)	61.2 ≤ f ≤ 62	Mandatory Operation	299
Near Normal Frequency (NNF)	58.8 ≤ f ≤ 61.2	Continuous Operation	Infinite
Low Frequency 1 (LF1)	57 ≤ f ≤ 58.8	Mandatory Operation	299
Low Frequency 2 (LF2)	f ≤ 57	N/A	N/A

2.4. Voltage-Reactive Power Control Mode Settings

An example Volt-Var characteristic is shown in Figure 2-1~~Figure 2-1~~. The voltage-reactive power characteristic shall be configured in accordance with the default parameter values specified in Table 2-6~~Table 2-6~~.

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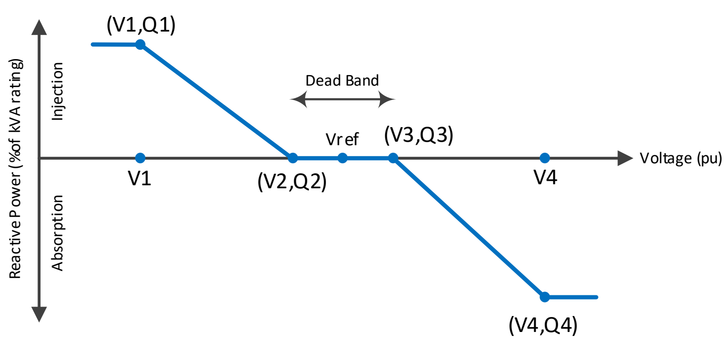

Figure 2-1. Example Volt-Var characteristic

Table 2-6- Volt-Var Settings – ACTIVATED

Volt-Var Parameters	Definitions	Default Values (% of nominal rating)	Allowable Range	
			Minimum	Maximum
Vref	Dead band center	VN	95% VN	105% VN
V2	Dead band lower voltage limit	98% VN	Vref – 3%VN	Vref
Q2	Reactive power injection or absorption at voltage V2	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V3	Dead band upper voltage limit	102% VN	Vref	Vref + 3%VN
Q3	Reactive power injection or absorption at voltage V3	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V1	Voltage at which DER shall inject Q1 reactive power	92% VN	Vref – 18%VN	V2 – 2%VN
Q1(1)	Reactive power injection at voltage V1	44%	0	maximum reactive power capability, injection
V4	Voltage at which DER shall absorb Q4 reactive power	108% VN	V3 + 2%VN	Vref + 18%VN
Q4(1)	Reactive power absorption at voltage V4	44%	maximum reactive power capability, absorption	0
Open loop response time	Time to 90% of the reactive power change in response to the change in voltage	5 sec	1 sec	90 sec

(1) This requires that the Smart Inverter operates with a reactive power priority and generate/absorb reactive power to the ranges specified in this table irrespective of active power production.

2.5. Voltage-Active Power Control Mode Settings

Two examples of these characteristics are shown in Figure 2-2~~Figure 2-2~~. The characteristic shall be configured in accordance with the default parameter values specified in Table 2-7.

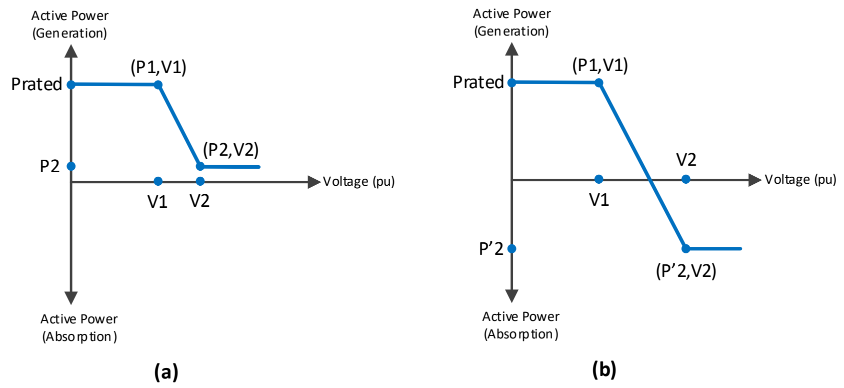

Figure 2-2. Example Volt-Watt characteristics

Table 2-7- Volt-Watt Settings – ACTIVATED

Voltage-active power parameters	Default Settings	Ranges of allowable settings	
		Minimum	Maximum
V1	106% VN	105% VN	109% VN
P1	P_{RATED}	NA	NA
V2	110% VN	V1 + 1% VN	110% VN
P2 (applicable to DER that can only generate active power)	The lesser of 0.2 P_{RATED} or P_{MIN}[1]	P_{MIN}	P_{RATED}
P'2 (applicable to DER that can generate and absorb active power)	0	0	P'_{RATED}[2]
Open-loop response time	10 sec	0.5 sec	60 sec

[1] P_{MIN} is the minimum active power output in p.u. of the DER rating (i.e., 1.0 p.u.).
[2] P'_{RATED} is the maximum amount of active power that can be absorbed by the DER.

2.6. Ramp Rate Settings

The following is the ramp-rate requirement during normal and reconnection operation of Smart Inverters:

- Normal ramp-up rate (Optional): For transitions between energy output levels over the normal course of operation, the default value is 100% of maximum current output per second with a range of adjustment between 1% to 100%.
- Connect/Reconnect Ramp-up rate: Upon starting power into the grid, following a period of inactivity or a disconnection, the inverter shall wait for 300 seconds before reconnecting and shall be able to control its rate of increase of power from 1 to 100% maximum current per second. The default value is 2% of maximum current output per second. The maximum active power step during restoring output is 20%