NEPR

Received:

Feb 10, 2025

5:30 PM

SESA PUERTO RICO

Input regarding real-world impact of new Smart Inverter Settings since going into effect January 1st, 2025, and Request for Urgent Modifications to required Smart Inverter Settings

Docket: NEPR-MI-2019-0009, INTERCONNECTION REGULATIONS

February 10th, 2025

Executive Summary

The Solar and Energy Storage Association of Puerto Rico (SESA), representing the leading smart inverter, battery, and solar companies active in Puerto Rico, has identified a series of negative impacts resulting from the implementation of the required **Smart Inverter Settings effective as of January 1, 2025**. These challenges, primarily tied to overly restrictive reconnecting voltage and frequency parameters, **prevent customers with distributed energy resources (DERs) connected since January 1st, both solar and battery, from promptly re-entering service**, leading to extended downtime, financial losses, and reduced grid stability.

Without regulatory adjustments, DERs would continue to face operational challenges, including excessive curtailment of many customers' solar and battery system output, which would hinder their effectiveness and financially harm the customer.

Initial data from SESA member company Enphase suggest that more than 55% of sites are affected by abnormal grid voltage and frequency conditions, which directly contribute to the negative outcomes related to the reconnect parameters. To mitigate these issues, SESA urges PREB to approve specific adjustments **by February 28, 2025**, ensuring that the revised settings take effect **by April 30, 2025**.

Contents

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1. Voltage and Frequency-Related Reconnection Issues

A. Frequency – Enter Service Maximum Value

i. Problem:

- The LUMA requirement for Enter Service maximum value is set to **60.1 Hz,** which has proven to be too restrictive. This has frequently prevented inverters from re-entering service when the grid frequency is high.
- This maximum Enter Service threshold is exacerbated by the enter service period of **5 minutes**. If the grid frequency crosses below the threshold and back up again, the enter service period is reset back to **5 minutes**. The combined effect of a long enter service period and relatively low upper threshold curtails the inverter from producing power.

ii. Impact:

- The effect is that, for extended periods, the inverter cannot enter service and produce power, resulting in prolonged solar curtailment due to relatively minor frequency variations.
- This loss of solar generation and storage utilization increases the island's reliance on fossil fuels.

iii. Proposed Solutions:

- Determine frequency settings using actual LUMA data from substations and feeders. Compose frequency distribution plots to determine the best frequency values for smart inverter settings.
- SESA's initial recommendation is to increase the enter service maximum value from **60.1 Hz** to **60.5 Hz**, with the potential for increasing up to 61.0 Hz (the upper limit tested and recommended by IEEE 1547-2018) following an initial evaluation period.
- The 60.5 Hz value would align Puerto Rico's standard with **California's 60.5 Hz reconnection threshold**.
- Ensure coordination between frequency reconnection and Frequency Droop settings to allow stable reconnection.
- SESA recommends the following changes to PREB's requirements:

2.6. Enter Service Settings

Smart Inverters shall be set to the Enter Service Settings in Table 2-8.

Table 2-8- Enter Service Settings

Enter Service Criteria			Ranges of allowable settings
Permit Service		Enabled	Enabled/Disabled
Applicable voltage within range	Minimum value	≥ 0.88 p.u.	0.88 p.u. to 0.95 p.u.
	Maximum value	≤ ~~1.06 p.u~~ 1.10 p.u.	1.05 p.u. to ~~1.06 p.u.~~ 1.10 p.u.
Frequency within range	Minimum value	≥ ~~59.5 Hz~~ 59.0 Hz	59 Hz to 59.9 Hz
	Maximum value	≤ ~~60.1 Hz~~ 60.5 Hz	60.1 Hz to 61.0 Hz
Enter Service Delay		~~300 s~~ 15 s	0 seconds to 600 seconds
Enter Service Randomized Delay		N/A	1 second to 1000 seconds
Enter Service Ramp Rate		50 s	1 second to 1000 seconds

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B. Frequency – Enter Service Minimum Value

i. Problem:

- LUMA's specified Enter Service Minimum Value for frequency, **59.5 Hz,** is also too restrictive. Enter Service criteria is used when the inverters turn on each day, after a trip, or when disconnection occurs.
- When inverters attempt to enter service, the grid frequency often remains below **59.5 Hz**, leading to long periods when the DER cannot reconnect.
- Similarly, the **5-minute** requirement for sustained stable grid frequency before reconnection further exacerbates downtime.

ii. Impact:

- Inverters will stay offline waiting for the 5-minute enter service period to terminate. If frequency goes outside the reconnect threshold during this period, the timer will reset and start a new enter service period. This behavior can extend over long periods of time, preventing inverters from producing power.
- This loss of solar generation and storage utilization increases reliance on fossil fuels.

iii. Proposed Solution:

- Lower the enter service minimum value from **59.5 Hz** to at least **59.0 Hz**
- This would align Puerto Rico's standard with California's Rule 21 setting of **59.0 Hz** reconnection threshold.
- SESA recommends the following changes to PREB's requirements:

2.6. Enter Service Settings

Smart Inverters shall be set to the Enter Service Settings in Table 2-8.

Table 2-8- Enter Service Settings

Enter Service Criteria			Ranges of allowable settings
Permit Service		Enabled	Enabled/Disabled
Applicable voltage within range	Minimum value	≥0.88 p.u.	0.88 p.u. to 0.95 p.u.
	Maximum value	≤~~1.06 p.u~~ 1.10 p.u.	1.05 p.u. to ~~1.06 p.u.~~ 1.10 p.u.
Frequency within range	Minimum value	≥~~59.5 Hz~~ 59.0 Hz	59 Hz to 59.9 Hz
	Maximum value	≤~~60.1 Hz~~ 60.5 Hz	60.1 Hz to 61.0 Hz
Enter Service Delay		~~300 s~~ 15 s	0 seconds to 600 seconds
Enter Service Randomized Delay		N/A	1 second to 1000 seconds
Enter Service Ramp Rate		50 s	1 second to 1000 seconds

C. Voltage – Enter Service Maximum Value

i. Problem:

- LUMA's required **voltage enter service maximum value** is set to **1.06 PU (127.2 V)**. This has proven to be too low, leading to unnecessary, sustained DER shutdowns in high-voltage areas.
- DER Tripping occurs when the voltage rises above **1.1 PU (132.00 V)**. In high voltage parts of the grid, where the voltage is routinely above **1.06 PU (127.2 V)**, the inverters will never enter

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service until the voltage drops below **1.06 PU (127.2 V)** at least **5 minutes,** after which the enter service criteria is met.

- In high-voltage regions, this results in extended periods of system curtailment.

ii. Impact:

- Enphase has collected the following maximum voltage statistics on new sites that were deployed in 2025, showing that more than half of new systems have recorded max voltages above 106 p.u.:

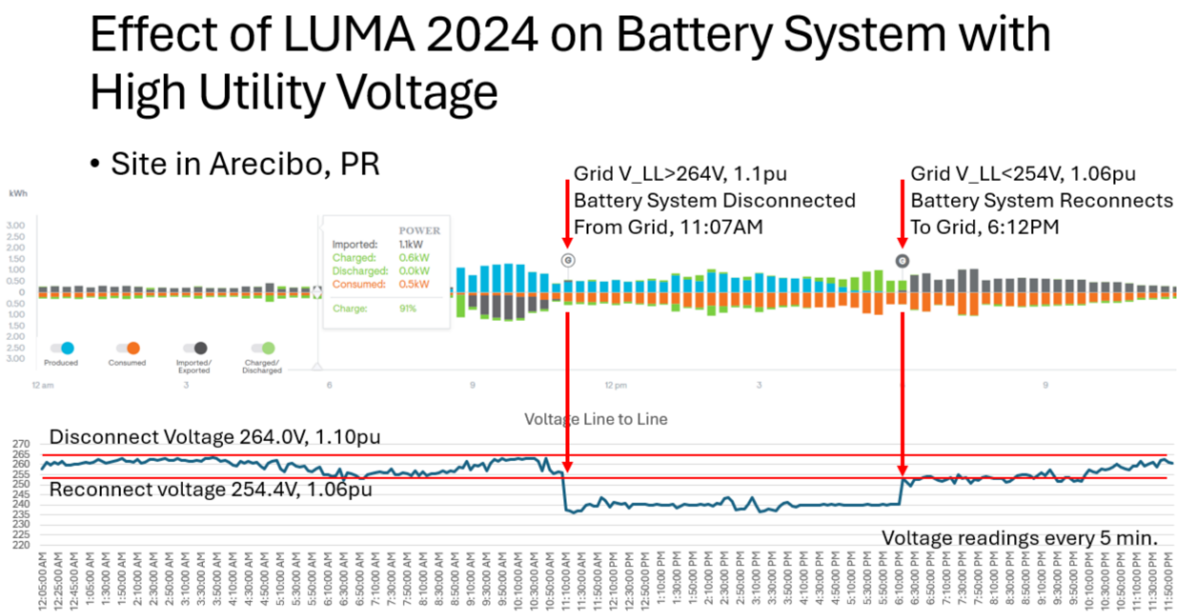
2025 New Enphase System Fleet Max Voltage Summary	
% of sites with Max Voltage above 106% p.u Volts	56.3%
% of sites with Max Voltage above 107% p.u Volts	40.1%
% of sites with Max Voltage above 108% p.u Volts	25.6%
% of sites with Max Voltage above 109% p.u Volts	17.9%
% of sites with Max Voltage above 110% p.u Volts	7.9%

- Similarly, the below table shows the amount of time that new Enphase systems deployed in 2025 have spent above the indicated voltage levels:

	2025 Enphase New System Fleet time spent above 106% p.u. voltage				
	X% of sites spend Column A percent of time above top row % above nominal voltage				
A (% time) ↓	percent above nomical voltage				
	%duration above 106% p.u Volts	%duration above 107% p.u Volts	%duration above 108% p.u Volts	%duration above 109% p.u Volts	%duration above 110% p.u Volts
10%	25.9%	14.0%	7.9%	4.5%	1.8%
20%	16.9%	9.5%	5.8%	2.7%	1.2%
30%	12.8%	8.2%	4.6%	1.8%	1.0%
40%	11.3%	6.7%	4.0%	1.3%	1.0%
50%	9.7%	5.5%	2.8%	1.0%	0.8%
60%	8.7%	5.1%	2.2%	0.9%	0.6%
70%	7.1%	4.0%	1.8%	0.8%	0.6%
80%	5.5%	3.1%	1.3%	0.8%	0.5%
90%	4.2%	2.2%	1.0%	0.6%	0.5%
100%	0.0%	0.0%	0.0%	0.0%	0.0%

- Enter Service voltage thresholds also affect battery systems

<u>Example of impact on one Enphase customer with batteries</u>



iii. Proposed Solution:

- Increase enter service maximum value for voltage from **1.06 PU (127.2 V)** to **1.10 PU (132 V)** to allow faster resumption of service.
- Implement reconnection criteria that enable inverters to resume operation without excessive delays.
- SESA recommends the following changes to PREB's requirements:

2.6. Enter Service Settings

Smart Inverters shall be set to the Enter Service Settings in Table 2-8.

Table 2-8- Enter Service Settings

Enter Service Criteria			Ranges of allowable settings
Permit Service		Enabled	Enabled/Disabled
Applicable voltage within range	Minimum value	≥ 0.88 p.u.	0.88 p.u. to 0.95 p.u.
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Frequency within range	Minimum value	≥ ~~59.5 Hz~~ 59.0 Hz	59 Hz to 59.9 Hz
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D. Enter Service Period

i. Problem:

- LUMA's smart inverter requirements set the Enter Service Period to **5 minutes,** which is too long. The enter service period is a timer that monitors voltage and frequency prior to reconnecting after DER tripping or at the beginning of each day. If the enter service criteria for voltage and frequency is within the set values, the inverter will connect to the grid and produce power. Enter service criteria is also governed by the enter service period, meaning the criteria must be met during the defined period. If voltage or frequency drifts outside the criteria range for any amount of time, the Enter Service Period timer is reset.

ii. Impact:

- The combined effect of the Enter Service value and period produces long periods of time when the inverter cannot enter service and produce power. **Proposed Solution:**
- Decrease the Enter Service Period from **5 minutes** to **15 s**.
- Align Puerto Rico's setting the requirement with CA Rule 21, which specifies a 15 second enter service period. A shorter time will increase solar generation and storage utilization, supporting grid operations and decreasing reliance on fossil fuels.
- SESA recommends the following changes to PREB's requirements:

2.6. Enter Service Settings

Smart Inverters shall be set to the Enter Service Settings in Table 2-8.

Table 2-8- Enter Service Settings

Enter Service Criteria			Ranges of allowable settings
Permit Service		Enabled	Enabled/Disabled
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Enter Service Delay		~~300 s~~ 15 s	0 seconds to 600 seconds
Enter Service Randomized Delay		N/A	1 second to 1000 seconds
Enter Service Ramp Rate		50 s	1 second to 1000 seconds

2. Frequency-Droop (frequency-power)

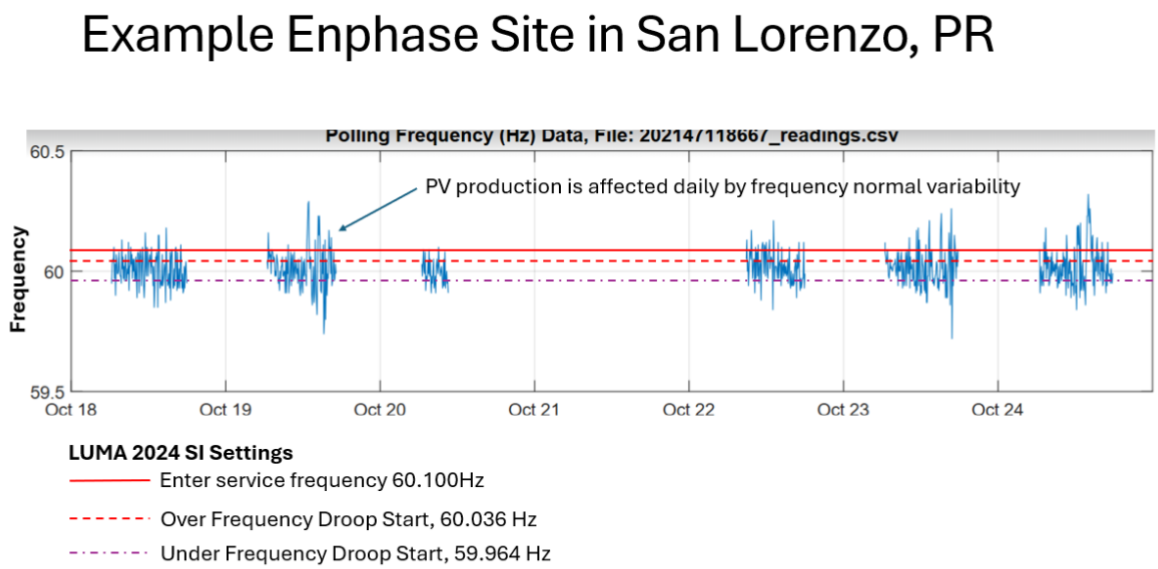
A. Frequency Droop Deadband

i. Problem:

LUMA's smart inverter requirements did not specify Frequency Droop (a.k.a. Frequency-Watt or FW) settings. Without such guidance, industry applied the IEEE 1547:208 default values. These default values have a very narrow deadband limit of 0.036 Hz (36 mHz) for the Frequency-Droop function, even though the IEEE 1547:2018 standard presents a wider range of allowable deadband settings, from 0.017 Hz to 1 Hz. The default deadband of 0.036 Hz is small and should only be used when operating within very stable grids, such as those on the mainland. Island communities, such as Hawaii, Virgin Islands, and Puerto Rico, do not have the luxury of a high inertia grid producing stable grid frequency. It's important to allow higher deadband settings to maintain DER connectivity and power production in a low inertia grid.

- Enphase has measured the frequency at several sites, and they have found the frequency is often outside of the IEEE 1547-2018 default deadband. This situation is particularly sensitive when a system enters service either at the start of the day or after a DER trips offline. If the frequency is outside the deadband, as is often the case, the DER will not produce power until the frequency returns into the deadband region.

- The below shows frequency data for a representative Enphase site:



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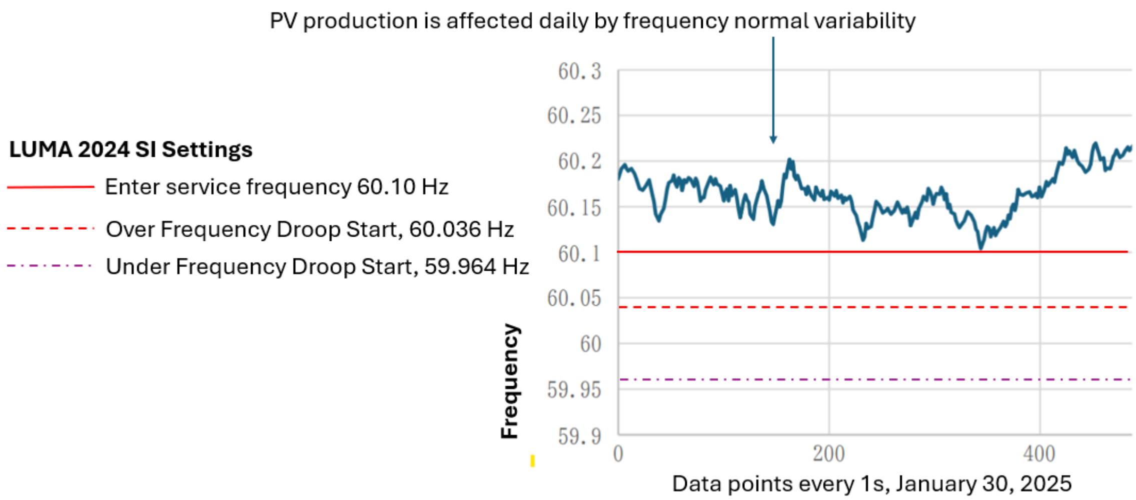
Example Enphase Site in Ciales, PR



ii. Impact:

- The effect of the narrow default frequency deadband is that, for extended periods of time, the inverter cannot produce power due to frequency instability.

iii. Proposed Solution:

- Increase the Frequency-droop deadband from 0.036 Hz (36 mHz) to 0.250 Hz (250 mHz).
- Enphase data indicates that this should help most sites sustain power production, for most of the time.

B. Frequency-Droop Open Loop Response Time

i. Problem:

- LUMA smart inverter settings did not specify a Frequency-Droop Open Loop Response Time (OLRT). Therefore, industry applied the IEEE 1547:208 default value of **5 seconds**, which has proven to overly curtail inverters from producing stable power.

ii. Impact:

- A slow or long OLRT lowers the reaction time for the Frequency-droop function.
  A long OLRT lowers the ability of the inverter to help stabilize grid frequency.

iii. Proposed Solution:

- The Frequency-Droop Open Loop Response Time (OLRT) needs to be specified, using Hawaii as a benchmark. Decrease the OLRT from **5 s** to **0.5 s,** which aligns the OLRT values with that set in Hawaii. The IEEE 1547:2018 standard provides an allowable range of adjustment from **0.2 to 10** seconds for this setting.

3. Delay implementation of Voltage Active Power Mode

i. Problem:

- LUMA has proposed the introduction of the Voltage-Active Power mode, commonly referred to as the Volt-Watt (VW) function, to begin in April 2025. With the identification of functional discrepancies and issues with the current requirements as outlined above, SESA asserts that is too early to introduce another function that has a high likelihood of causing significant impacts to DER power production.

ii. Impact:

- High voltage conditions on the LUMA grid are widely observed and documented. The VW function will further curtail power during high voltage conditions, resulting in symmetrical negative impacts to customer experience and ROI.

iii. Proposed Solutions:

- Allow more time for manufacturers to adjust for the recommended changes to LUMA requirements, as outlined above.
- Set any possible introduction of the VW function to no earlier than **one year** after the published effective date for any changes made to the LUMA requirements, as outlined above.

4. Address other gaps and errors in the current Technical Bulletin for Smart Inverter Settings:

i. Problem:

- The currently approved Technical Bulletin for Smart Inverter Settings contains several typographical errors and inconsistencies, which has caused confusion among solar companies and manufacturers, and with LUMA staff alike when reviewing customer applications to interconnect and operate their DER systems.

ii. Impact:

- These errors have resulted in some customers' systems being denied for interconnection on the grounds of noncompliance with Smart Inverter Settings requirements, despite actually being in compliance.

iii. Proposed Solutions:

a) Include defined settings for Frequency Droop, as recommended above.

b) Update the Table of Contents to include missing sections and fix inconsistencies with headers.

c) Update the list of tables to include missing Table 2-8, and modify the formatting of Table 2-8 to be consistent with other tables.

d) Correct the mathematical symbols used in Tables 2-3 and 2-5, which currently specify impossible ride-through criteria.

e) Remove "Connect/Reconnect Ramp Up Rate," as this is a duplicative requirement to the Enter Service Ramp Rate setting in Section 2.6. This latter setting is most consistent with the adopted IEEE 1547-2018 standard.

f) Include relation of IEEE 1547-2018 Abnormal Operating Categories to voltage and frequency ride-through performance.

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5. Include Common File Format Version

i. Problem:

- There doesn't yet exist an EPRI Common File Format version of the Smart Inverter Settings.

ii. Impact:

- Inclusion of a Common File Format version in the next version of required Smart Inverter Settings would minimize implementation errors.

iii. Proposed Solution:

- Require Common File Format version to be included with next version of Smart Inverter Settings

6. Proposed Regulatory Action Plan and Timeline

SESA urges PREB to **approve specific changes to smart inverter reconnection settings** based on industry consensus and as recommended herein. Our recommended timeline for making these changes is as follows:

1. **February 11th, 2025:** PREB workshop – SESA, on behalf of industry, presents a unified proposal outlining the above issues and proposed solutions.
2. **February 14th, 2025:** SESA circulates a detailed proposal for changes to the currently required Smart Inverter Settings.
3. **February 28th, 2025:** PREB issues an order mandating revised smart inverter settings.
4. **April 30th, 2025:** New reconnection thresholds and response times become mandatory for all newly installed and reconfigured smart inverters on a going-forward basis.

By acting on these targeted adjustments within this timeframe, PREB can ensure **Puerto Rico's transition to a resilient, decentralized energy system is not hindered by unnecessarily rigid interconnection rules**.