

Full off-grid/standalone Enphase Energy System

Applicable regions: North America

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1. Overview

Full off-grid or standalone systems do not have utility connections and rely solely on the power produced by solar panels and an AC standby generator. The power produced is either consumed by loads or stored in the Enphase IQ Batteries.

This tech brief contains information for design engineers and installation personnel to analyze a site and plan an off-grid system's design installation, commissioning, and operation using the 3rd generation Enphase Energy System (EES). It also covers recommendations for optimizing off-grid sites installed before October 2024 using older-generation components. The information provided covers the best practices for a successful installation and operation of the system. This information is also provided as supplementary information to other design material and tech briefs that may be needed for a specific configuration.

For commissioning off-grid systems, the installer must complete the following Enphase University courses:

- *EES (Enphase Energy System) 3.0 installer certification training featuring the IQ Battery 5P*
- *Enphase Storage Generator Support*
- *Enphase off-grid system training*



NOTE: All off-grid system designs must undergo a mandatory and free design review before installation. The review can be accessed from the Enphase Installer Portal. Contact offgridsupport@enphaseenergy.com for a coupon. Enphase is not liable for after-sales support for systems not completing the design review.



IMPORTANT: Installer must carry 4 kW load (2kW per L-N) to the site to meet load requirements during commissioning or troubleshooting. Two hair dryers should meet this requirement.

2. System sizing

A proper load study is the first step in effectively sizing a system. Load data for system size must be obtained through a site survey.

The PV array should be capable of producing enough energy to meet the site's daily energy needs and keep the battery array charged to provide sufficient backup.

Sufficiently size the IQ Battery power rating to power loads and charge from PV power generation. You can increase the power rating by adding additional IQ Battery units that provide additional backup.

An additional factor to consider is the inrush current if a large appliance, such as an air conditioner or a pool pump, needs to be powered. See the appliance nameplate or the manufacturer's literature to determine the inrush current requirement. To meet this need, the battery array must be of an appropriate size. For more information, see the [IQ Battery 5P Power Start capability white paper](#).

All standalone or off-grid sites must have an appropriately sized standby generator from the list of supported generators. The system must adhere to the battery or PV to generator sizing restrictions specified in the following tables to protect the generator from momentary backfeeding during significant load state changes. The sizing imposed also considers the power required for charging the batteries while ensuring the power drawn is not more than 70% of the generator's nameplate, as

drawing more than 70% of the rated power can cause some generator models to see a drop in voltage and frequency.

Table 1: Examples of minimum generator nameplate rating for a system with IQ8 Series Microinverters and IQ Battery 5P

| Microinverter type | Rated output (W) of one microinverter | No. of microinverters | Rated power output of the microinverter array (kW) | IQ Battery 5P units | IQ Battery power (kW) | Min. generator nameplate (kW) |
|--------------------|---------------------------------------|---------------------------|--|---------------------|-----------------------|-------------------------------|
| IQ8 | 240 | 16 (one branch circuit) | 3.84 | 1 | 3.84 | 5.49 |
| IQ8 | 240 | 32 (two branch circuits) | 7.68 | 1 | 3.84 | 7.68 |
| IQ8PLUS | 290 | 13 (one branch circuit) | 3.77 | 2 | 7.68 | 10.98 |
| IQ8PLUS | 290 | 20 (two branch circuits) | 5.8 | 3 | 11.52 | 16.47 |
| IQ8H-240 | 380 | 15 (two branch circuits) | 5.7 | 4 | 15.36 | 21.94 |
| IQ8H-240 | 380 | 40 (four branch circuits) | 15.2 | 4 | 15.36 | 21.94 |

Table 2: Examples of minimum generator nameplate rating for a system with IQ8 Series Microinverters and IQ Battery 3T/10T

| Microinverter type | Rated output (W) of one microinverter | No. of microinverters | Rated output power output of the microinverter array (kW) | IQ Battery 3/3T units | IQ Battery 10/10T units | IQ Battery power (kW) | Min. generator nameplate (kW) |
|--------------------|---------------------------------------|---------------------------|---|-----------------------|-------------------------|-----------------------|-------------------------------|
| IQ8 | 240 | 16 (one branch circuit) | 3.84 | 1 | — | 1.28 | 3.84 |
| IQ8 | 240 | 32 (two branch circuits) | 7.68 | 2 | — | 2.56 | 7.68 |
| IQ8PLUS | 290 | 13 (one branch circuit) | 3.77 | 3 | (One IQ Battery 10/10T) | 3.84 | 5.49 |
| IQ8PLUS | 290 | 20 (two branch circuits) | 5.8 | 4 | — | 5.12 | 7.31 |
| IQ8H-240 | 380 | 15 (two branch circuits) | 5.7 | 5 | — | 6.4 | 9.14 |
| IQ8H-240 | 380 | 40 (four branch circuits) | 15.2 | 6 | (Two IQ Battery 10/10T) | 7.68 | 15.2 |
| IQ8H-240 | 380 | 40 (four branch circuits) | 15.2 | 12 | (Two IQ Battery 10/10T) | 15.36 | 21.94 |

When selecting a generator for off-grid sites, it is essential to evaluate the loads that will be connected and increase the size of the generator to stay within the 70% duty cycle. Even though the IQ System Controller 3G supports an 80 A breaker for the generator, an upsized generator will allow the starting of loads, such as well pumps and AC units while the batteries are charging. Suppose the generator was only sized to the minimum sizing requirements. In this case, it may require the maximum

generator efficiency to be lowered, which will reduce the charging capacity of the batteries, allowing for more power to be available for loads.



WARNING: Some manufacturers also have a limited or no warranty when used in an off-grid scenario.

If large loads are used, using the Load Control feature of the IQ Load Controller and configuring it to run during a state of charge (SOC) window will prevent depleting the batteries. Load Control can also be configured only to turn on when the generator is connected; this will be helpful if the site has intermittent loads that the batteries may not support.

An appropriately sized system will result in less generator assistance. If a site consumes more at nighttime than the nameplate of the batteries, the extra power will be sourced from the generator. Generator power will also be used if batteries run out of charge at night. This could happen, for example, if a large battery bank is installed and not enough solar is installed to provide power for the loads and allow the batteries to charge.



NOTE: Use the Enphase [System Estimator](#) and [System builder](#) tools to size the system and generate bill of materials needed for installation.

3. System configuration

All off-grid PV systems must have the following components:

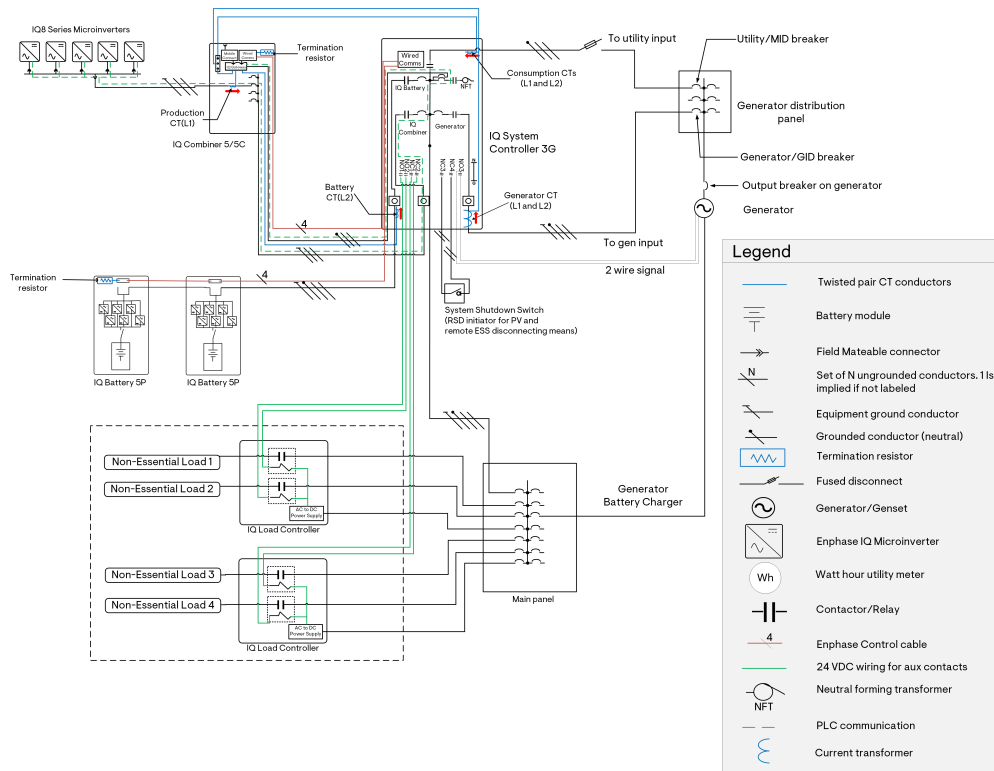
- IQ8 Series Microinverters
- IQ Battery 5P
- IQ System Controller 3G
- Supported standby generator, as listed in [System builder](#) or the [Generator integration with Enphase Energy System Tech Brief](#).



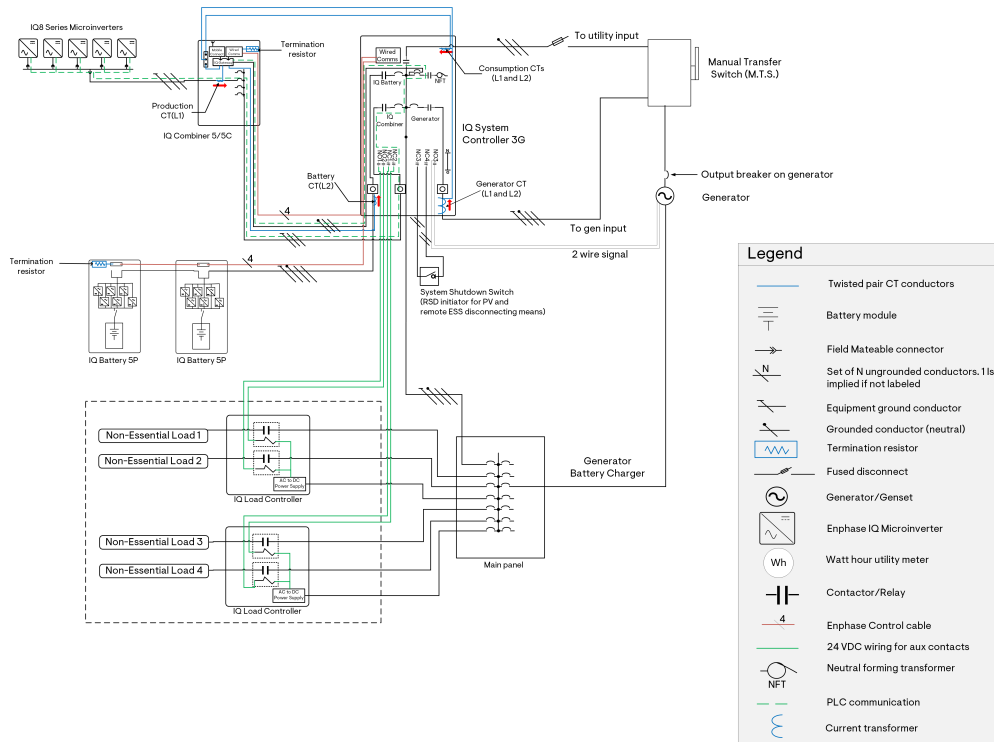
NOTE: PV-only + generator systems (Sunlight Backup) and battery only + generator systems are not supported.

For off-grid systems, Enphase requires the following:

- The generator output must be connected to both the utility and generator input of the IQ System Controller. The generator is turned on manually and connected to the utility input of the IQ System Controller to allow commissioning and software updates. The generator is then connected to the generator input to enable generator current transformers (CTs) and verify the automatic starting of the generator using the CT wizard. Connecting the generator to the utility input as well as the generator input can be done by using
 - An off-the-shelf electrical panel with breakers installed that will feed the utility and generator input called the generator distribution panel (GDP). The minimum rating of the GDP should match the Generator output, rounded up to the next available panel size. For example, for a 22-kW generator, the GDP size shall be $22,000/240 \times 1.25 = 114$ A, rounded up to the next available panel, that is, 125 A. The wiring from the Generator to the GDP must meet the maximum output of the generator and breaker installed.



- A manual transfer switch (MTS) that is rated to the output of the generator.



- One pair of Consumption Current Transformers must be installed on the microgrid interconnection device (MID), and one pair of generator CTs must be installed on the generator circuit. The CTs must be connected in parallel to the Consumption Current Transformer terminals in the IQ Gateway.

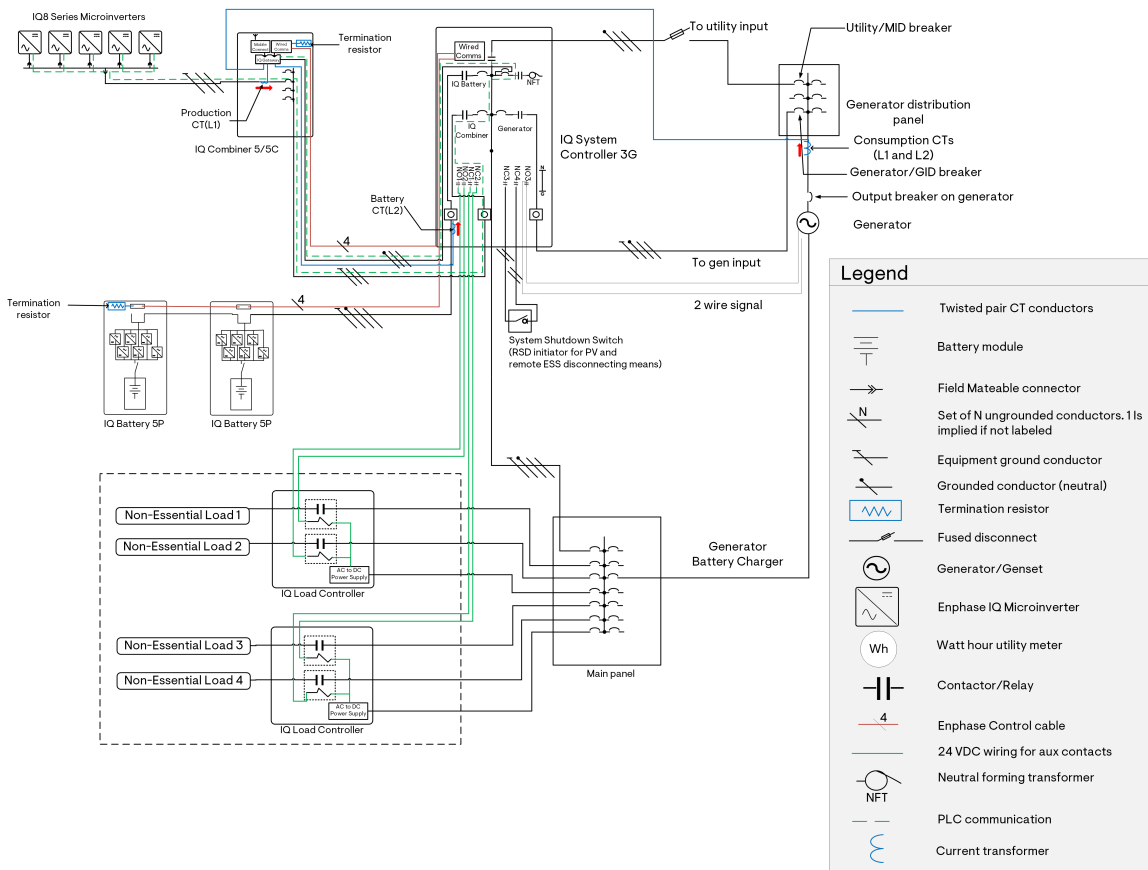
NOTE: Consumption Current Transformers must be installed on the L1 and L2 conductors from the generator distribution panel or the manual transfer switch to the utility input, that is, MID input of the IQ System Controller. Consumption Current Transformers should never be placed on the load side of the IQ System Controller, as this will negatively impact the system's operation.

DANGER: CTs must be oriented correctly to prevent PV or battery backfeeding to the generator and damaging it.

- The battery CT must be installed on the L2 conductor of the battery circuit for all systems.
- All new standalone or off-grid systems must install an AC standby generator to support the system when needed.
- All new standalone or off-grid systems must use IQ8 Series Microinverters to facilitate Sunlight Jumpstart to form a grid and charge the batteries when they are completely depleted. Older-generation microinverters do not support this feature and will require a site visit by the installer to recover the site in the event of batteries being depleted and generator running out of fuel, as described in the [State of charge recovery for an Enphase Energy System technical brief](#).
- All standalone or off-grid systems must have internet access using Wi-Fi or Ethernet and an Enphase Mobile Connect cellular modem for backup internet access.

WARNING: Portable generators should not be used for system commissioning as it may lead to system issues requiring the installer to return to the site and perform system recovery activities.

Instead of using two pairs of Consumption Current Transformers to measure the utility side input and the generator port input, a single pair of Consumption Current Transformers can be placed between the generator and the GDP/manual transfer switch, as shown in the following diagram.



3.1 Generator selection

Generators are typically available at two engine speeds: 1800 RPM and 3600 RPM.

Units that run at 3600 RPM are primarily air-cooled models with shorter run times between oil changes and should limit run time in hot weather. Some manufacturers also have a limited or no warranty when used in an off-grid scenario.

The 1800 RPM models are often water-cooled units that can run for an extended time and will have a longer lifespan with better motor efficiency due to the unit cooling; these models would be the best to use for off-grid sites.

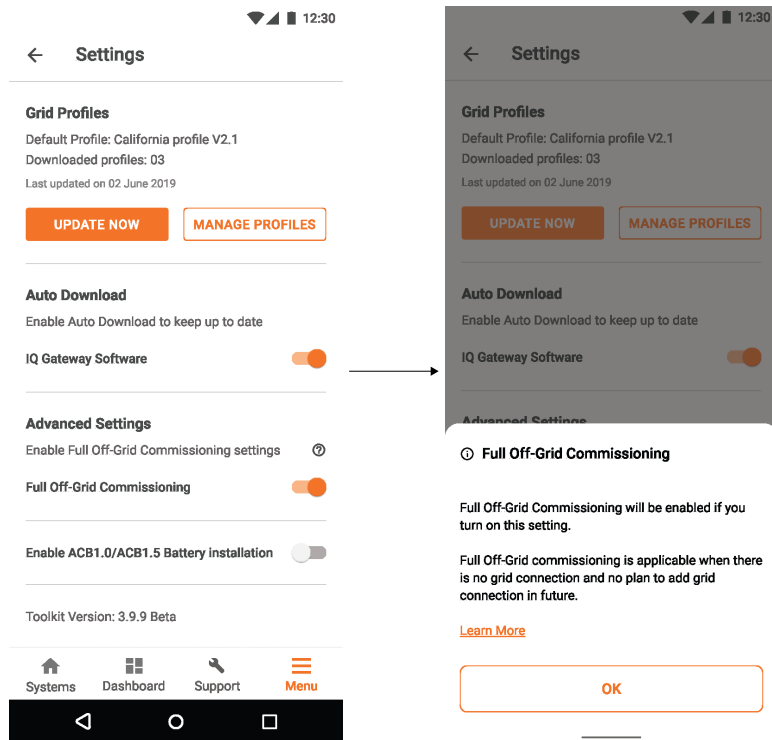
For information about generator models supported by the Enphase Energy System, see the [System builder](#) or [Generator integration with Enphase Energy System Tech Brief](#).

4. Commissioning an off-grid system using the Enphase Installer App



IMPORTANT: Use Enphase Installer App version 4.3 or later to commission off-grid systems.

1. On the Settings page of the Enphase Installer App, enable **Full Off-Grid Commissioning** and click **OK** when prompted.



NOTE: This step can be skipped if the app had the setting enabled before.

2. Create the site and select **Primary Electrical Source** as **Pure Off-Grid (No utility service)**.

12:30 📶 🔋

Step 1 of 6: System Details
< Edit Details ?

1 Time left 62 mins

Site ID: 698932083

System Name *

Installer Reference ID ?

Type of Installation *
Residential

Owner Details

Third-party owned (eg: PPA or leased) ?

First Name * Last Name *

Email *

🇺🇸 +1 ▼ Mobile Number *

Street Address 1 *

Street Address 2

Zip Code *

State * City *
California

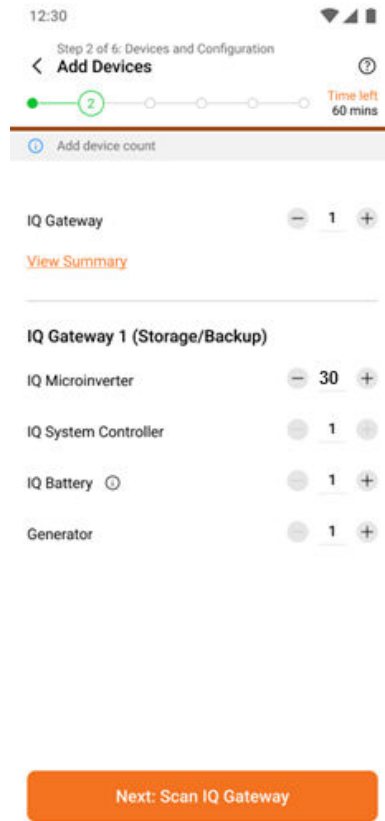
Country *
United States

Grid Connection Details

Grid Connection Type *
Full Off-Grid (No utility service)

Cancel **Confirm**

3. Add devices.



4. Follow the instructions on the Enphase Installer App until the commissioning is complete.



WARNING: Follow the instructions carefully to avoid microgrid collapse during commissioning.



WARNING: Keep the DC switches for the batteries in the OFF position. The Enphase Installer App will turn on the DC switches automatically during commissioning. Any attempt to manually turn on the DC switches will lead to microgrid collapse.

5. System profiles

Use only the Self-Consumption profile for off-grid systems. This profile alerts the homeowner when the system reaches the set reserve level. However, this will not impact system operation when off-grid. During software updates and service, set the reserve below the current SOC of the batteries.



NOTE: Disable the **Charge from Grid** option for off-grid sites.



NOTE: Turn off the Storm Guard feature for off-grid systems because it is not useful and may send unneeded events to the homeowner.

6. Generator configurations and control

Maximum continuous generator amps: When integrating a generator with the IQ System Controller, the installer will need to tell the system how much power can be expected from the generator. It is recommended to set this to no more than 70% of the generator's nameplate based on the fuel source used, such as propane. Natural gas generators support up to 80% of the nameplate for efficient operation. Using a setting higher than 70% or 80% (based on the fuel type) may result in the generator's voltage and frequency dropping below the levels supported by the system, resulting in the system disconnecting from the generator.

Maximum generator efficiency setpoint: This setting is the percentage of the maximum continuous generator amps the system uses from the generator. The system will reduce battery charging or even discharge the battery to keep the generator loading at or below this percentage. Systems may see differing characteristics based on season or time of day because PV generation can also help power the load and charge the batteries. At this point, the maximum generator efficiency setpoint can be adjusted only by the installer. During commissioning, the installer should run the generator to verify if the batteries are charging at full power and test large loads to ensure that the settings will allow the generator to remain stable and connected.

Minimum generator efficiency setpoint: This setting configures how much power the loads or battery must draw from the generator before the system brings on PV to assist the system. For example, if the maximum continuous generator amps is set to 60 A and the minimum generator efficiency setpoint is set to 10%, the first 6 A would always need to be supplied from the generator.

Exercise cycle: Manufacturers such as Generac and Honeywell cannot turn off the onboard exercise cycle for the warranty, so adding an exercise cycle while adding the generator in the Enphase Installer App will result in unnecessary cycles and consume more fuel. Consider using this when the onboard exercise cycle can be turned off. The generator should also be set up to exercise with the site location in mind and should happen in the early morning if there will be high temps during the summertime.

Control type: There are two selections: two-wire and Utility Sense. This setting will not change the system's operation and will allow Enphase Support to identify the workflow needed when helping with troubleshooting, starting, and stopping issues. Generac and Honeywell units use Utility Sense controls from the factory and require additional off-the-shelf hardware to control them. Alternatively, these generators can be converted to two-wire start using a manufacturer's kit.

Cool down: Cool down time is set to determine the amount of time that the system will run the generator without load before shutting down the generator. Some manufacturers have a built-in cool-down cycle. If so, adding a cool-down cycle will use extra fuel and may not be needed.

Warm-up: Warm-up time is set to determine how long the system will run the generator without load after turning it on. Some manufacturers have a built-in warm-up cycle. If the generator does not have an in-built warm-up cycle, it is optimal to have a 2-minute warm-up cycle for normal operating temperatures and a 5-minute warm-up cycle for cold climates.

7. Manually starting the generator

Sites that are running off-grid may need to adjust generator settings for manual starting when required. This can be done by the homeowner using the Enphase App by switching the mode from ECO to Automatic. To turn off the generator, the homeowner can switch back to the ECO mode, and

the generator will turn off if the battery SOC is above the start limit. This is useful when there is limited solar production.

The homeowner can also adjust the start SOC to above the current SOC level to initiate a run cycle, and the generator will then turn off at the selected stop SOC.

8. Legacy system support

- IQ System Controller and IQ System Controller 2 support a 60 A and 80 A breaker for the generator, respectively. An upsized generator will allow starting loads like well pumps and AC units while the batteries are charging.
- All systems must follow the sizing guidelines listed in the [Generator integration with Enphase Energy System Tech Brief](#) based on the microinverter and battery type.
- All recommendations in this document for the EES 3.0-based off-grid system also apply to older-generation systems.
- After the grid profile is set, legacy systems with microinverters other than IQ8 Series Microinverters must be de-energized before transferring the IQ System Controller from manual override to normal mode.
- All legacy systems must use the off-grid profile: Advanced Off Grid Profile (IEEE[®] 1547.2018-based with Wide Trip, no AGF, 500 VA Export, Island detection disabled) (1.3.14).
- Off-grid workflow in the Enphase Installer App 4.3 will not work for EES 1.0 or 2.0 systems.



WARNING: Enphase does not support IQ Battery 3/3T/10/10T based off-grid systems activated after November 2024. Use only IQ Battery 5P for off-grid systems.

9. Troubleshooting

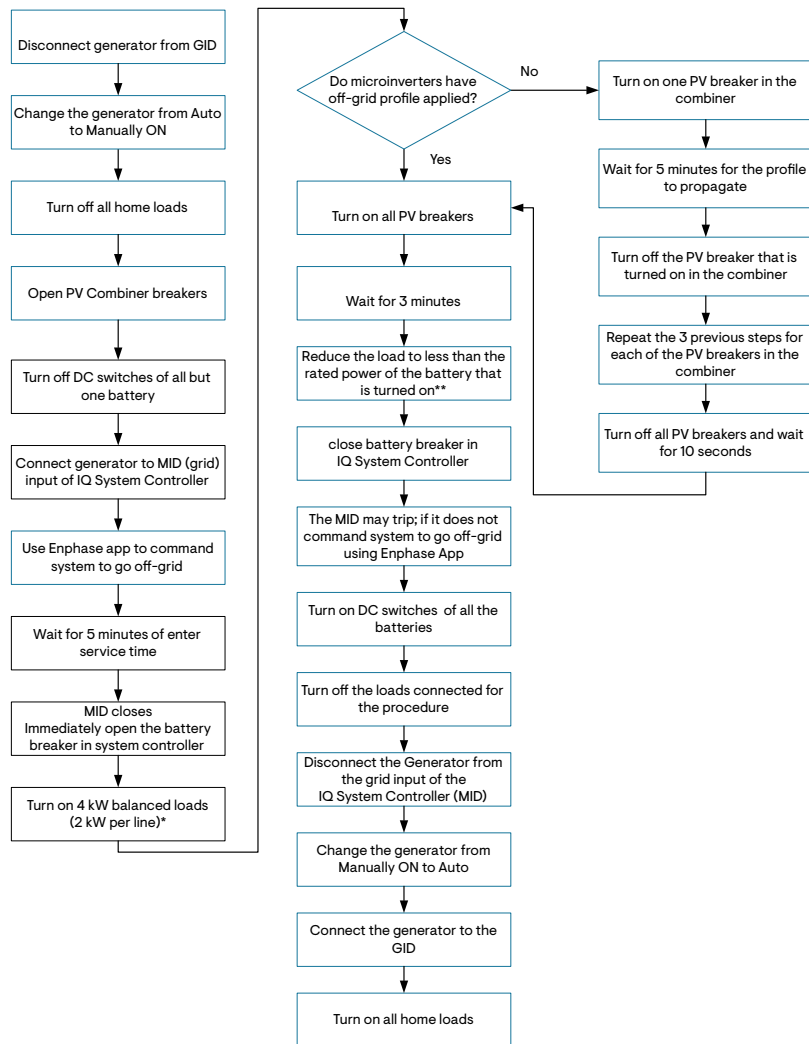
Workflow to recover off-grid systems with microinverter aggregation issues

Ensure the system has off-grid profile (Advanced Off Grid Profile (IEEE[®] 1547.2018-based with Wide Trip, no AGF, 500 VA Export, Island detection disabled) (1.3.14)) before visiting the site.

If the off-grid profile is not applied to the site, contact [Enphase Support](#) and request to apply off-grid profile to the site at least 24 hours in advance before visiting the site.

Once at the site, refer to the following flowchart.

Workflow to recover off-grid systems with microinverter aggregation issues



* Two hair dryers at high power (1 per line) should be sufficient.
 ** Rated power is 3.84 kW for IQ Battery 5P or 1.28 kW for IQ Battery 3 or 3T.

10. Revision history

| Revision | Date | Description |
|---------------|---------------|--|
| TEB-00175-2.0 | November 2024 | <ul style="list-style-type: none"> Updated information regarding GDP in section “System configuration”. Added information regarding the off-grid profile in section “Legacy system support”. Added section “Troubleshooting”. |
| TEB-00175-1.0 | July 2024 | Initial release. |