

PCS Integration in Enphase Storage System

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Introduction to Power Control System (PCS)

Power Control Systems (PCS), as defined in NFPA 70, National Electrical Code 2020 Edition, control the output of one or more power production sources, energy storage systems (ESS), and other equipment. PCS systems limit current and loading on the busbars and conductors supplied by the power production sources and/or energy storage systems.

This tech brief describes the need for PCS Integration and its benefits and details the various devices that are crucial in implementing PCS Integration in an Enphase Storage System, namely:

- Enpower Smart Switch
- Envoy
- Current Transformers

The tech brief also describes how these devices work together for real-time current monitoring and export limiting to enable PCS Integration.

The Tech brief then explains the 2 functions supported by Enphase Storage System for PCS Integration:

- **ESS Import Only Mode** - This use case ensures the Enphase Storage System never exports any power to the grid.
- **Main Panel Upgrade (MPU) Avoidance Mode** - This use case limits the back feed of the PV back to the grid to avoid having to upsize the main panel.

Need for PCS Integration in the Enphase Storage System

The two use cases for PCS Integration covered in this tech brief for the Enphase storage system are as follows:

- **Avoid costly Interconnection Equipment Upgrades or Installations:** In the absence of PCS with ESS import only mode, utilities in California such as Pacific Gas & Electric (PG&E), San Diego Gas & Electric (SDG&E) and South California Edison (SCE) require the installation of an additional Net Generation Output Meter(NGOM). This increases the cost of installation of the ESS for the homeowner. To avoid this additional cost, the homeowner may have to limit their ESS to under 10kW which may not be sufficient for backing up their home loads. No such trade-off is required when installing an Enphase Storage System. It also enables homeowners as well as utilities to avoid unnecessary transformer upgrades.
- **Main Panel Upgrade Avoidance:** In many PV and storage systems, the Main Panel busbar rating at the site can be a limiting factor when adding a new Distributed Energy Resource (DER). A Main Panel upgrade can lead to a significant installation cost of several thousand dollars. DER systems that can avoid a Main Panel Upgrade have a significant competitive advantage over systems that require a replacement.
Main Panel Upgrades are also often challenging for the installer as well as require multiple hours of labour from a certified electrician on-site. PCS Integration uses smart real-time current sensing to monitor and limit the current fed back to the main panel, thereby eliminating the need for a Main Panel upgrade. PCS Integration enables the installation of large system sizes while ensuring the main panel is NEC code compliant.

PCS Integration in Enphase Storage System

Enphase’s PCS is a Supplementary PCS. Supplementary PCS are systems or devices intended for use in circuits with an overcurrent device suitable for service, feeder, or branch circuit protection.

Components of Enphase’s PCS

- **Current Transformers** - An Enphase PCS enabled site would require a Production CT (1 CT shipped with the Envoy) and a pair of Consumption/PCS CTs (quantity 2 of CT-200-SPLIT, to be purchased separately by the installer or included). The production CT provides revenue grade metering of the power generated by the PV. The Consumption/PCS CTs are installed inside the Enpower cabinet to monitor the current being backfed from the Enpower to the grid or Main Panel in real time.
- **PCS controller (Envoy)** - An Enphase PCS enabled site incorporates the IQ Envoy to support IQ microinverter systems or the Envoy S Metered to support the M-series microinverter systems. The Envoy monitors the currents as reported by the CTs and uses this information to limit PV and ESS power production as required.
- **Enpower Smart Switch and Encharge Storage System** - Enphase’s PCS ensures Encharge does not export any power back to the grid and the PV backfed from the Enpower smart switch to a main load panel is limited per the NEC code requirements.

Supported SKU’s

Device	Supported SKU’s
PCS Controller (Envoy)	IQ Envoy(ENV-IQ-AM1-240), Envoy S metered(ENV-S-AM1-120)* Combiner boxes containing the Envoy gateway: X-IQ-AM1-240-3C, X-IQ-AM1-240-3, X-IQ-AM1-240-3-ES, X-IQ-AM1-240-3C-ES, X-IQ-AM1-240-2, X-IQ-AM1-240-B
Current Transformers	CT-200-SPLIT (quantity 2 needed) CT-200-SOLID (included with the Envoy)
Enpower Smart Switch	EP200G101-M240US00
Encharge Storage	ENCHARGE-3-1P-NA, ENCHARGE-10-1P-NA, ENCHARGE-3T-1P-NA, ENCHARGE-10T-1P-NA
Microinverters	<ul style="list-style-type: none"> • IQ6 series (IQ6, IQ6Plus), IQ7 series (IQ7, IQ7A, IQ7Plus, IQ7X, IQ7PD) • M215 and M250 series*

* Envoy S metered and M-series inverters do not support PV curtailment for MPU avoidance.

Table 1: Supported SKU's

Setting Up Enphase’s PCS Integration System

Please refer to the Enpower Quick Install Guide (QIG) for detailed instructions on how to setup a PCS enabled Enphase Storage System. Step 6 of the QIG contains detailed information required for installers to correctly setup a PCS enabled systems and provides information on the labels required to be added to the PCS enabling devices by the installer. These labels are shipped as an accessory as part of the Enpower box.

Supported PCS functions in an Enphase Storage System

Import Only Mode for Energy Storage System (ESS)

Import Only mode of PCS Integration is supported when the Enphase Storage System is being installed on a site that has Enphase's M series or IQ series range of microinverters. In this use case, the system ensures that Encharge never exports power to the grid.

PCS Integration ensures that the storage system only exports power to home loads and no ESS power is exported to the grid. In the absence of a PCS system with ESS import only mode, utilities such as PG&E, SDG&E and SCE require the installation of an additional NGOM meter to measure the current being exported by the ESS system.

Enphase's PCS Integration in this configuration ensures that a homeowner can add up to 12 Encharge 3's i.e., 15.36 kW of power (40 kWh storage) without requiring the installation of a NGOM meter. It also enables homeowners as well as utilities to avoid unnecessary transformer upgrades in cases wherein the .

System sizing with Encharge

A special benefit of the ESS Import Only Mode is seen in the partial home backup configuration. Since ESS does not export current past the Consumption/PCS CT, the ESS need not be accounted for when calculating the backfeed current of the system. In a partial home backup scenario, the Encharge is only used to power the loads connected to the sub-panel [as shown below](#). However, there may be additional loads connected on the main panel. The Encharge does not power any of these loads since Encharge does not export to the main panel.

PCS Integration ensures no Encharge current is exported to the main panel. This is accomplished by measuring and controlling all production current and power. PCS ensures that the current being backfed into the main panel never exceeds the PV production current. As a result, installers only need to account for the size of the PV system while calculating backfeed and need not account for size of the ESS system installed. This eliminates the need for main panel upgrades saving labour and cost for installers and system owners. Note that PCS is covered in article 705.13 of the NEC 2020 edition. Authorities Having Jurisdiction (AHJs) may not recognize the PCS feature until the 2020 NEC is adopted in their region.

Installation of the Consumption/PCS CT

In this configuration, installer must ensure that the CT is installed correctly. The correct position for installing the CT is above the MID inside the Enpower cabinet.

NOTE: In this configuration, readings on the PCS/consumption CT have no visibility into consumption by the loads on the main panel.

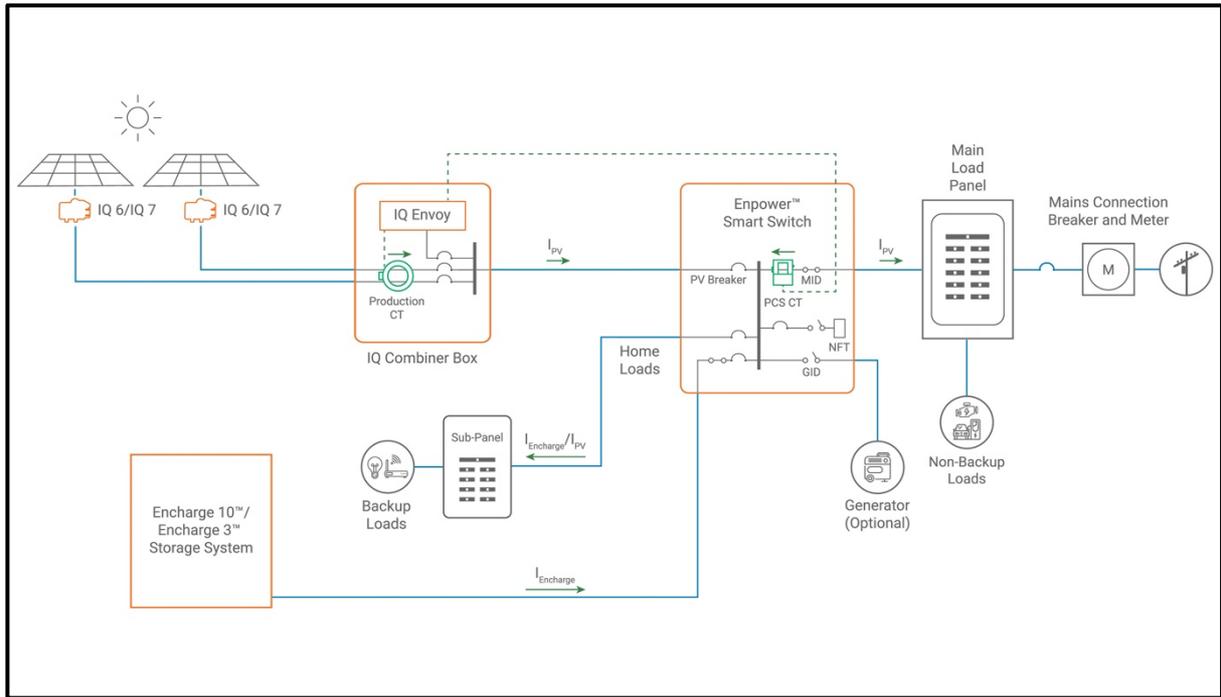


Figure 1 CT Placement in Partial Home Backup

Wiring Diagram of CT Placement inside the Enpower box over the MID and connection to the Envoy Terminal block

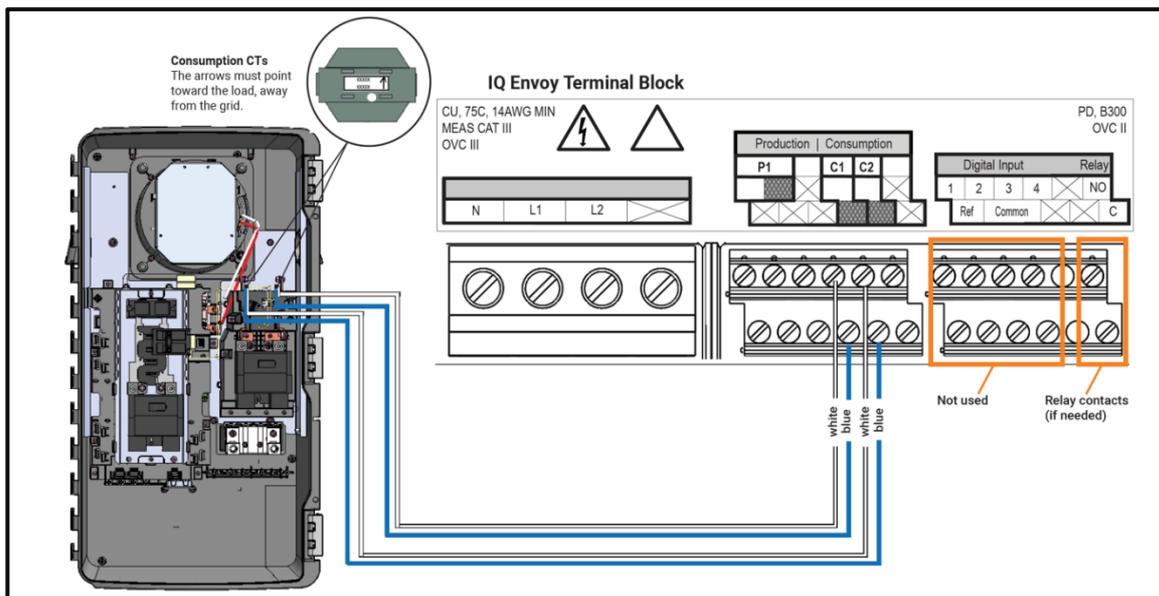


Figure 2: Wiring Diagram of PCS CT Placement inside Enpower and connection to Envoy

Image of Actual CT Placement inside Enpower

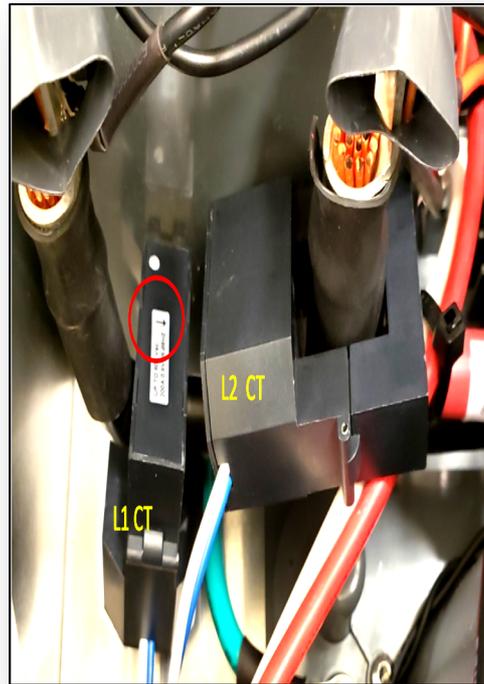
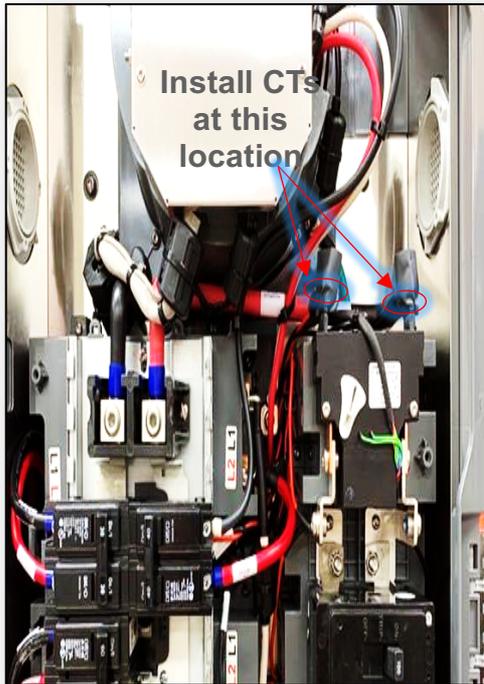


Figure 3: PCS CT placement location inside Enpower

Figure 4: Enpower with PCS CT installed

Alternate Position for Installing PCS CTs

Enphase's CT-200-SPLIT CT has recently been certified and modified for service entrance rating. CTs that have the "Service Entrance" label can be installed on the line side of the MID i.e., on the L1 and L2 supply cables. CTs that do not have the "Service Entrance" label can be installed on the L1 and L2 supply cables only if Enpower is not service entrance equipment and the mains breaker inside the Enpower is not acting as the service disconnect.

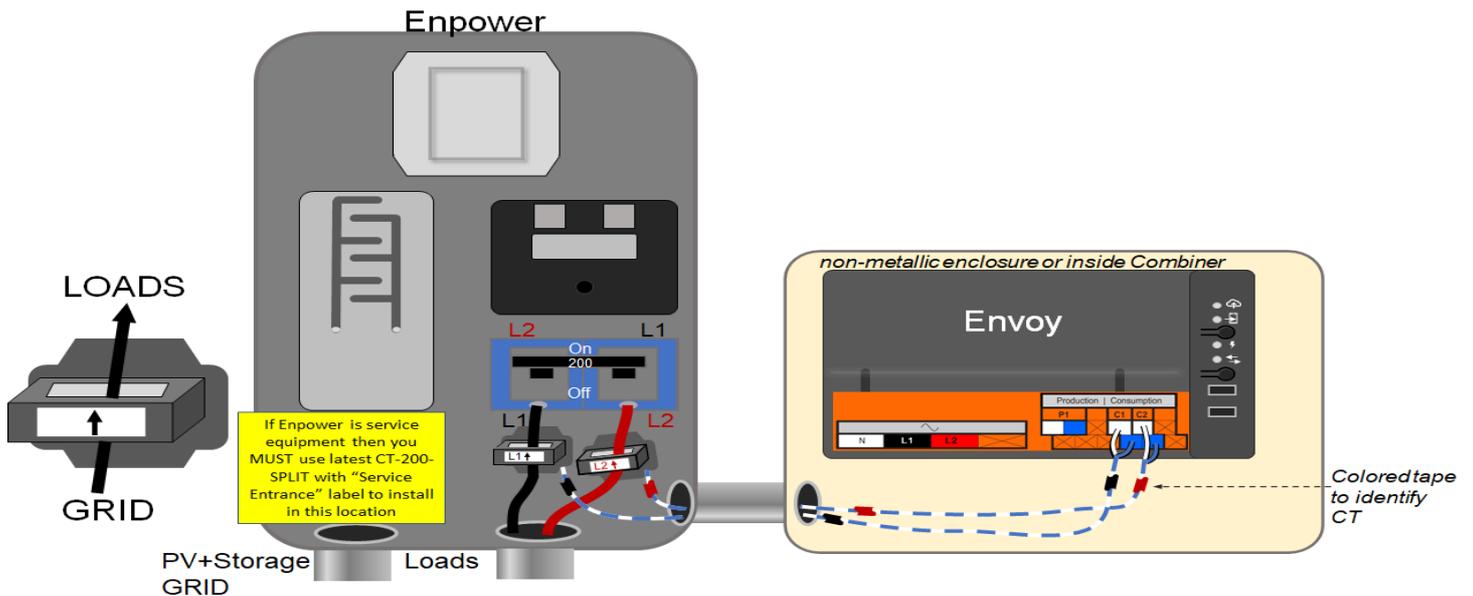


Figure 5 PCS CT Installation at service entrance

Main panel Upgrade avoidance Using PV Current Limiting

In the previous section, we explained how ESS does not export power back to the grid. Enphase's PCS also provides a configurable feature to limit the PV being backfed to a main panel in a partial home backup scenario.

When using the Encharge storage system in a partial home backup configuration, the back feed current allowed into the main panel is limited by the 2020 NEC article 705.12:

The *National Electric Code (NEC) 2020 705.12* allows back feed of current from solar/storage into the main panel subject to the following limit:

$$\text{Backfeed allowed} \leq ((120\% \text{ of busbar rating}) - \text{Ampacity of the overcurrent protection device protecting the busbar}) / 125\%$$

Note: This is the most common article limiting backfeed to the main panel. The NEC 2020 705.12 section also contain other articles that may be used to determine the backfeed limit. Later in this document, this rule may be referred to as the NEC120% rule.

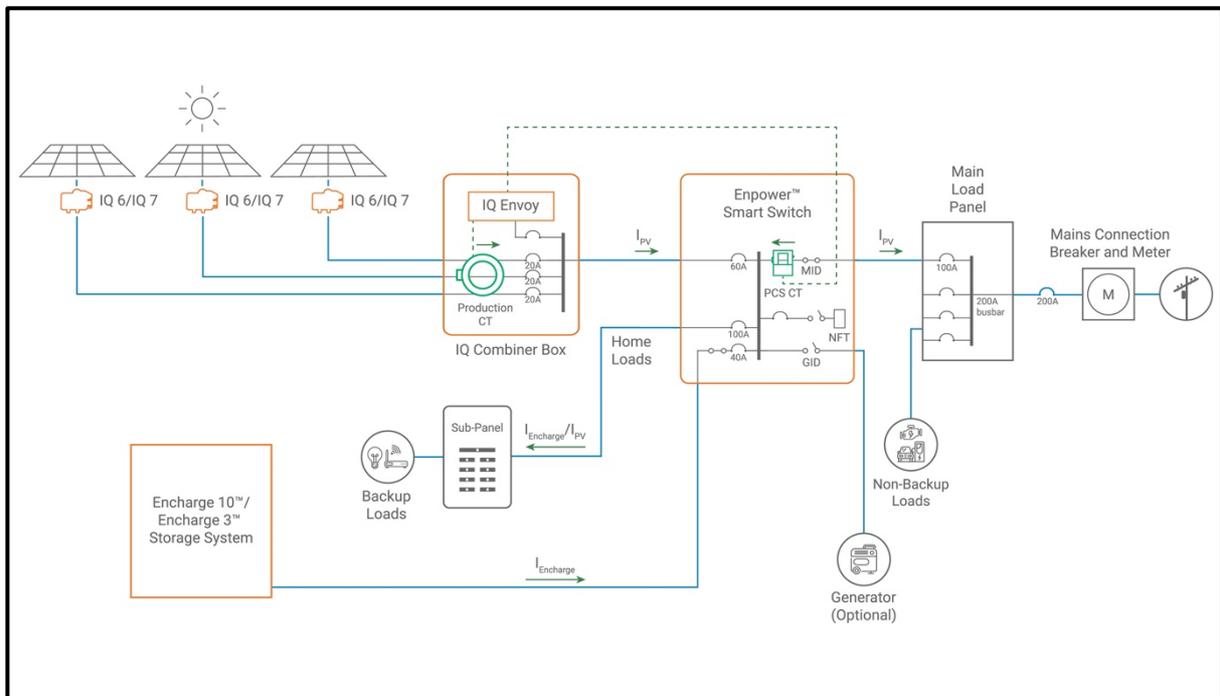


Figure 6: MPU avoidance by PV export limiting

For example, as seen in the diagram above, if the Main Load Panel Busbar is 200A and the grid size breaker is also 200A, the maximum continuous current back feed allowable from the Enpower and to the main panel is limited to:

$$((120\% * \text{busbar rating}) - \text{Main Breaker size}) / 125\% = \text{total DER current}$$

$$((120\% * 200) - 200) / 125\% = 32A$$

Thus, the system, in this scenario, will ensure that no more than 32A of continuous current is exported back to the main panel. The PCS/Consumption CTs are placed inside the Enpower cabinet over the MID relays (Refer the section *Installation of the Consumption/PCS CT* mentioned previously) and monitor the current being exported in real time and feed this information to the Envoy. ESS or Encharge batteries never export past the consumption CTs. If the current exported increases beyond 32A, the Envoy sends a signal to the PV microinverters to limit their production.

It is a good idea to estimate the baseline usage of the backup loads and account for the installation of Encharge batteries when determining the size of the PV system to be installed on a site. For example, consider a scenario where baseline usage of the backup loads is 1500W. If IQ7+ PV's are being

installed on a site that have max continuous AC output of 290W, we can effectively have 1500/290 i.e. 5 extra IQ7+ installed on a site with little risk of clipping. Even more PV's can be installed if the site has an Encharge present as the battery would consume a portion of the generated current for charging. Thus, the maximum allowable back feed should not be solely taken as a limiting factor in determining the size of the PV array.

Complying with Power Export Limit Regulations (PEL)

In certain jurisdictions, the max permissible output current is limited not just by the size of the busbar and breakers, but also by PEL regulations. Export Power regulations limit the maximum current that can be fed back by a Distributed Energy Resource (DER) connected to the grid. This maximum current value varies across jurisdictions.

Enphase provides grid profiles that comply with PEL limits for various jurisdictions. Enphase's ITK mobile app allows for the selection of the appropriate grid profile for any installation. Once the installer sets the profile, the system ensures that the current exported to the grid shall never exceed the PEL limit. In a situation where both the PCS Integration and a PEL profile are being used, the maximum current backfed from the Enpower to the main panel is always the lower of the PEL limit and the PCS limit.

PCS Compliance in Failure Mode

Enphase's PCS system is designed for robustness. The system ensures adherence to the NEC guidelines of current backfeed even when one or more devices have stopped communicating with the Envoy.

Failure Mode	Resolution Mechanism
Encharge Communication Failure	If the Envoy loses communication with Encharge for more than 20 seconds, the Encharge battery discharge is completely curtailed.
Microinverter Communication Failure	If Envoy loses communication for more than 10 seconds with the microinverter, the PV production will be curtailed to the safe limit.
PCS controller or Envoy Failure	All PV and Encharge discharge are curtailed
Current Transformer not reporting correct value/ Missing Current Transformer	PV production will be curtailed to at most 80% of the breaker size

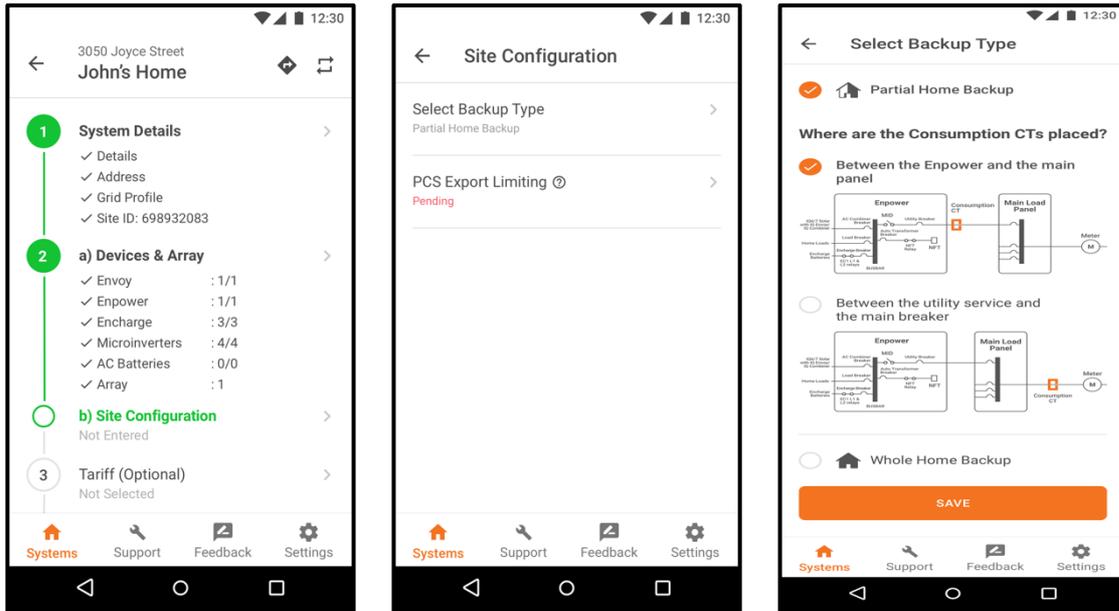
Configuring MPU Avoidance via ITK

Installers can configure Enphase's PCS Integration for Main Panel Upgrade avoidance through their ITK app. The MPU avoidance use case can be enabled via ITK during installation at *Step 2 b) Site Configuration* as shown in the figure below.

In the site configuration menu, the user can see 2 options:

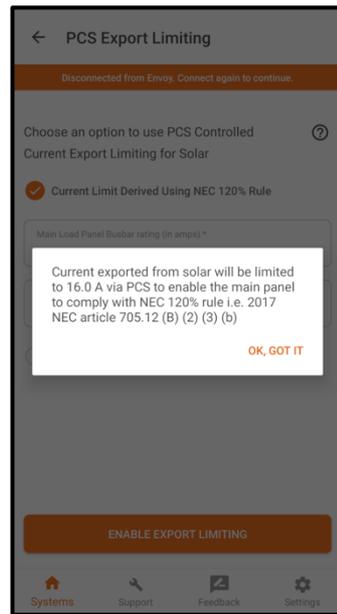
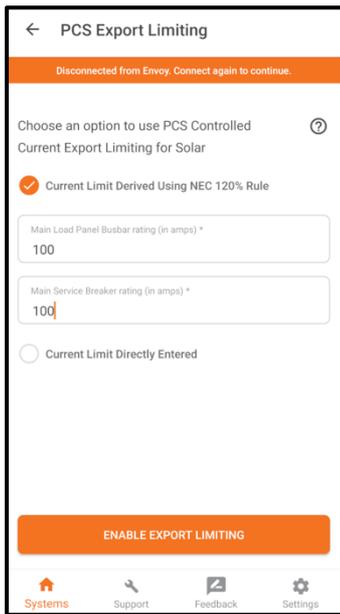
- Select Backup Type
- PCS Export Limiting

As the MPU avoidance use case can only be enabled in the partial home backup mode, the installer must first select the *'Partial Home Backup'* configuration under *'Select Backup Type'*. Once this is done, the installer can move to the *'PCS Export Limiting'* section.

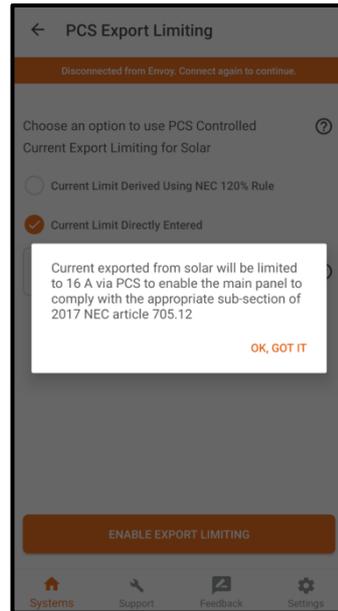
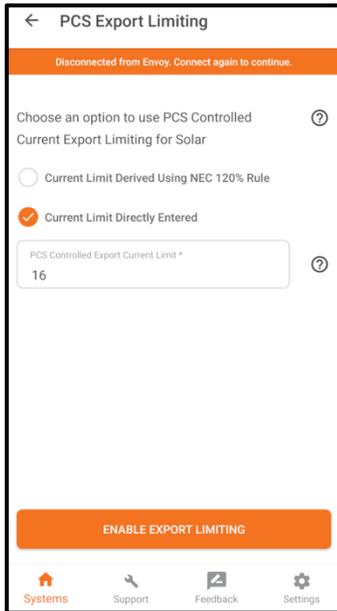


In the *PCS Export Limiting* section, the installer has two ways of setting up PCS Integration:

- Current limit Derived using NEC 120% rule:** In this option, the installer adds information on the rating of the main load panel busbar & the main service breaker rating. The system then auto-calculates the export current limit based on the 2017 NEC 705.12(B)(2)(3) rule.



- Currently Limit Directly Entered by Installer:** In this option, the installer has the ability to directly set the PCS export current limit based on their discretion.

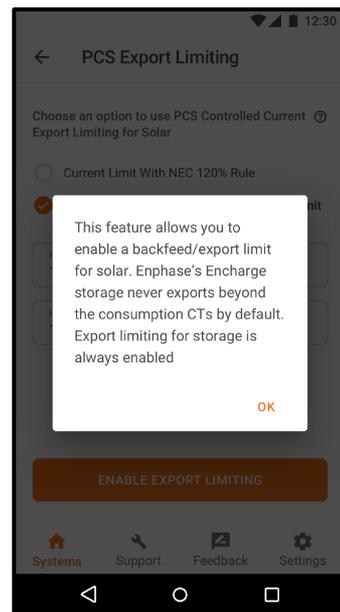
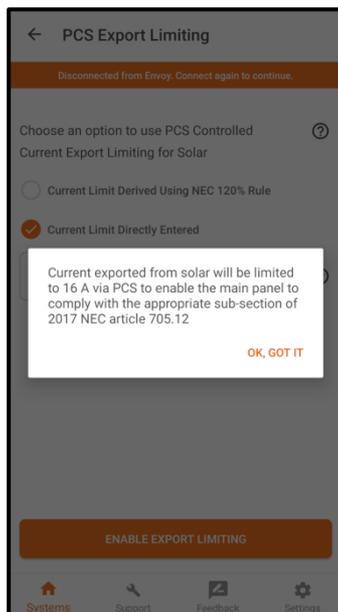
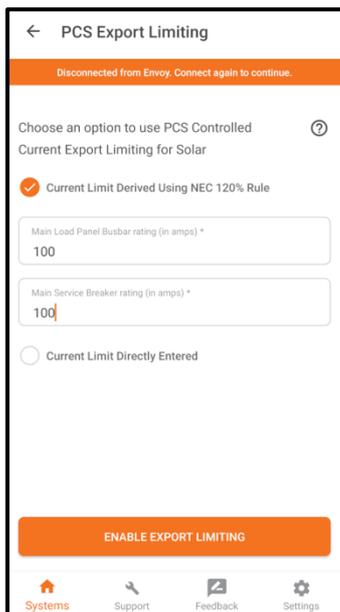


Case Study: Setting up PCS Integration at Mary’s Home that has the Enphase Storage System installed

Mary’s home has a system with 26 IQ7+ microinverters deployed on the site. Based on this configuration, the back feed from the Enpower to the main load panel can be as high as 31A. However, her home has a main load panel busbar rating of 100A and a main service breaker rating of 100A. For a site with these configurations, the maximum allowable back feed as per the NEC 705.12 rule is 16A.

In the absence of PCS Integration, Mary would have to opt for a main panel upgrade in order to add these many desired microinverters. This could cost her thousands of dollars and would require multiple hours of labour from a certified electrician on-site.

Now, with Enphase’s Main panel upgrade avoidance mode, all such issues are eliminated. The installer simply enables the *PCS Export Limiting* feature during site installation and the system will ensure that the current backfed to the main panel never exceeds 16A.



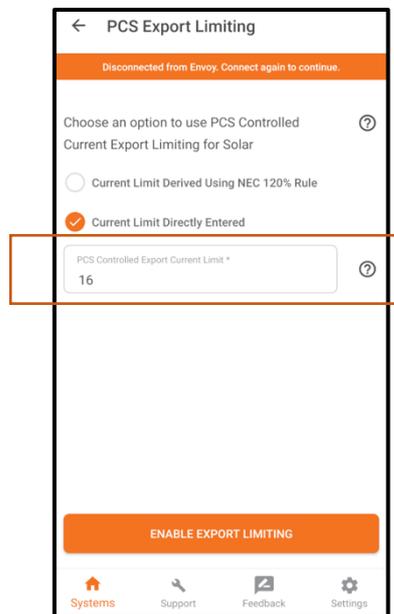
Curtailing Max Export Current for compatibility with additional systems on site

There may be situations where a homeowner may have an addition DER system connected to the main panel that is not monitored by Enphase’s PCS Integration. This could be a DER from another manufacturer or Enphase’s legacy micro-inverters. In either case, it is important for the installer to account for the current being back fed from such a system and ensure they limit the max current export value of the Enphase Storage System so that the total current exported back to the grid remains compliant with the NEC guidelines.

Also, there may be other situations where the site may be compliant with one of the subsections of 2017 NEC 705.12 rule other than the 2017 NEC 705.12(B)(2)(3)(b) rule that Enphase’s PCS Integration uses for auto calculating the max backfeed current allowable.

To account for such situations, the ITK app provides installers with the ability to define the max allowable back feed current by setting the ‘PCS Controlled Export Current Limit’ parameter in ITK. Only if this parameter is not set will the system auto calculate this value.

For example, Mary may want to add another DER system to her home. Because of the addition of this new DER, the Enphase Storage System installed at her residence should ensure it does not export any more than 16A of continuous current. To do so, the installer simply has to set the PCS controlled export limit to 16A in the ITK app. Enphase’s PCS will ensure it uses this installer defined value to limit the current.



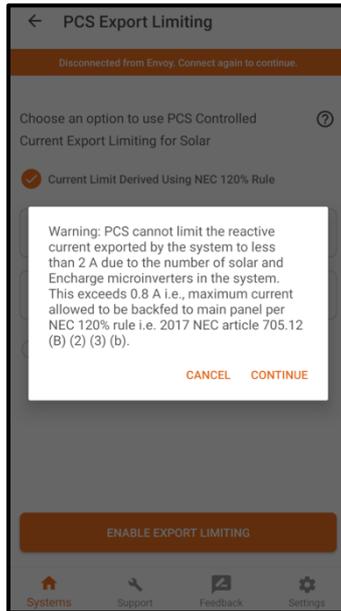
Accounting for currents due to reactive power in the system

There is a certain amount of reactive power always generated in the system due to the presence of capacitors inside the PV and Encharge microinverters present in the system. Due to the presence of this reactive power in the system, the current from the system can never be completely curtailed down to 0.

This does not impact our functionality of limiting export to grid in any way because reactive power is not accounted for by utilities when measuring the export from DER to the utility grid. Utilities calculate export based on the active power component. However, this current due to reactive power has to be taken into account when using PCS for controlling the export current from the DER to the main panel to avoid a main panel upgrade.

Handling reactive power when current limit is derived based on the NEC 120% rule

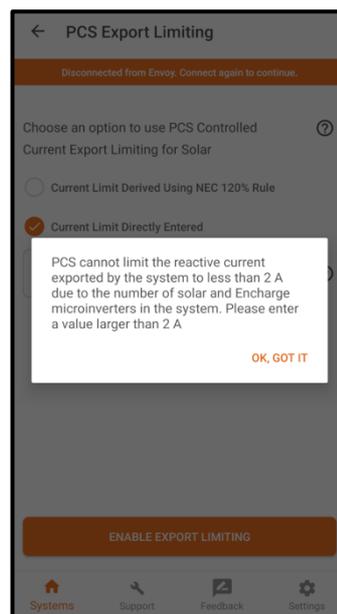
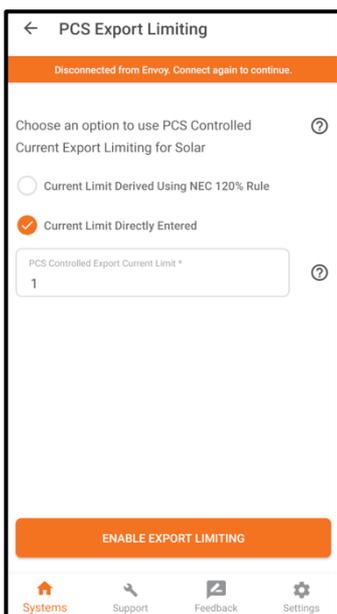
If the installer enters a system configuration such that the total current in the system due to reactive power will exceed the limit to which the export current needs to be curtailed based on the NEC 120% rule, the installer will see a popup similar to the one mentioned below:



The installer will have the option to click 'CANCEL' and re-enter the system configuration if required or click 'CONTINUE' and proceed. If installer chooses to proceed, the system will limit the export current to the current generated due to the reactive power generated in the system and cannot limit to any value below that and hence there is a possibility of the system not being compliant with the NEC 120% rule.

Handling reactive power when current limit is directly entered by the installer

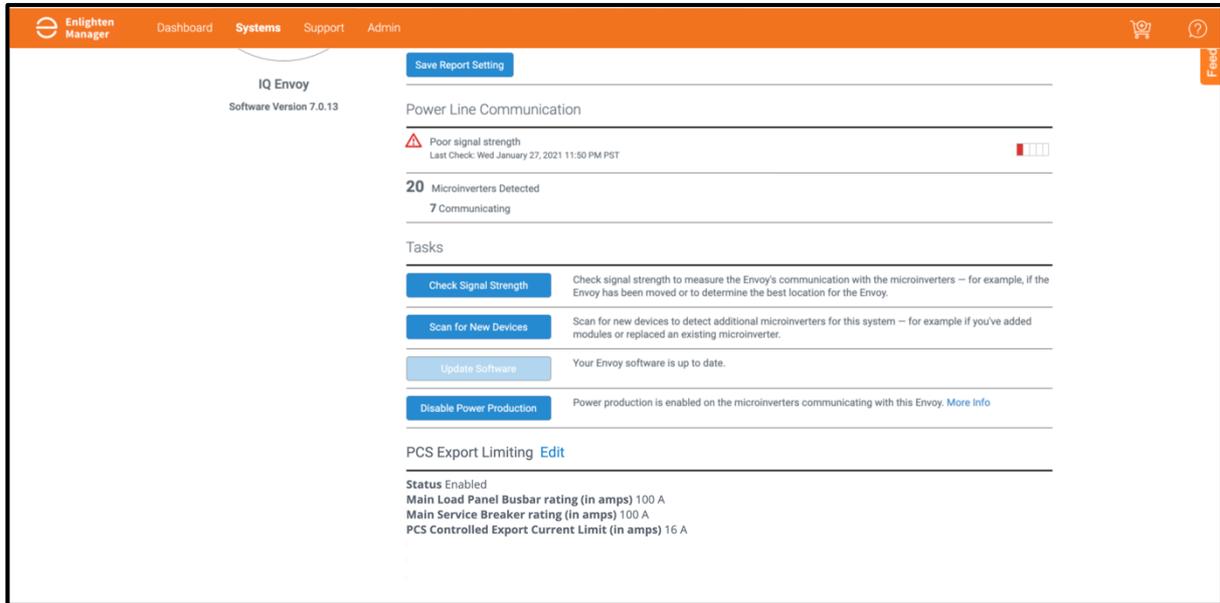
We need to account for the presence of currents due to reactive power in the system. If the installer enters a value that is lower than the total current generated by reactive power in the system, the installer is shown a pop as below asking the installer to re-enter an appropriate value.



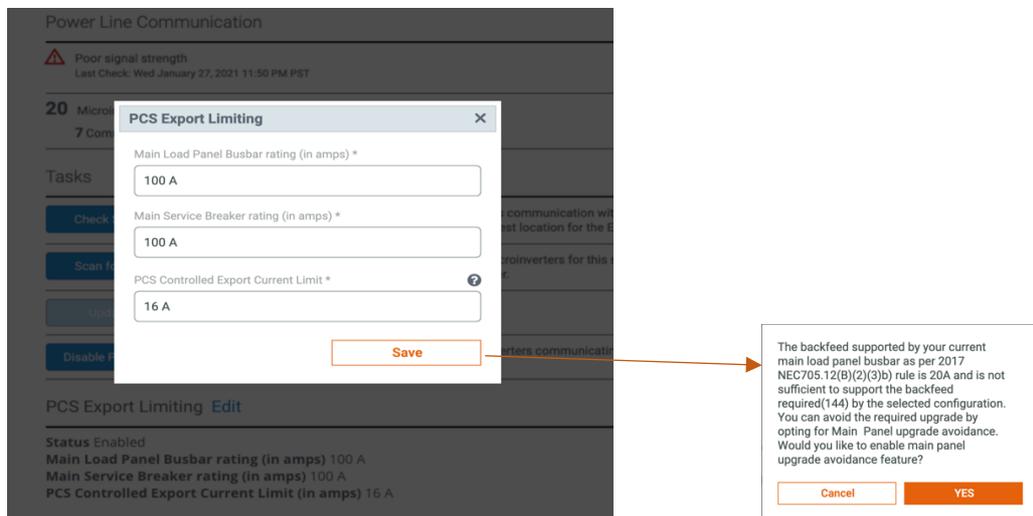
Configuring MPU Avoidance via Enlighten Manager

PCS Integration for MPU avoidance is available in Envoy device details page of Enlighten Manager (ENLM). Once the PCS Integration is set up in ITK, the same info will be available in ENLM.

NOTE: At any point of time, Installer can change this setting within ENLM.



The installer will be able to see an 'Edit' option next to the 'PCS Details' section. Once the installer clicks this, they will have the ability to edit the system details that they added via the ITK.



The installer can use this to edit the entered system configuration as required. Once the installer saves the new values, the system will ensure it uses this data to calculate the new backfeed limits and will limit the current exported from Enpower to main panel to this newly calculated maximum value.