Power Control System Technical Brief

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Overview

Power Control Systems (PCS), as defined in NFPA 70, National Electrical Code 2020 Edition, Section 705.13, control the output of one or more power production sources, energy storage systems (ESS), and other equipment.

This document describes the functionality of FranklinWH PCS.

Components of PCS

The FranklinWH PCS is comprised of the following components:

- **aGate.** The system's power controller, which interconnects grid, solar, generator and battery energy to support home loads.
- **aPower.** An AC-coupled battery. A FranklinWH ESS can have one or more aPowers. Each aPower has battery cells, a battery inverter and a battery management system (BMS).
- **CTs.** The PV production CTs and grid CTs are factory-installed in the aGate. The PV production CTs monitor the power generated by the PV. The PCS CTs monitor the backfeed current from the aGate to the grid / Main Panel in real time.
- **Energy Management System (EMS).** Integrated in the aGate, the EMS receives the current reported by the CTs and limits the aPower current as required to comply with aGate grid connection.
- **APbox**. Optional certified PCS accessory to FranklinWH ESS, which allows independent metering and EMS relay control of PV circuits routed through it.
- **FranklinWH App.** Authorized personnel only are able to change PCS settings through the smart phone app.

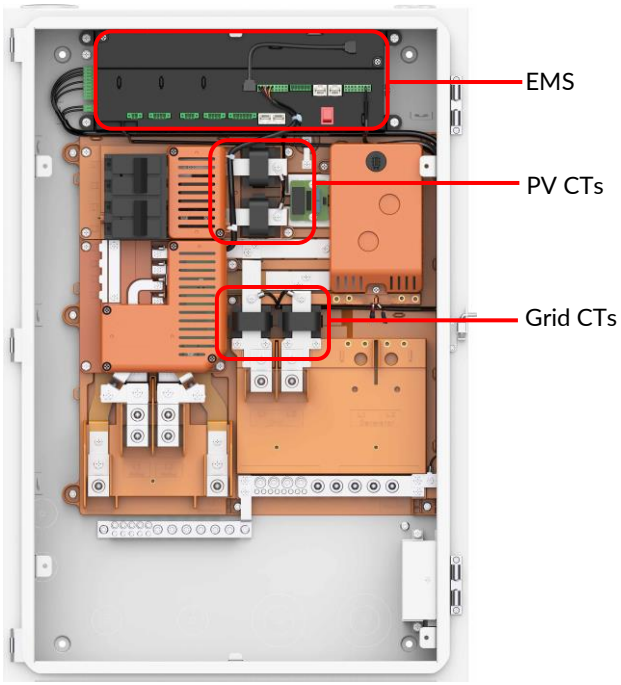

Figure 1 PV & Grid CTs placement inside the aGate

Supported PCS functions in the FranklinWH ESS

ESS Import Only Mode

In ESS Import-Only Mode, the residential ESS never exports power to the grid, the battery is only allowed to discharge power to home loads. The FranklinWH PCS integration with Import Only Mode, which is UL1741 PCS certified, limits the battery discharge power so that it never exceeds the home consumption. This import only mode is factory preset in the software.

Complying with Power Export Limit (PEL) Regulations

In some jurisdictions, local power export regulations limit the maximum current that can be fed back by a Distributed Energy Resource (DER) connected to the grid. For example, in the Customer Self Supply(CSS) Program, customers in Hawaii are not allowed to export any electricity to the grid. This zero export extends to both solar PV and battery output – no power can return to the grid from the home energy system.

Partial home backups with meter main combination panels where loads remain in the upstream main panel will have smaller breakers feeding the aGate's grid input. The PCS limitation may be set to prevent nuisance tripping.

The FranklinWH PCS controller ensures the maximum backfeed current from aGate to main panel is always lower than the PEL limit and the panel busbar limit.

During commissioning, the installer can configure the export power to the grid through the FranklinWH App, as shown in the screenshot below. Once "Allow solar feed to grid" is disabled, PCS function ensures the system never exports any power to the grid.

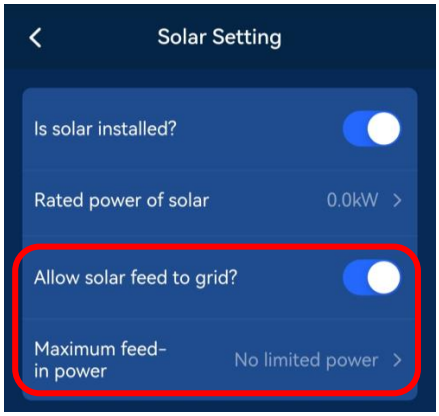

Figure 2 Solar setting

Grid Import Limitations

In some jurisdictions, the utility limits how much DERs, such as the aPower, can charge from the grid, or may even prohibit the DER from charging from the grid. That means no power from the grid may be stored in the aPower battery and the aPower battery can only be charged from the solar system or generator. In this situation, FranklinWH PCS controller can ensure the system meets the charge limits configured via the app, as shown below.

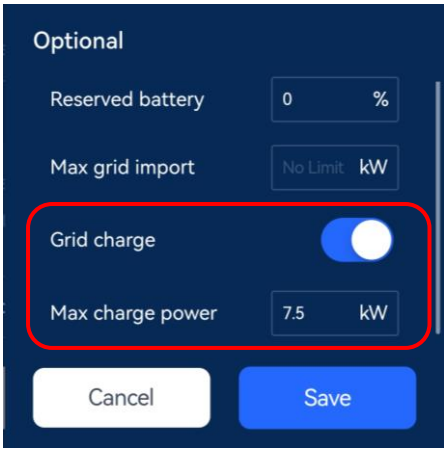

Figure 4 Grid charge setting

Main Panel Upgrade Avoidance

Main panel upgrade avoidance using the NEC 120% rule

2020 NEC 705.12 B(3)(2) mandates export from PV/storage to the main panel as follows:

125% (PV + Battery) backfeed + Main Breaker Size ≤ (Busbar Rating x 1.2)

In many PV plus storage systems, the main panel busbar rating may become a limiting factor when expanding the system size. One solution is to replace the existing main panel with a new panel that has a higher busbar rating, which may cost thousands of dollars and result in permitting delays. FranklinWH's PCS can measure and limit the backfeed current from solar or aPower to the main panel, make sure that the export to the grid never results in a busbar overload, thus avoiding a main panel upgrade (MPU).

Scenario 1 – Partial home back up on a 200A busbar with a 40A breaker

As seen in the diagram below, if the main service panel busbar is 200A and the main breaker is also 200A, the maximum continuous current backfeed allowable from the aGate to the main panel is limited to 32A using the 120% rule.

((*Busbar Rating x 1.2*) – Main Breaker size)/125%= DER current

((200*1.2)-200)/125% = 32A

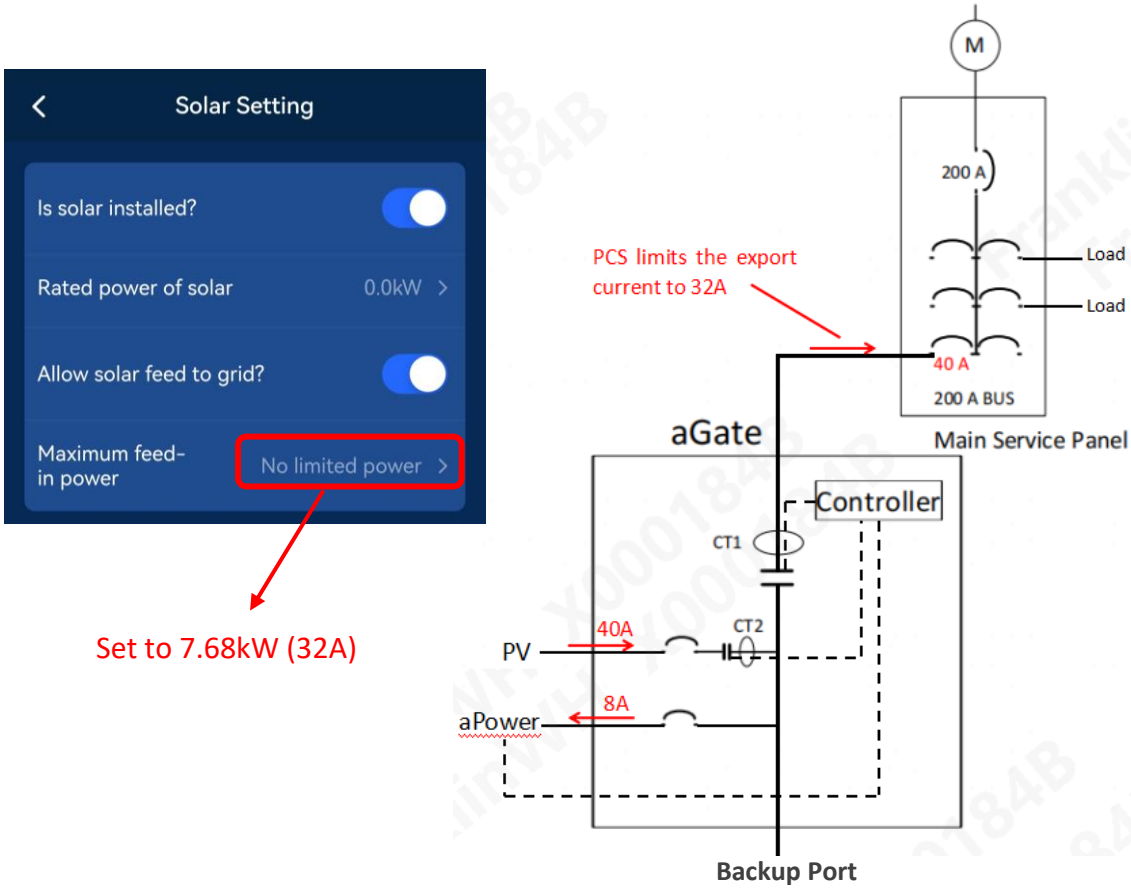

Figure 5 Partial home back up on a 200A busbar with a 40A breaker

In this scenario, the aGate PCS will ensure that no more than 32A continuous current is exported back to the main panel. The grid CTs (Figure 1) inside the aGate monitor the current being exported in real time and feed this information to the EMS. If the current exported to the main panel goes beyond 32A, the aGate will send a signal to cut off the PV system by opening the PV relay inside the aGate, preventing the main panel busbar from overloading. This process means an MPU is not required.

Scenario 2 – Whole or partial home back up on a 100A busbar

Typically, the connection between the aGate and main panel is not lower than 100A. In a meter main combo with a 100A main breaker and 100A busbar, depicted in the figure below, when introducing a solar PV or battery energy storage system that can supply additional power from the opposite side of the main breaker supply. There are now two separate sources feeding power from opposite ends and no single protection device that prevents the busbar from becoming overloaded. To remedy that, one solution is upgrade the main panel with a higher busbar rating, which may cost thousands of dollars.

Alternatively, to avoid a MPU, connect the PV system output to aGate PV interface, relocate all the circuit breakers from the original main panel to a panel mounted at the aGate backup port, and replace them with a single 100A circuit breaker in the original main panel whose conductors are run directly to the aGate grid entrance which can sustain a current flow of up to 200A.

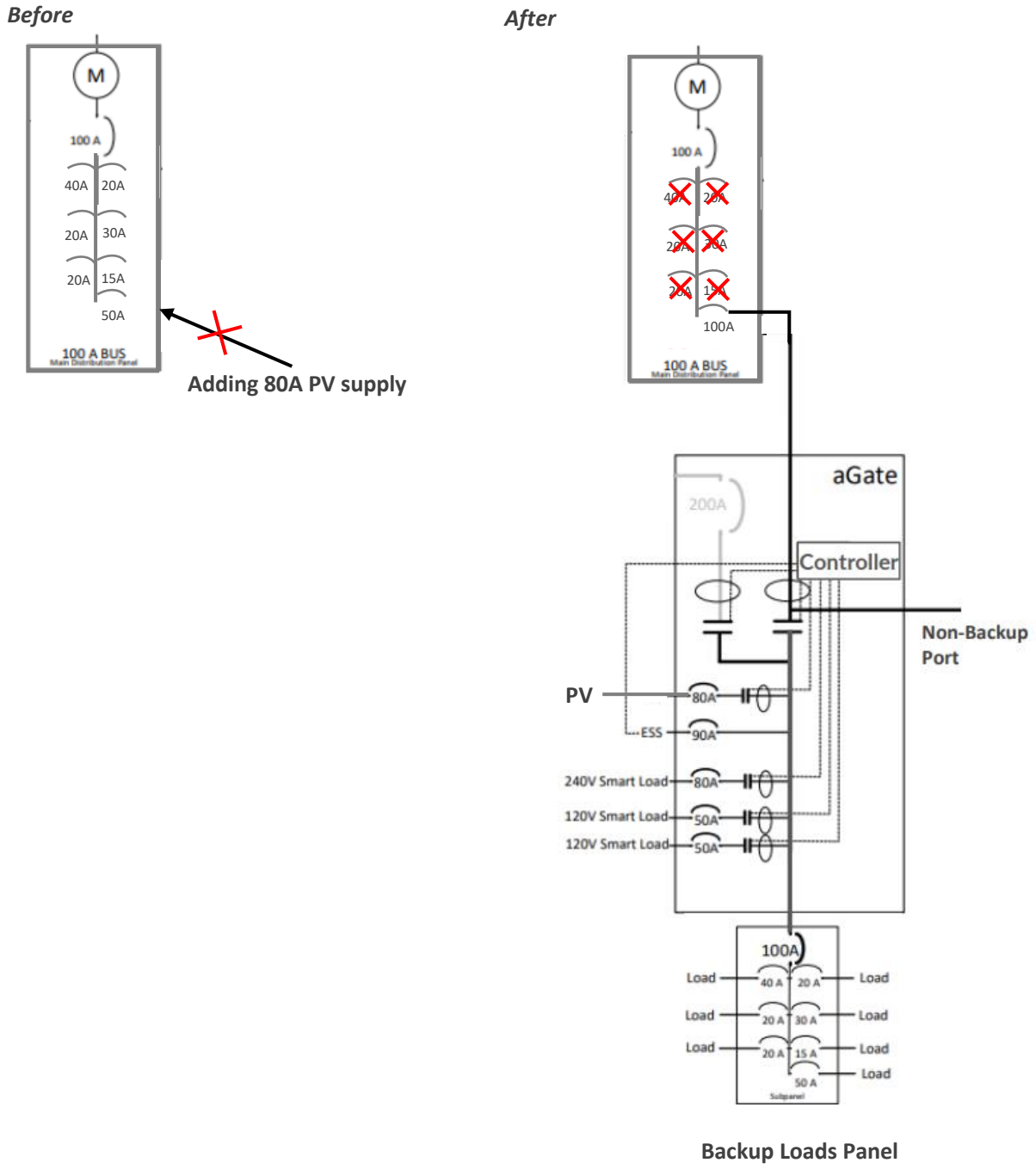

Figure 6 Whole or partial home back up on a 100A busbar (In a meter main combo)

In a similar scenario as above, in a main panel with 100A main breaker and 100A busbar, and the meter is separate, as depicted below, to avoid an MPU when adding PV or energy storage system, connect the PV system output to aGate PV interface, rewire the original main panel to the aGate backup port, if allowed by the utility, and connect the service conductors to the grid entrance terminal inside the aGate.

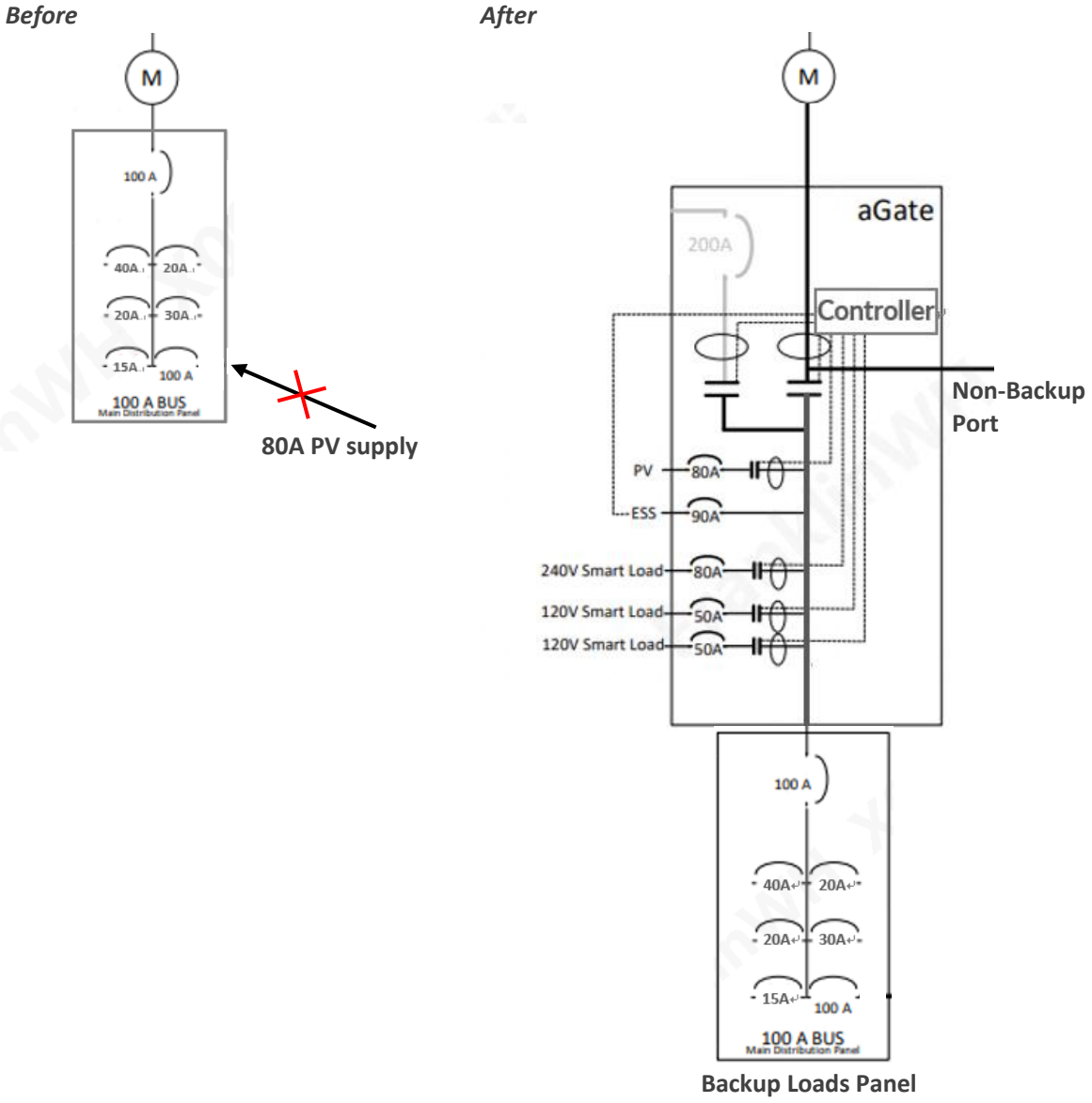

Figure 7 Whole or partial home back up on a 100A busbar (in a main panel with a separate meter)

aGate Busbar Overload Protection Mechanism

The busbar of the aGate is rated at 280A. The over current protection devices (OCPD) populated inside the aGate for the aPower circuit, PV input and grid entrance are shown in the table below.

Table 1 OCPD Size

OCPD	Size (Maximum current)
aPower circuit	100A
PV input	80A
Grid entrance	200A

The EMS communicates with aPower batteries via CAN bus cables. The aPower batteries discharge/charge according to the commands from the aGate, including limiting the discharge/charge power. The aGate monitors the current at the PV input and grid entrance through the CTs.

The FranklinWH PCS can adjust the aPower charge/discharge power, or cut off the PV to make sure that the aPower discharge current + Grid input + Solar input ⩽ 280A, or the Grid input + Solar input⩽ 280A (when the aPower is charging). This is NEC 705.13 compliant and is factory-programmed into the system.

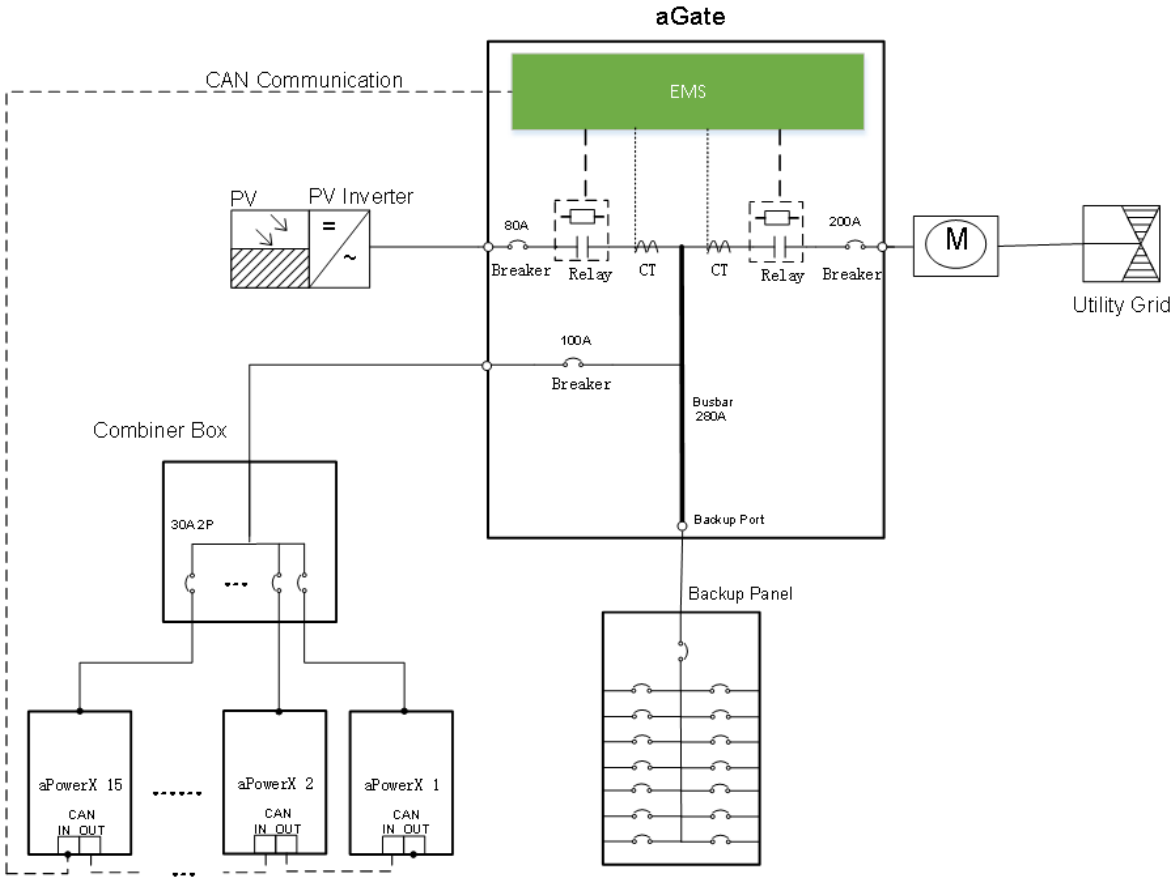

Figure 8 aGate Busbar Overload Protection Mechanism

NEM/NBT Compliant PCS Application

Case 1: Partial Home Backup

In some other situations, among a 200A main panel with a 200A busbar, a legacy PV, which is allowed to export to the grid, is connected to the main panel.

In a partial backup solution, when adding a new PV plus storage operating in NEM/NBT, to maintain NEC 120% rule without affecting customer's legacy PV export credit, it's recommended that:

1. Connect the new PV directly to the aGate PV breaker.
2. Relocate the factory-installed grid CT to the main panel for monitoring the grid current.
3. Add an external CT to monitor the legacy PV generation.
4. Set the **Service entrance breaker rated current** ensuring complying with NEC 120 rule during commissioning.

The aGate PCS function will make sure the current exported to the grid will not exceeds the legacy PV generation (i.e., $I_{grid}<I_{pv}$).

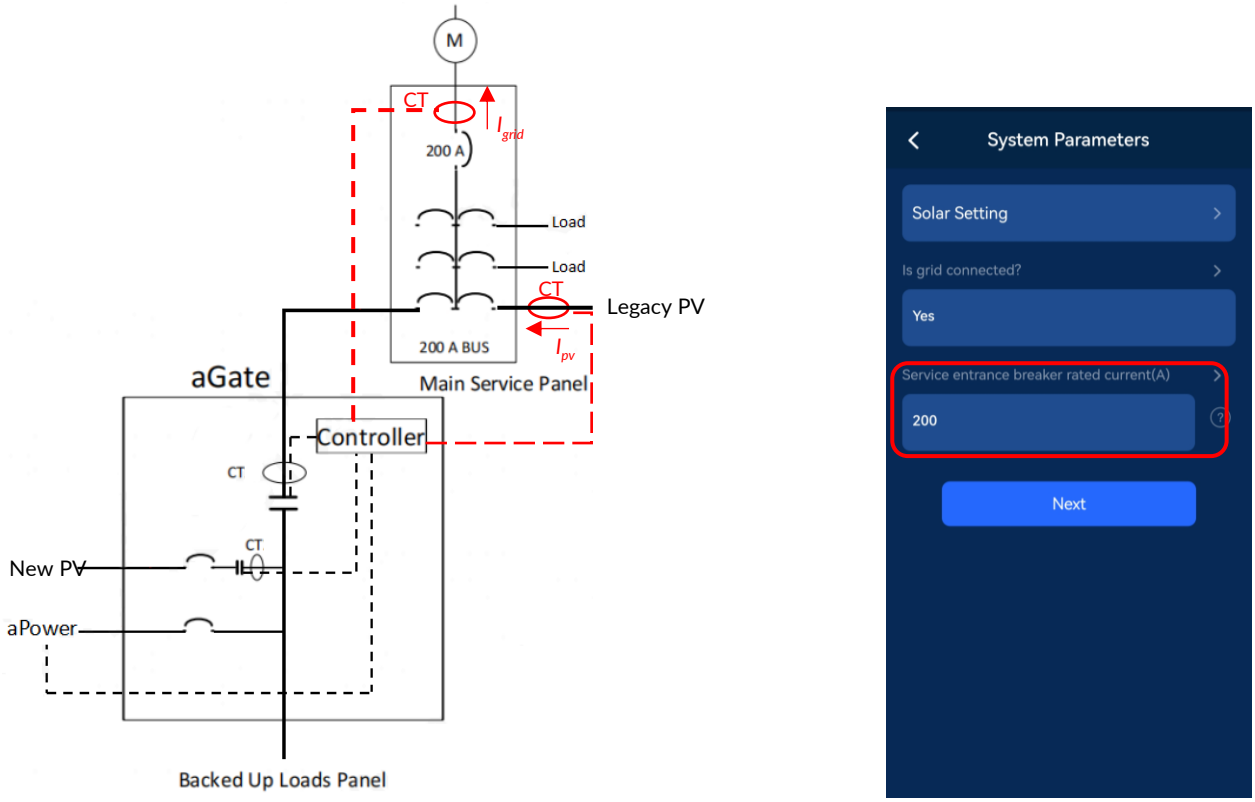

Figure 9 Partial home backup

Case 2: Whole Home Backup

In some other situations, among a 200A main panel with a 200A busbar, a legacy PV, which is allowed to export to the grid, is connected to the main panel.

In a whole home backup solution, when adding a new PV plus storage, to maintain NEC 120% rule without affecting customer's legacy PV export credit, either solution A or B described below is practical.

Solution A

1. Connect the grid service conductors to the aGate grid terminal.
2. Relocate the main panel to the aGate backup port.
3. Connect the legacy PV to the backup panel via a FranklinWH aPbox.

The aGate PCS function will make sure the current exported to the grid will not exceeds the legacy PV generation (i.e., $I_{grid}<I_{pv}$).

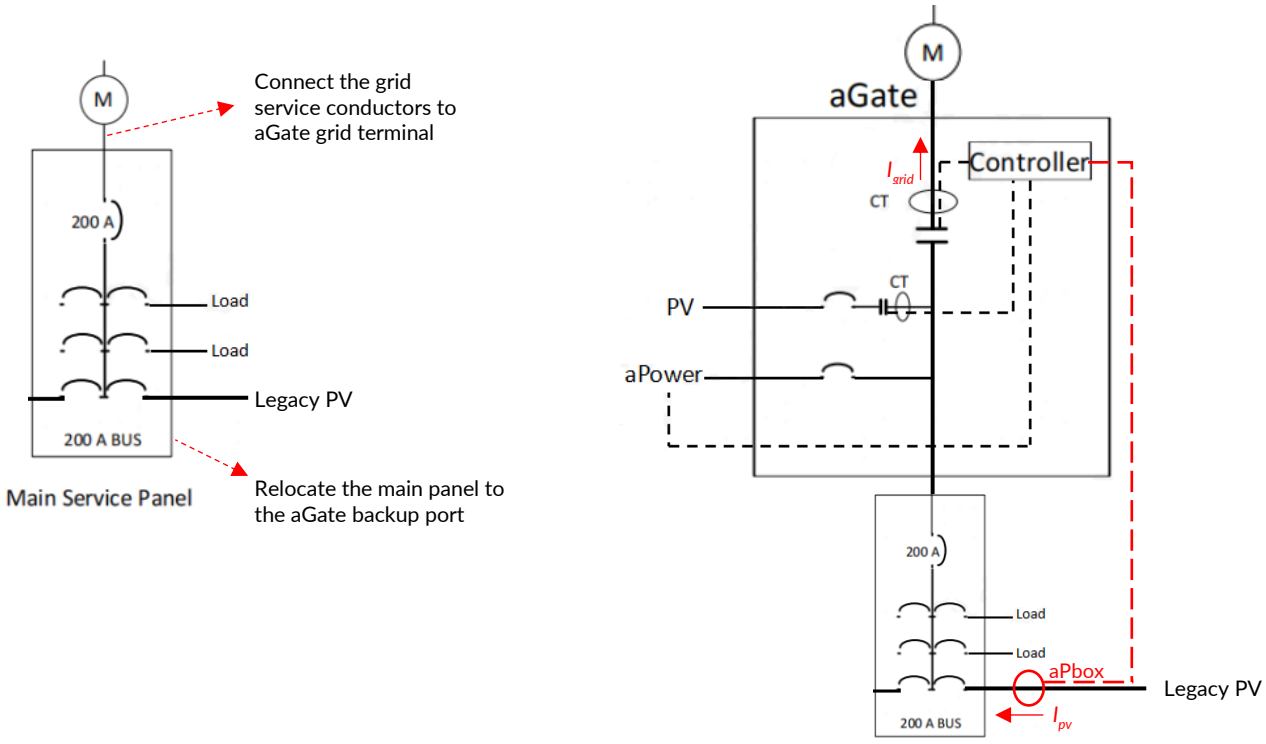

Figure 10 Whole home backup solution A

Solution B

1. Connect the grid service conductors to the aGate grid terminal.
2. Relocate the main panel to the aGate backup port.
3. Relocate the legacy PV to the grid.
4. Install an external CT to monitor the legacy PV generation.

The aGate PCS function will make sure the current exported to the grid will not exceeds the legacy PV generation (i.e., $I_{grid}<I_{pv}$).

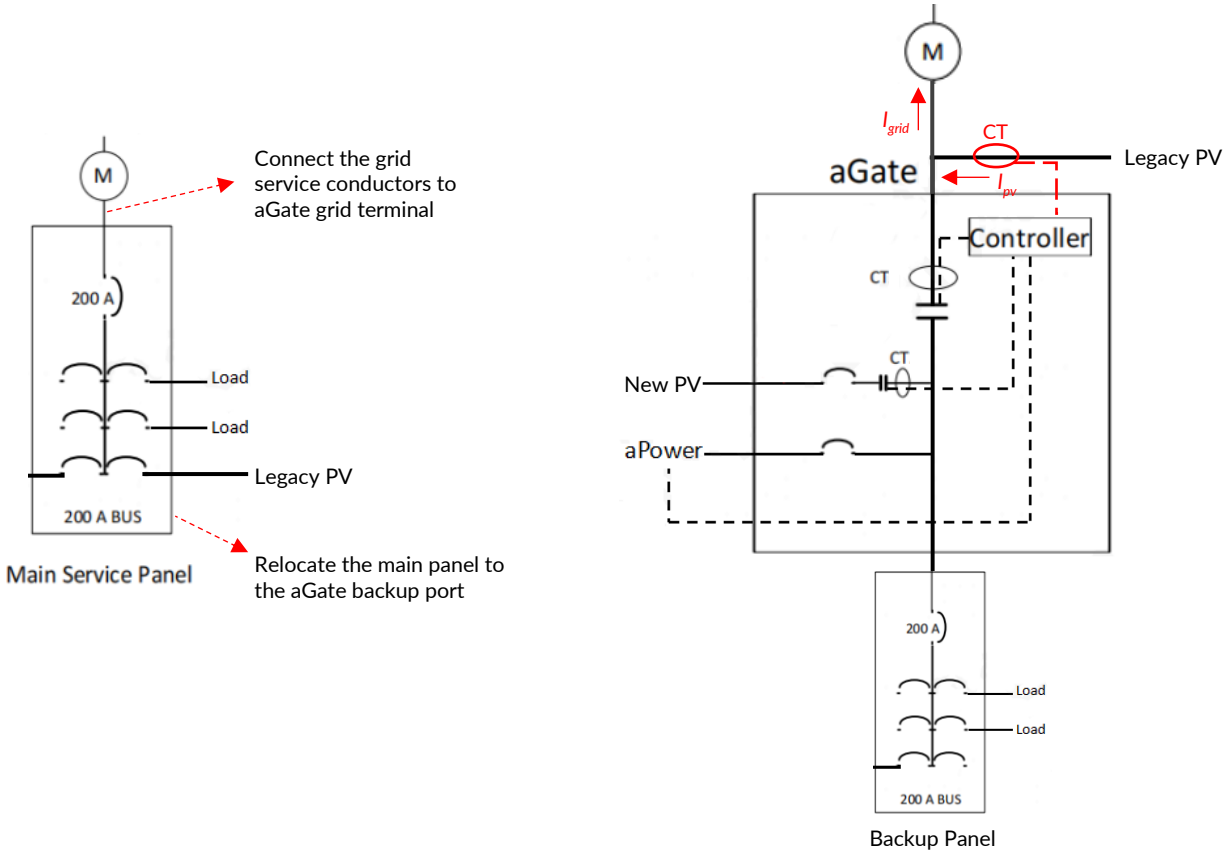

Figure 11 Whole home backup solution B

Supplement to PCS

Prohibit generator feedback to the grid

The aGate has a built-in generator port, where a standby generator can be connected. The aGate controller ensures the generator is disconnected when the grid is normal. The generator operation can be configured by installers during the commissioning via the FranklinWH App, as shown in the image below.

In case a fault occurs with the grid, the system will automatically disconnect from the grid with anti-islanding technology (the grid relay will be open) and the ESS supports the load demand of the backup circuit. When the aPower battery capacity drops below the reserved SOC threshold and the solar production cannot keep up the battery recharging, the generator will take over to power the home and charge the batteries (the generator relay will be closed) until the aPower battery SOC reaches the reserved value or the grid returns to normal. There is no possibility that the generator will feed power to the grid due to dual relay isolation. Grid relay and generator relay placement are shown below.

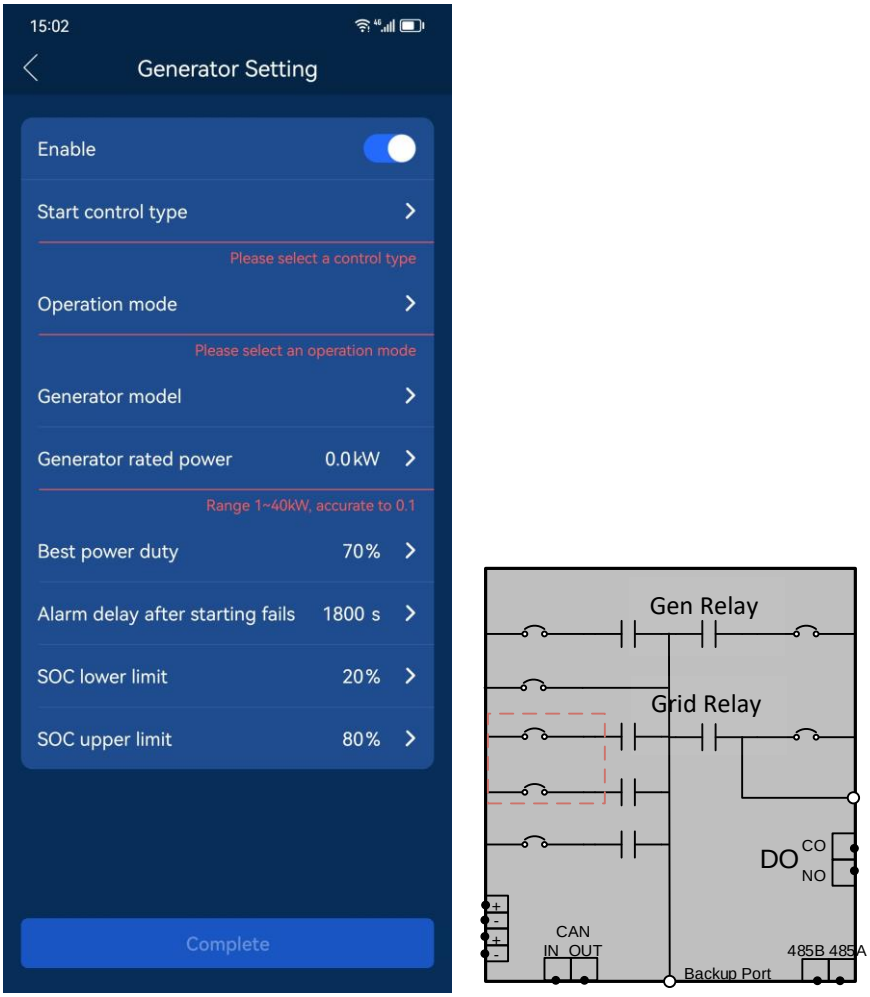

Figure 10 Prohibit generator feedback to the grid