POWERWALL OFF-GRID SYSTEM DESIGN AND INSTALLATION

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1. Powerwall Off-Grid Overview

Off-Grid Requirements

- Stable internet connection is needed, not just for install and commissioning – Off-Grid features will not be available without it.

- Compatible with Backup Gateway 1.

- Powerwall must be installed in the heat envelope of the home (10– 30°C / 50- 86°F).

- A secondary energy source, such as a generator, is best practice. See page 5 for compatible options.

- Single phase loads only.

To qualify for the 10-year Powerwall warranty, <u>all system requirements defined in this document are mandatory.</u>

Differences from Grid-Tied Systems

- Always whole-home backup.

- All load centers must be on the load-side of the Backup Gateway.

- The line-side of the Backup Gateway should be left open or connected to a compatible generator.

- No need to relocate loads in most cases.

- Firmware updates are required and will cause a momentary outage. Please inform customers of this requirement.

Generator Functionality

If the Powerwall system reaches a low state of energy, the generator will automatically turn on – this threshold will be set at the time of commissioning. Once the generator turns on, it will be able to supply power to home loads and charge the Powerwall. The generator will not turn on if solar panels are producing power. The default thresholds are 20% and 40% of the Powerwall's state of energy, however these are variable and will result in longer runtime or more frequent generator starts depending on the site.

2. Design Guidelines

System Sizing Principles

Incorrect sizing will result in additional generator usage or power outages.

To size a system, use the Off-Grid Sizing Tool in Partner Portal. This tool will help determine customer usage and the site's annual low point of solar. Systems should have enough solar to address energy needs at the annual low point.

Key design guidelines:

- At least one Powerwall per 5 kW AC of solar.
- At least enough Powerwalls to support loads for 1 day – assume 80% of Powerwall's energy is available.
- At least one Powerwall per 5 kW of expected peak load on site.
- Sizing guidelines increase when solar is the only energy source
- Minimum of 2 Powerwalls per install without solar and minimum of 2 Powerwalls without generator.

State of Energy

Low State of Energy – Wait for Solar

When an Off-Grid Powerwall system reaches 10% energy remaining, it will stop grid forming and enter "wait-for-solar" mode – this will cause the home to lose power. Powerwall will check for excess solar generation every hour from 8:00 a.m. to 4:00 p.m. local time by grid forming for ~6 minutes to allow the solar inverter to wake up and start producing. If Powerwall does not see enough solar generation to power loads and begin charging, the power will remain off.

When sizing for one day of autonomy, 10% of energy will not be useable.

High State of Energy – Solar Curtailment

Once Powerwall is at full charge capacity, the Backup Gateway alters the frequency to notify the inverter to curtail solar generation to match home loads. This allows Powerwall to remain at 100% charge and power the home loads directly from solar power. To review frequency settings, see page 13.

Grid Forming

When Off-Grid, Powerwall will reserve some energy within the top 5%-10% for grid-forming. This means the Powerwall app may not show the system reaching a full 100%. This is normal and should be considered when sizing.

Electrical Layout

Below is a typical system layout. Follow the electrical guidelines of the country of install.
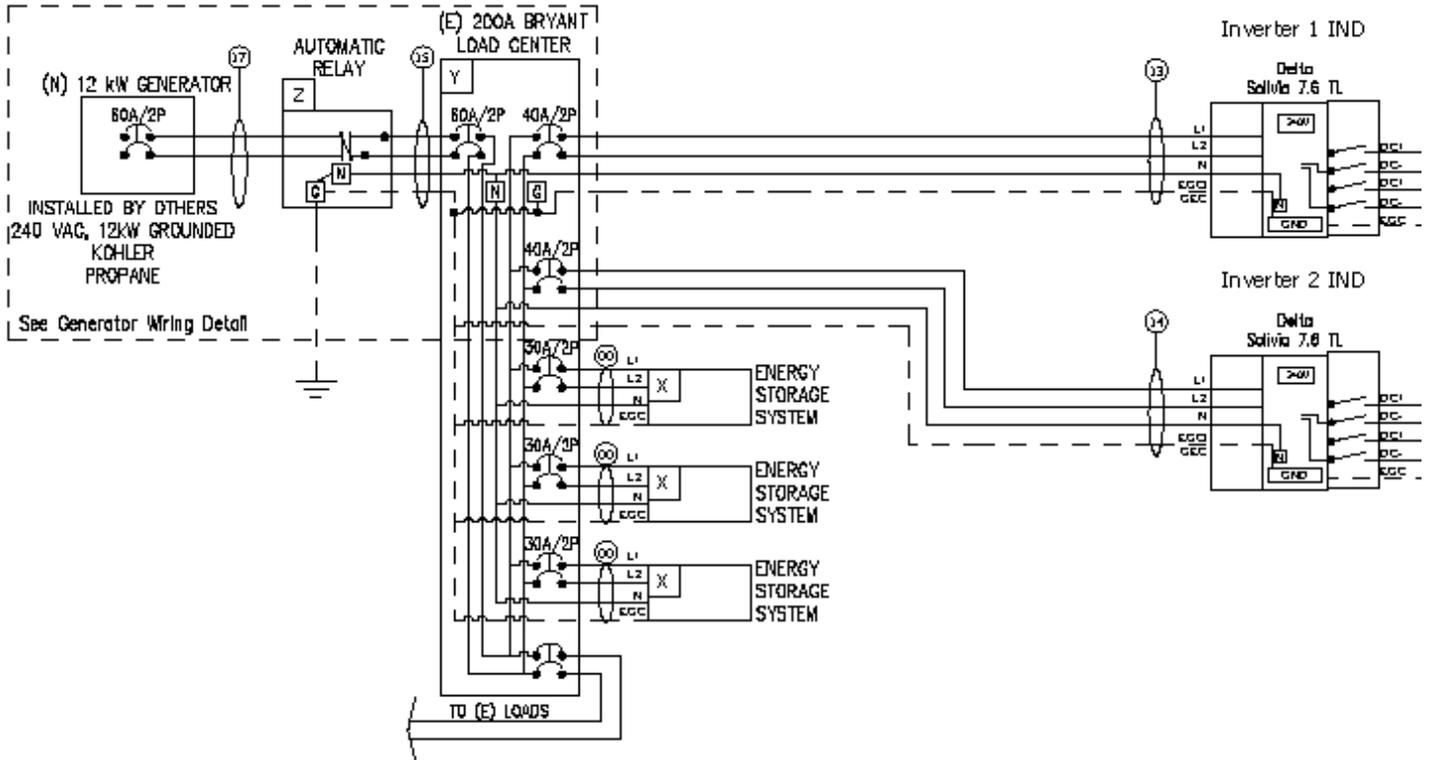

Figure 1: Example Electrical Layout (Generation Panel vs Load Panels)

NOTE: There is no main breaker from the grid. The only energy sources are solar, Powerwall, and generator.

Solar Design Guidelines

Panel Orientation

It is best to split solar panels evenly on all mounting planes (80 – 280 degrees), rather than just south-facing. This extends the window during which solar can be generated and minimizes solar curtailment.

NOTE: Follow best practice for stringing; one MPPT per mounting plane.

Inverter Selection and Sizing

It is best to split systems across multiple smaller inverters as opposed to one large inverter. This ensures the home will not be without power generation if one fails.

NOTE: Size inverters to 5 kW AC or less per Powerwall.

(120/240V Grid compatible inverters with frequency-watt droop enabled – see inverter settings below)

Approved Solar Inverters for Off-Grid

- Delta
- SMA
- Enphase

These inverters have been tested and are the best performing and most reliable for Off-Grid purposes. Please note these approved inverters can be changed at Tesla discretion and it is the CI's responsibility to regularly check the Partner Portal for updates to this Application Note.

Generator Selection and Placement

Installing a generator is best practice for Off-Grid systems. Customers must select a Tesla-compatible generator. Install the generator per the manufacturer instructions.

Tesla-Compatible Generators

- Kohler RESA (8kW-20kW)
- Kubota (GL Series)
- Himoinsa (HYW Single Phase Series)

Install location

AC wiring and 12V wiring must be run from the generator to the Backup Gateway and a breaker panel. This should be considered when placing the Backup Gateway and breaker panel.

Install a Circuit Breaker in the Backup Gateway

A circuit breaker is required between the generator and the Backup Gateway. If this is NOT in the generator, it can be installed in the Backup Gateway, see the Installation Manual for instructions.

Electrical Connections

Although the customer is responsible for the generator install, a Tesla Certified Installer will make the final electrical connections which must be included on the plans.

12V and Communication Guidelines

If a generator is available, 12V can be supplied from the generator battery. If not, an external 12V kit can be assembled from the supplies below (rows 1-4). The control, communication, and 12V kit all need to be properly enclosed.

Part	Use	Supplier	Part Number	Image
11000mAh Battery AC Charger USA Plug 12.6v & 1.5A DC Barrel Y-Splitter 2.1mm Female to (2x) 2.1mm Male	12V kit (only necessary if no generator)	Amazon	B016BJCRUO	
2.1mm Female DC Barrel to wire terminals		DigiKey	1568-1510-ND	
Inline fuse holder for 12v, automotive syle fuses, #16 AWG		DigiKey	BF353-ND	
3 amp / 12V fuse		DigiKey	F4194-ND	
2 conductor controller (20 gauge / 0.81 mm or larger wire)	Connect Backup Gateway & Generator	See Powerwall Installation Update: Communication Wiring		

Controls

To control the Generator, wire the generator's 12V two-wire start/stop ports into the Backup Gateway's auxiliary ports "1" and "2" (Figure 3).

To power the Tesla Backup Gateway, tap into the generator's 12V battery circuit and connect it to the Backup Gateway's "jump" ports (Figure 3).

The generator's AC output wiring will connect to the line side of the Backup Gateway.

NOTE: If there is no generator in the system, the 12V kit is directly wired into the two-pin "jump" ports on the Backup Gateway (Figure 3).

NOTE: The generator's 12V battery maintenance charging circuit, the "trickle charger" must be installed to prevent the 12V battery from depleting. Refer to the generator manufacturer instructions to power the 12V battery maintenance circuit from any 120V AC home circuit
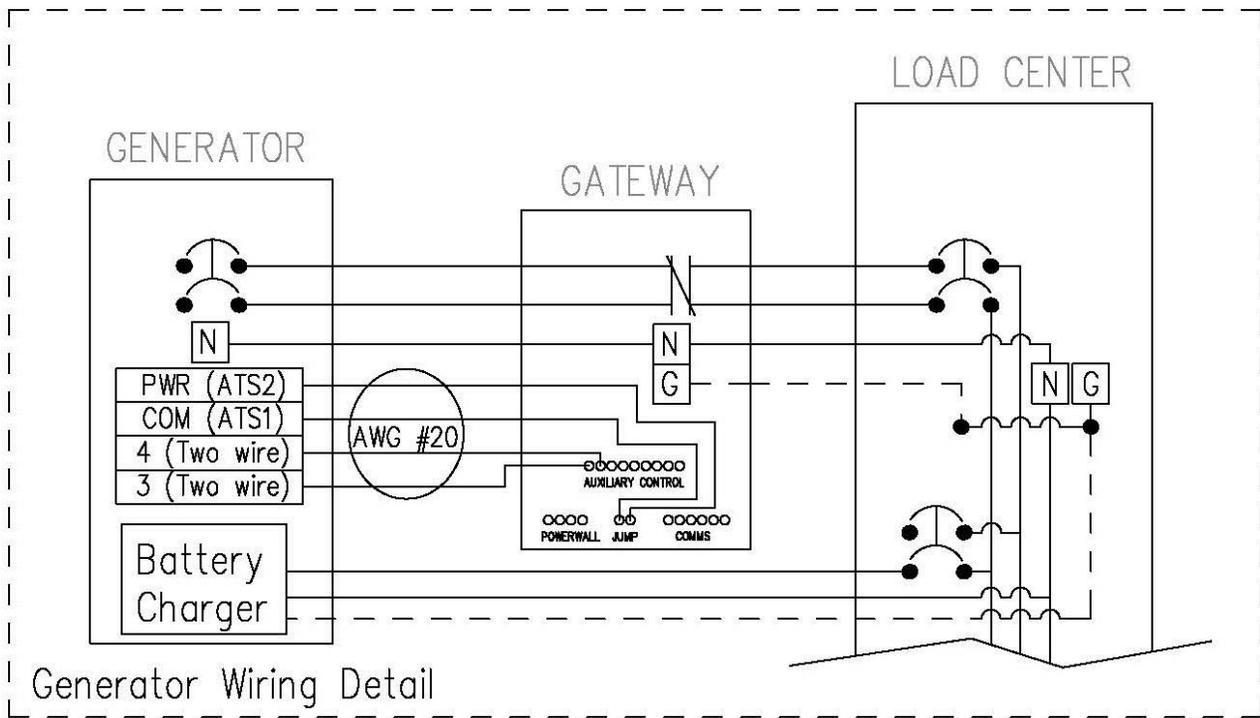

Figure 2: Example Off-Grid Generator Wiring

3. Pre-Installation Guidelines

This Application Note describes the installation steps that are unique to Off-Grid systems. All other information can be found in the Installation Manual.

NOTE: A Tesla Tier 2 Technical Support agent will need to assist with Pre-Install Software Updates in warehouse.

Pre-Install Software Updates in Warehouse

For the most reliable off-grid commissioning experience, it is best practice to update the software of the Backup Gateway in warehouse before going out to the site. Since a reliable internet connection is required and off-grid sites tend to be in more remote areas, adopting this practice will reduce the time spent on site.

### Establish Communication with the Gateway

Ensure the gateway is connected to a 12V power source to turn the Sitemaster on. The lights of the Gateway will be on, and connection to the Gateway can be established via the Gateway Ethernet port or using a Wi-Fi capable device (phone, computer or tablet).

Tips for establishing communication with the Gateway:
- Ensure the Gateway is receiving power:
  o Verify the Communication/Power wiring.
  o Check the 12V output on the 4-pin Powerwall connector.
- Confirm the 12V power source has sufficient charge; it is possible it may only be charged enough to turn the Gateway lights on and not the Wi-Fi.

To establish communication with the Gateway using Wi-Fi:

1. The Gateway Wi-Fi network will appear as "TEG-XXX", where XXX is the last 3 digits of the Gateway serial number. It is recommended to disable your device's mobile data until you have finished commissioning to avoid intermittently losing connection to the network. If the network does not appear, turn off and turn on Wi-Fi on the device, and wait to see if the network appears.

2. The Wi-Fi password can be found on the internal plastic cover of the Gateway underneath the serial number. Note that this password will be needed again in later steps, so it is useful to record it somewhere, such as in the notes section of your phone.
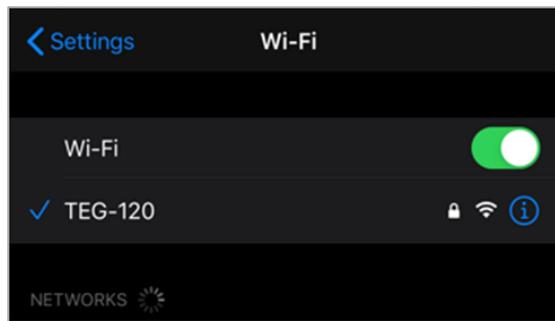

3. Launch a browser and enter the following URL: **http://teg-XXX**, where the XXX is the last 3 digits of the Gateway serial number.

- If the browser does not load try: **https://teg-XXX**. If an error page is displayed, try refreshing the browser.
- Alternatively, use the IP address **http://192.168.91.1**

4. If a "Connection is not private" warning shows:

- If in Safari, select **Show Details**, then **visit this website**.

- If in Chrome, select **Advanced**, then **Proceed**.
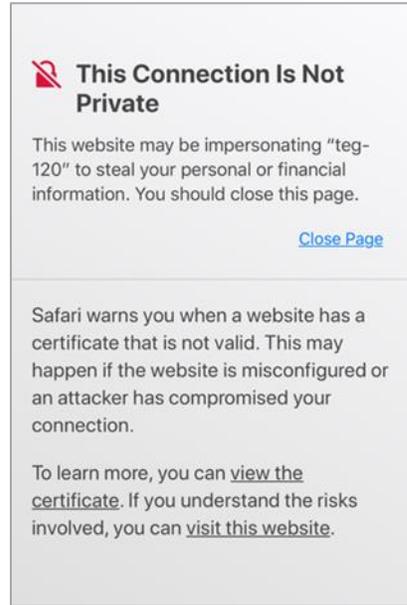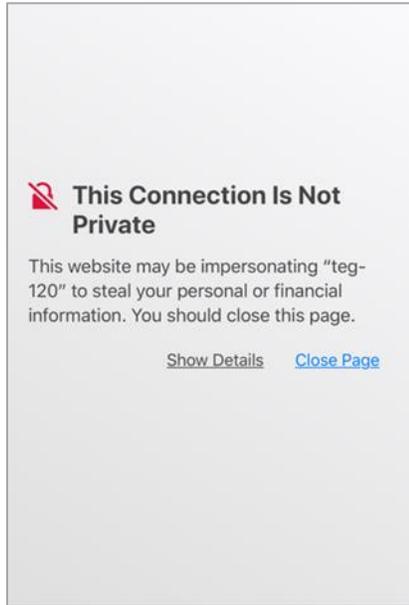

Complete the Initial Commissioning Steps

1. After connecting to the Gateway, the Commissioning Wizard landing page appears. Select **LOGIN**.

2. On the *Login* page, choose **Installer** from the Login Type menu and enter the installer email address. The password is the same password used when connecting to the Gateway Wi-Fi.

Note: After the commissioning process is complete, the Commissioning Wizard automatically generates a new Installer password.

3. If an error message appears after logging in, select **click for more**, then tick the **FORCE LAUNCH WIZARD** box.
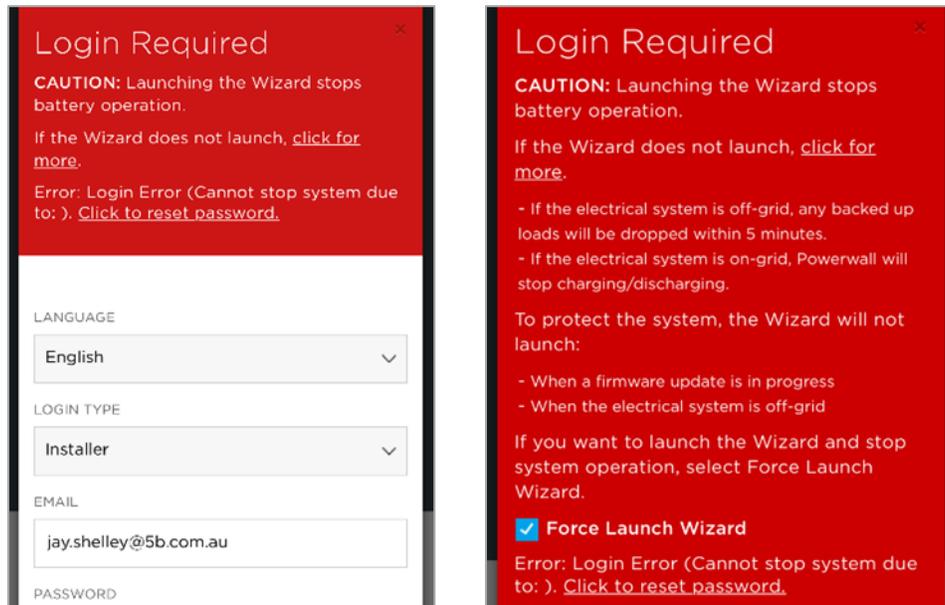
4. Once logged in, select **RUN WIZARD**. The *Network* page will be displayed; connect the Gateway to the Internet by each of the following means whenever possible. The Gateway manages network connectivity dynamically. To take advantage of this feature, configure all available network connection types (Ethernet, Wi-Fi and Cellular), even if network extension equipment is needed to establish a connection.

Ethernet – best option if router is accessible from Gateway and permanent cable run is possible. This type of connection is most reliable and has the highest bandwidth.
   a. On the *Network* page, click the arrow for Ethernet.
   b. Choose **DHCP** (most common) or **Static** (only if necessary and you know the Network settings).
   c. Select **Connect**.

Wi-Fi
   a. On the *Network* page, click the arrow for Wi-Fi.
   b. Click the home Wi-Fi network name and enter the network password.
   c. Click the blue arrow.

Cellular
   a. Cellular connects automatically and shows cellular signal strength.

Note: Do not rely on cellular service to provide the primary network connection unless all other options are unavailable. Installers should make every reasonable effort to configure all available network connection types during commissioning.

5. Select **CHECK INTERNET CONNECTION** to verify the Internet connection is working and then select **CONTINUE**.

6. The *Update* page will display the system's current firmware version; select **CHECK FOR GATEWAY UPDATE.**

> a. A **CHECKING FOR DOWNLOAD** message will display, followed by a **DOWNLOADING** status on the *Update* page.

> b. During the download a completion percentage will be displayed. Once the download is complete a **STAGING – PLEASE WAIT A FEW MINUTES…. – DO NOT POWER CYCLE** message will be displayed. After five minutes a message should display indicating the update is staged. If this message does not appear, refresh the window.

> c. Once Staging is completed, select **NEW VERSION STAGED – UPDATE NOW. An UPDATE SYSTEM** message will display; during this time, the system will disconnect from the Wi-Fi network and must be reconnected.

> d. When logging in again the message on the *Update* page will display to **VERSION UP-TO DATE**; verify the firmware version has changed and select **CONTINUE.**
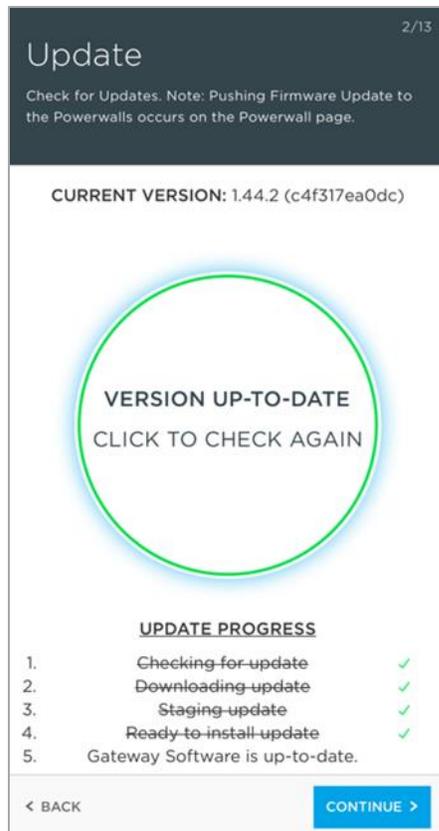
7. Tesla will now remotely configure the Gateway for off-grid. Contact Tesla and inform them the Gateway is connected to a power source and has internet connection. Provide the following information:

- Gateway serial number
- Installer information
- Generator capacity

NOTE: Tesla is unable to configure the Gateway for off-grid unless the Gateway is connected to a 12V source and has stable internet connection. Once Tesla has confirmed the Gateway has been completely configured, it can be disconnected it from the 12V source.

8. The Gateway is now ready to be installed for off-grid.

4. Installation Guidelines

Best Practices for Off-Grid Installations

Labels must be clear so homeowners can quickly and safely identify parts in the event of an outage. A homeowner should be able to easily locate the Backup Gateway serial number, installer support number, and Tesla support number.

Installation Instructions

Plan the Installation Site

The generator AC output is on the line side of Backup Gateway and all loads, Powerwalls, and solar are on the load side of the Backup Gateway, see Figure 3.

Connect Generator and the Backup Gateway

1. Check the neutral / ground bond:

- The green neutral / ground must be kept in the Backup Gateway if there is NOT a neutral/ground in the generator.

- If there is a neutral / ground bond in the generator, it must be removed from the Backup Gateway.

NOTE: There must be one neutral / ground bond on site.

2. Connect the generator AC output and neutral to the line side of the Backup Gateway.

3. Leave the CTs in the factory-installed position; these will be configured as "Site" in the Commissioning Wizard.

12V and Communication

1. Run communication wire from the Backup Gateway (auxiliary spots "1" and "2") to the two wire start / stop terminals on the generator (typically labeled "3" and "4").

2. Run communication wire from the Backup Gateway "jump" ports to the 12V DC terminals on the generator (labeled "COM" and "PWR", or "ATS#" as shown below).

3. Land the 12V from the generator starter batter on the +/- 2 pin "jump" input in the Backup Gateway. Install a 3A fuse / 12V fuse on the positive.

NOTE: The generator 120 volt AC charging circuit is terminated to a breaker in downstream load center (this keeps the generator battery charged from Powerwall/house power – Kohler has a built-in "trickle charger").
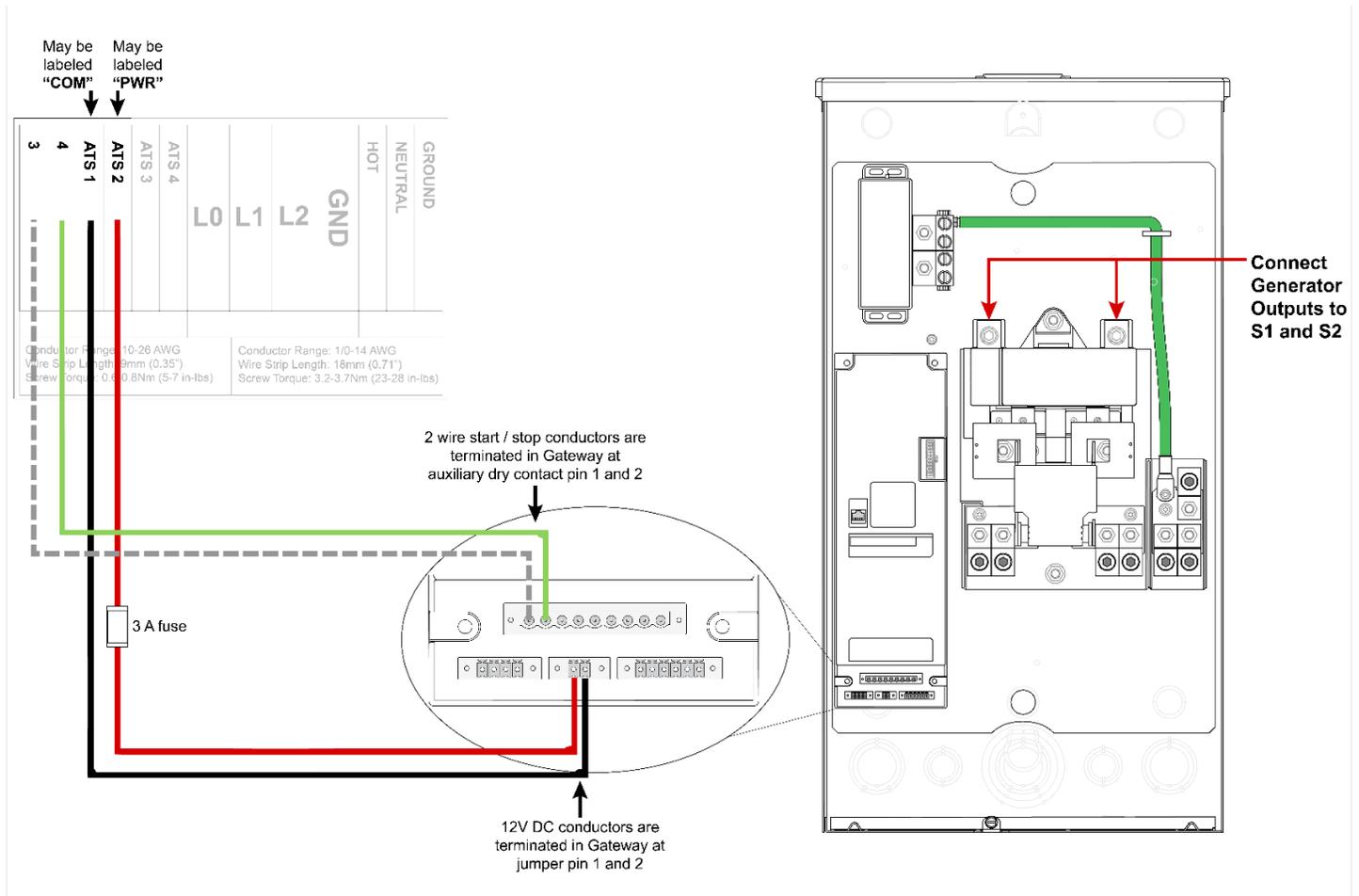
Figure 3: 12V and Comms Wiring between Backup Gateway and Generator

Install Energy Metering for the System

Always follow whole-home backup practices. All solar on site must be metered.

Configure the Solar Inverter

The solar inverter must be configured for Off-Grid use; refer to the solar inverter manual for information on inverter configuration.

Below are the required settings for Off-Grid operation.

Off-Grid + Powerwall Solar Inverter Settings	Max Reconnect Frequency [Hz]	Trip Frequency [Hz] (fSTOP)	Curtailment Start Frequency [Hz] (100% Power)	Curtailment End Frequency [Hz] (0% Power)	Curtailment Power Ramp [%/Hz]
60 Hz	61.5	62	60.5	61.5	100

5. Commissioning Instructions

Once the entire system has correctly been installed, it can now be commissioned.

Establish Communication with the Gateway and Complete Initial Commissioning Steps

1. Follow steps 1-4 in Establish Communication with the Gateway beginning on page 8.

2. Follow steps 1-5 in Complete the Initial Commissioning Steps beginning on page 9.

3. On the Update page, confirm the current firmware is the most recent version then select CONTINUE.
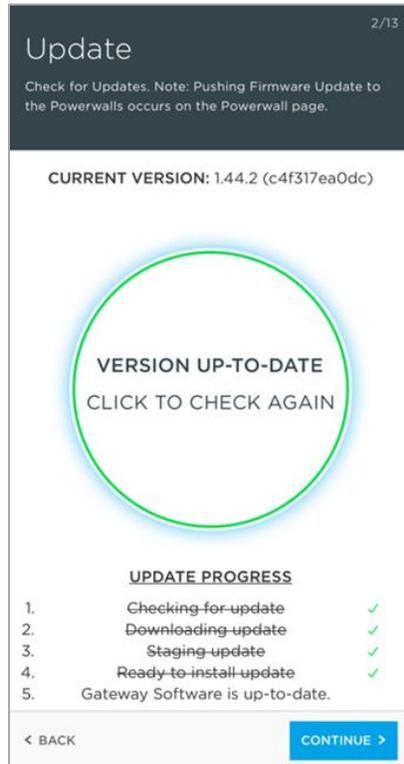
4. On the *Installer Information* page fill out all fields then select **CONTINUE**.

5. Select the correct time zone on the *Time Zone* page then select CONTINUE.
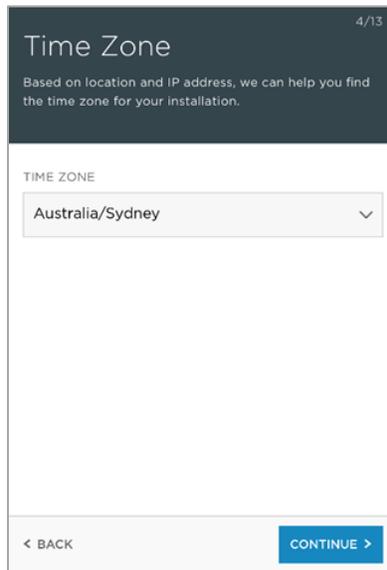
6. On the *Powerwall* page, each Powerwall will need to be scanned in and its firmware updated.

    a. To ensure success when scanning for Powerwalls; <u>BEFORE starting the scan</u> check the following:

- The enable button on each Powerwall is switched on
- The circuit breaker of each Powerwall is be closed and all terminations are completed properly.

    b. Select SCAN to search for the Contact Controller and each Powerwall.

    c. Check to make sure each Powerwall listed matches each Powerwall on-site, then select UPDATE FIRMWARE to update the Powerwalls.

    d. Once finished updating, a green tick should be displayed next to each Powerwall, if so select CONTINUE.
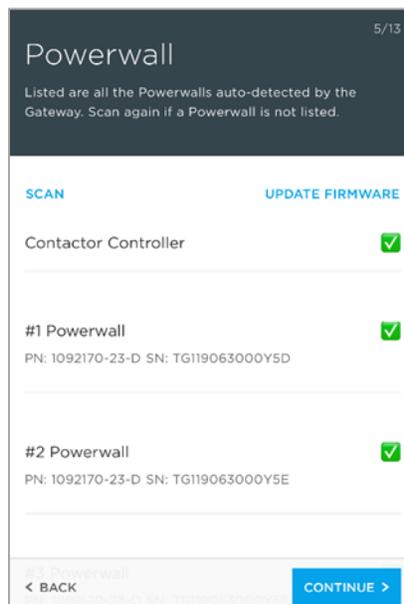
7. A *"Grid Detection Results"* message will appear; confirm the site is off-grid by selecting the "Is the system off-grid?" box and selecting **SAVE**.
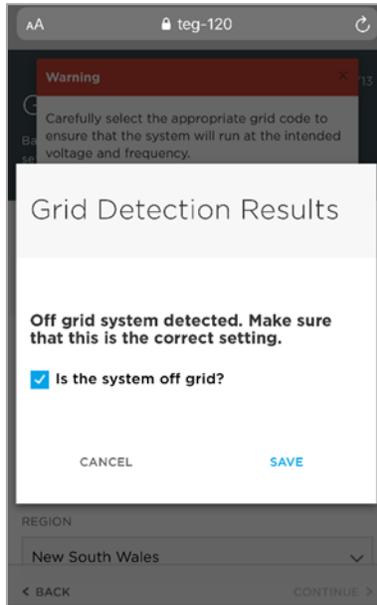

8. Enter in the location details but <u>do NOT check the box at the bottom</u> which says: "Confirm the selected grid code applies to this location". As the site has already been configured for off-grid, selecting a grid code will override this setting. Instead:

    a. Skip through this page.

    b. Go to the next page by following **https://teg-XXX/generation** (the browser URL field will read **https://teg-XXX/grid**; delete "**grid**" and replace with "**generation**" so the URL is **https://teg-XXX/ generation**).

    Note: If you entered the URL **http://192.168.91.1**, it will appear as **http://192.168.91.1/grid**
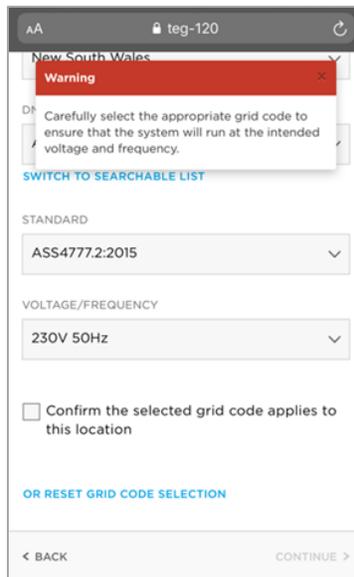
9. On the *Generation* page:

   a. Enter the Solar information for each array; to add multiple arrays select **+ ADD SOLAR**.

   b. Add the generator information by clicking **+ ADD GENERATOR**.
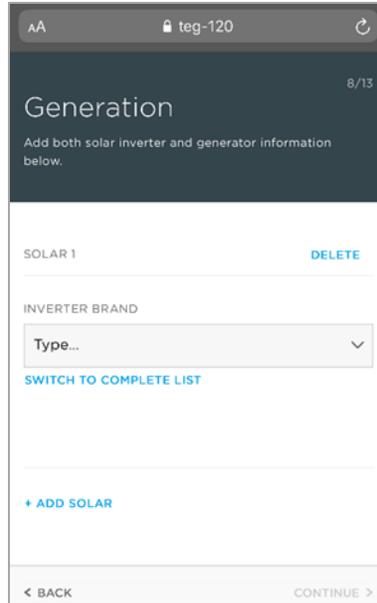
10. On the *Meters* page a *"Starting Powerwall"* message will display and you should hear Powerwall starting up. <u>Do NOT click CONTINUE on the meter page</u>; instead skip over this page by changing the URL from **https://teg-XXX/meter** to **https://teg-XXX/settings**.
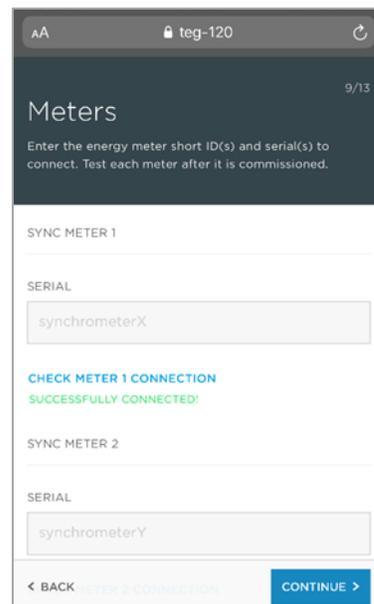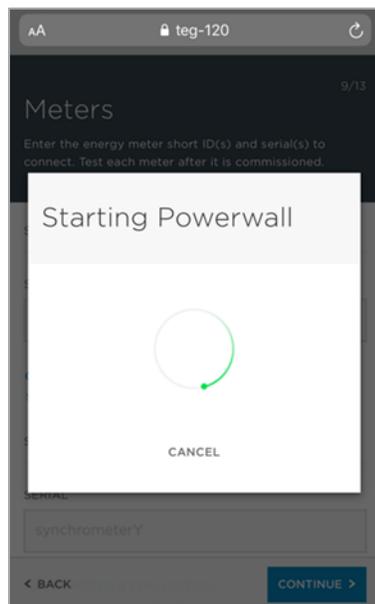
11. On the *Operation Settings* page change the Site Name from the pre-populated "Home Energy Gateway". The default operation mode to set is "*Self-consumption* Mode"; a Gateway which has already been configured by Tesla will instead be set to "*Backup Mode*". To avoid overriding the Backup Mode, <u>do NOT click CONTINUE</u>, and instead skip through to the next page by changing the URL from **https://teg-XXX/settings** to **https://teg-XXX/diagnostics**.
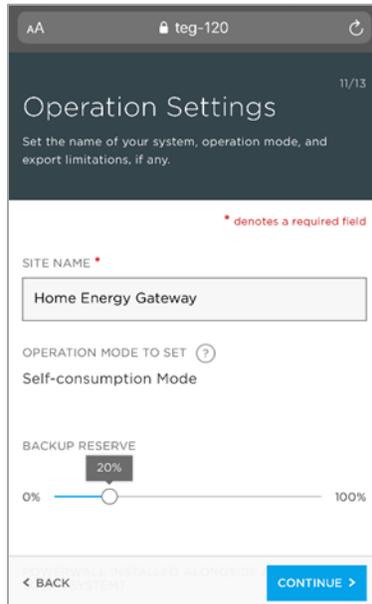
12. On the *Diagnostics* page, if the following error messages show after selecting **Run all selected tests (**this is expected for Off-grid sites), continue to the next page. If any other errors are present, please check installation.
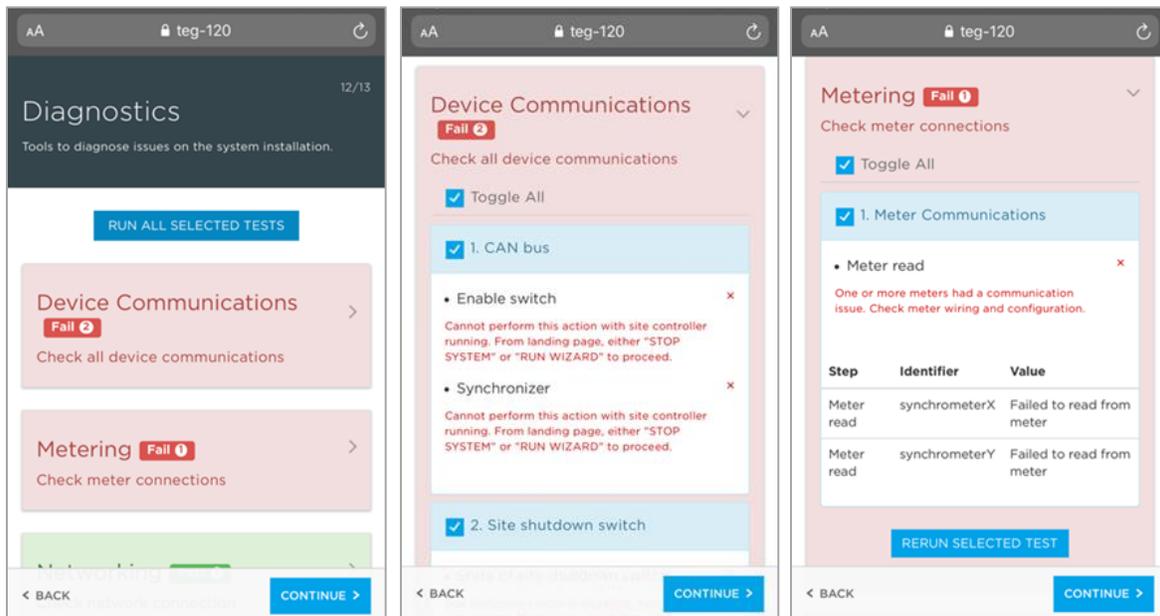
13. After completing the *Tesla Customer Privacy Policy & Limited Warranty* and *Site Information* pages, the *Summary* page will be displayed. The *Mode* should be set to **"Backup"**. Similarly, the *Grid Code* should be blank or set to "50Hz_230V_1_OffGrid_2018_Generator". If the *Mode* is set to "**Self Consumption**" or the *Grid Code* is set to "50Hz_230V_1_ASNZS4777.2:2015_AU" contact Tesla Technical support as the site has not be correctly configured for off-grid.

14. The Commissioning Wizard automatically generates a new Installer password. Copy this password onto your clipboard as it will be required when you log in a second time. Select the Complete button and you will be brought to a user interface page.
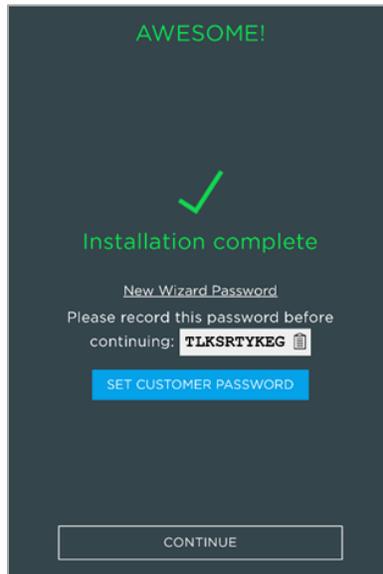
Complete the Second Run through the Commissioning Wizard

1. Wait about five minutes to allow time for Powerwall to be updated, then select **Run Wizard** again. Use the password you just copied to log in again and commission the meters and CTs.

Note: Do not go through every page of the Wizard, as you could override the pre-set off-grid settings, instead enter the URL **https://teg-XXX/meter**.

2. The serial numbers of *Sync Meter 1* and *Sync Meter 2* will already be prefilled. Instead of skipping through this page select **Continue**.

        a. If you have any Neurio or Wi-Fi meters, add them now, ensuring they are powered.
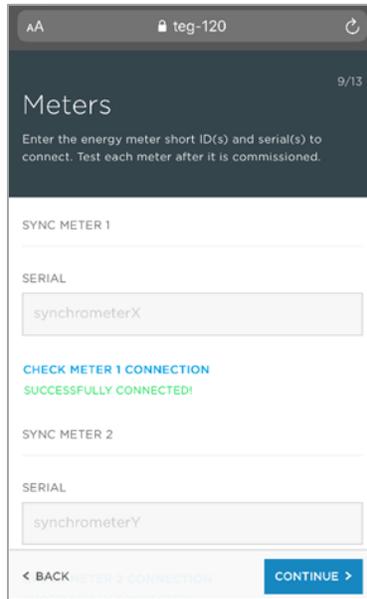
3. On the *Current Transformers* page, two warning messages will show at the top of the page. Under *Sync Meter 1* select *Site* for *CT1* and leave *CT2* and *CT3* as *None*. Under *Sync Meter 2* select *Solar* for *CT1* and leave *CT2* and *CT3* as *None*, then select **Continue**.
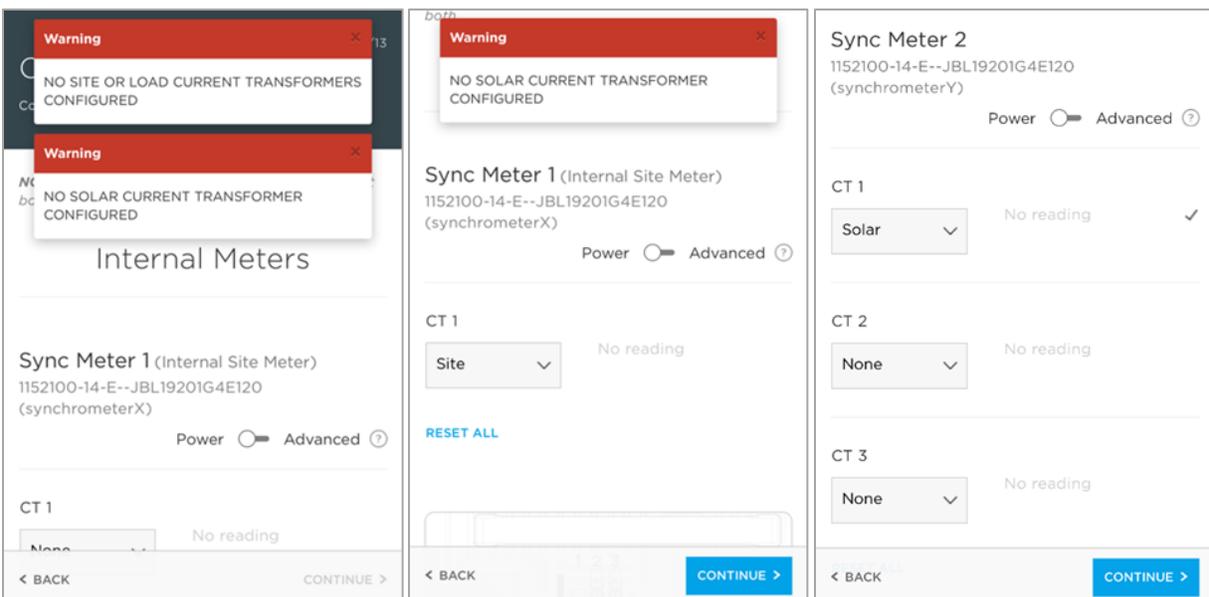
4. Skip through the *Settings* page again by changing the URL from **https://teg-XXX/settings** to **https://teg-XXX/diagnostics**, then follow steps 11 through 14 on pages 18-19.

The Landing page of the Commissioning Wizard displays when the system is off-grid by superimposing an 'X' over the Grid icon.