LIONENERGY™

CT Guide

Current Transformer / Tracking Energy Usage

Instruction Manual

Updated 4/09/26

READ THIS USER MANUAL IN ITS ENTIRETY BEFORE OPERATING THE UNIT.

This unit provides safe, quiet, and renewable electric power. It is very important to carefully read this Installation Guide before using the product. Keep this guide for future reference.

Carefully read and comply with all safety directives before installing and using the Sanctuary System. Otherwise, personal bodily injury or death may result.

Symbols Used:

WARNING: Indicates a hazardous situation which, if not avoided, could result in injury or death.

CAUTION: Indicates a hazardous situation which, if not avoided, could result in minor injury or damage to the equipment.

NOTE: Indicates an important step or tip that leads to best results, but is not safety or damage related.

Follow these directives for safe use:

System Integrity: The inverter and all system components must not be disassembled or altered by unauthorized personnel. Unauthorized modifications can compromise system safety, void warranties, and result in serious injury or death.

Electrical Hazard: Always disconnect all power sources, including the AC and DC terminals, before performing any maintenance or cleaning. Use lockout/tagout procedures to ensure the system remains de-energized during maintenance.

Grounding Requirements: Proper grounding is essential for safe operation. Ensure that the system is connected to a permanent, grounded wiring system, and comply with all applicable grounding and bonding requirements.

Load Calculations: Ensure all connections follow the specifications outlined in the Installation Guide and comply with the National Electric Code (NEC). Using incorrect wire sizes, breaker ratings, or failing to properly balance loads can lead to system malfunction or pose safety hazards. Always verify that all load connections meet both installation and code requirements.

Heavy Equipment: This system includes heavy equipment. Use lifting assistance during installation to prevent injury.

Compliance with Regulations: All installation and maintenance activities must comply with local, state, and national electrical codes and standards, including but not limited to UL 9540 and UL 1973. Adherence to these standards is mandatory to ensure safety and compliance.

Final Continuity Check: Do not power on the system until a final continuity check is performed to ensure all connections are secure and correctly installed.

Battery Handling: Strictly follow the manufacturer's instructions for handling and installation of batteries. Failure to do so may result in fire, explosion, or electric shock.

Tool Usage: Exercise caution when using metal tools around batteries and electrical components. Dropping tools can cause short circuits, leading to potential explosions or fires.

Ventilation: The installation location must provide adequate ventilation to prevent overheating of the system components. Ensure that the unit is installed in a well-ventilated area according to the manufacturer's recommendations.

Weatherproofing – IP65 Compliance: When installing the Sanctuary system outdoors, it is critical to maintain IP65 and NEMA 3R protection to ensure long-term performance and safety. • Any holes made in the wire box for conduit or wiring must be sealed using the appropriate fittings and components. • Improper sealing may lead to water or dust ingress, which can cause equipment damage, corrosion, or electrical faults. • Always use the appropriate conduit connectors, grommets, and glands to maintain enclosure integrity. • It is the installer's responsibility to ensure that the final installation meets the appropriate standards for outdoor use.

Qualified Personnel Only: Installation, service, and maintenance of this Sanctuary system must be performed by qualified personnel/technicians. Only certified professionals with the appropriate training should install or service the unit, with or without a battery. For questions on how to become certified for installing the Lion Energy Sanctuary, please contact the Lion Energy ESS Support team.

General Safety Guidelines

Emergency Procedures: In case of fire, evacuate the area and contact emergency services immediately.

Handling of Damaged Equipment: If the unit or any of its components are damaged, do not operate the system. Contact a qualified technician, or Lion Energy's ESS Support Team for inspection and repair.

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Introduction

CT Basics

A current transformer (CT) is used to measure the amount of alternating current flowing in a wire. The wire being measured acts as the primary of the transformer, while the CT signal acts as the secondary. The inverter can measure the direction of current flow by comparing the phase of the CT signal with the phase of the voltage on the wire. To properly measure the direction of current, the CT orientation must be correct, or the current's direction will be interpreted to be the opposite.

The output signal of the CT is an AC current at a fraction of the measured current, depending on the CT ratio. Common CT ratios are 1000:1 or 2000:1, meaning the output current is 1/1000th or 1/2000th of the measured current. If the measured wire is conducting 100A, and the CT is a 1000:1 ratio, then the CT's output current will be 0.1A. This output current can be conducted through a resistor to translate current into a voltage which can be easily measured.

CTs usually have more features than a simple transformer. Many CTs have voltage clamping circuitry inside to prevent high voltages on the sense wires when they are not connected to a load resistor. A split-core CT can be clamped around a wire without needing to disconnect the wire.

Why does the inverter have CTs?

The CTs tell the inverter how much power the entire home is using. High-power loads such as air conditioning might not be connected to the inverter's load port. Any loads not on the load port are not backed up in the event of a grid outage and will lose power when the grid goes down. Since these loads are not measured by the load port, the inverter needs a way to measure the power drawn by home loads between the grid port and the billing meter.

To maximize the electric bill savings, the inverter can send power to those loads on demand, without sending more than necessary. If the CT is reading zero current, then the inverter knows it's sending enough power to the home loads without selling excess to the grid. If the inverter has more solar power than necessary for loads, the excess power can be used to charge the battery or be sold to the grid.

If the buy vs. sell exchange rates were equal, then there would be no need to store energy in a battery except for powering loads when the grid goes down.

A typical Utah resident in 2025 may be charged $0.10 per kWh for electricity used, but only earns $0.05704 per kWh sold between June and September, and only $0.04199 between October and May. Since it costs significantly more to buy electricity than we gain by selling it, we use the battery to store solar energy produced during the day to use at night.

Where should the CTs be located?

Recommended Placement

The recommended placement is on **the customer's side of the meter, upstream of any loads** (including the inverter's grid connection), as shown in **Figure 1.**

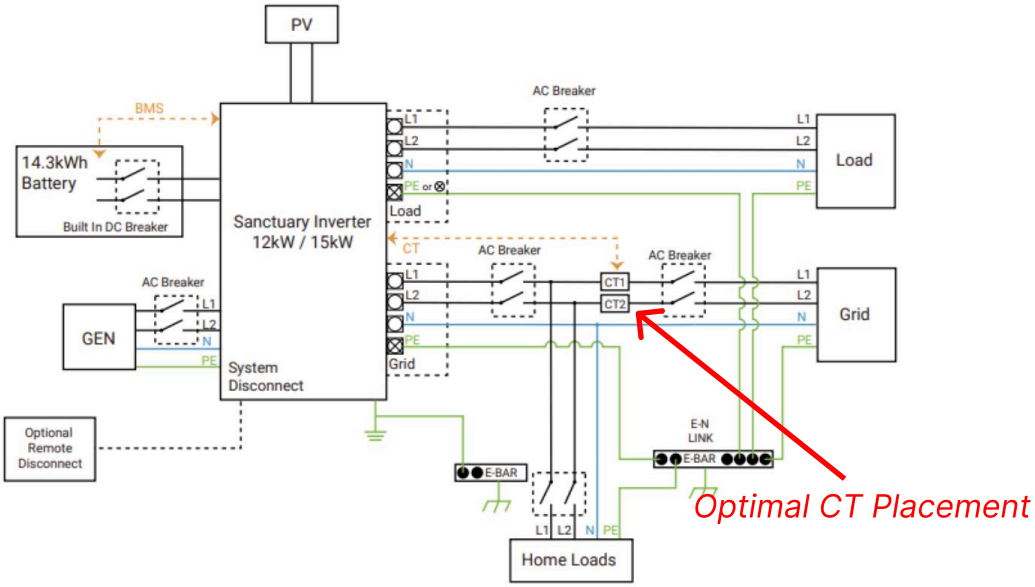

Figure 1. Typical wiring diagram

If there are no "home loads" between the inverter's grid connection and the meter, then the CTs may be placed at the inverter's grid port. This would be electrically equivalent.

For the example in **Figure 2**, the CTs are between the main panel and the meter. Any loads on the main panel will not be backed up if the grid goes down. But the Sanctuary can supply power to these loads from the battery by sending enough power so that the CTs measure zero current.

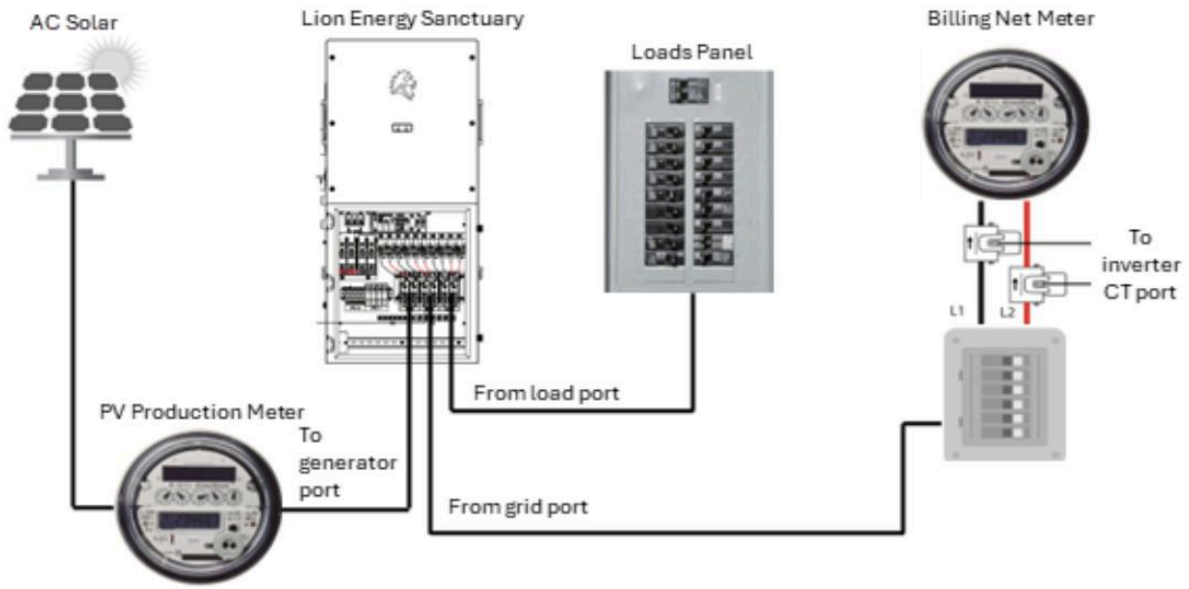

Figure 2. Typical wiring diagram

For the example in **Figure 3**, the Sanctuary will not report any solar power because there is no solar connect to the inverter, but the CTs will sense power being sold back to the grid. This allows the Sanctuary to store excess solar power to use later. The Sanctuary will draw power from the grid port, targeting enough draw to maintain measuring zero current at the CTs. After sun-down, the Sanctuary can send power to non-backed-up loads by producing enough power from the battery to make the CTs read zero current.

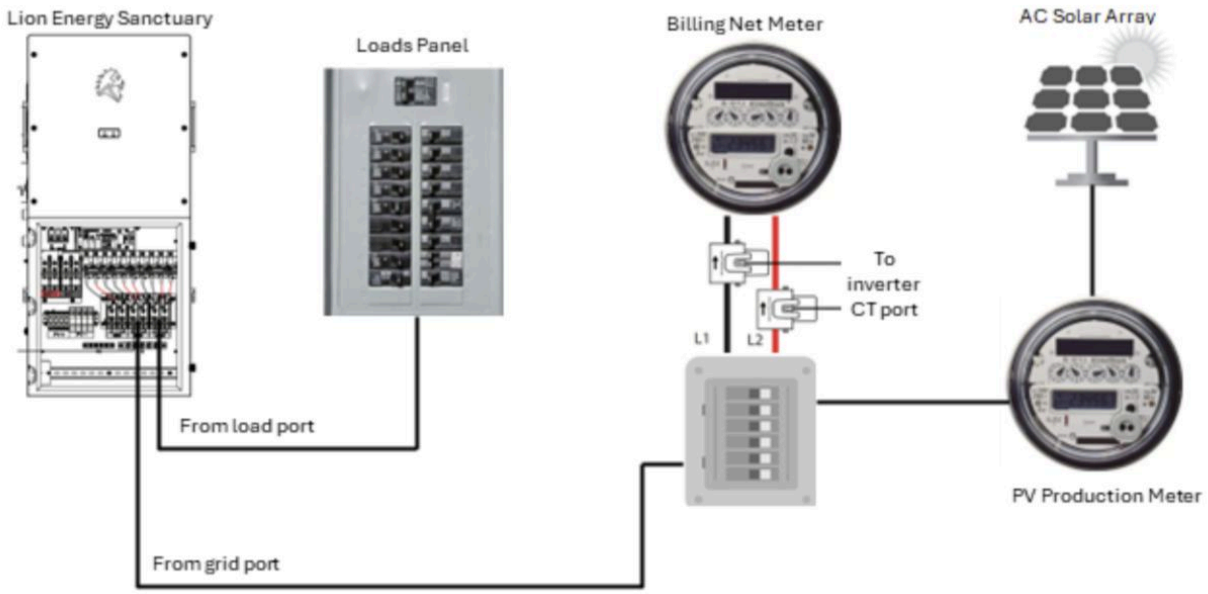

Figure 3. Separate AC Solar

Parallel Inverters

If two or more inverters are configured in parallel, you may use a single set of CTs plugged into the parent inverter as shown in **Figure 4.** Parallel inverter operation will be the same as described for Figures 1, 2, and 3.

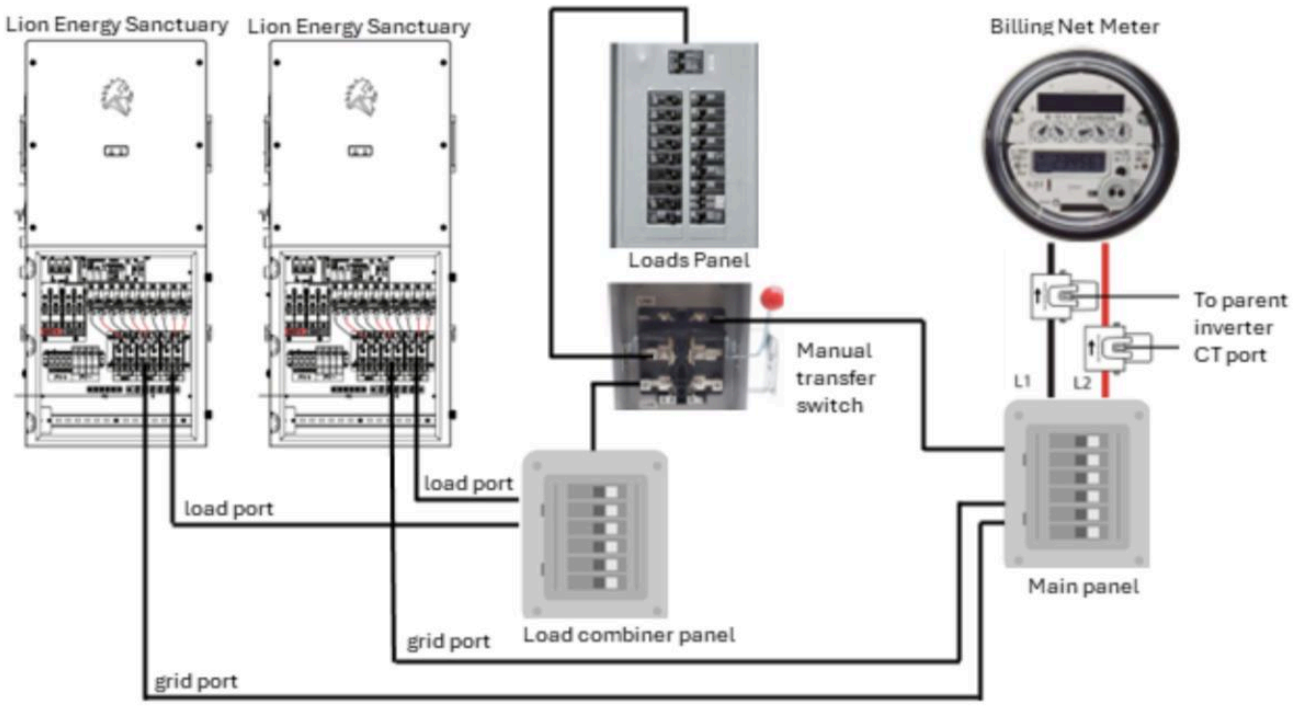

Figure 4. Parallel Inverter Diagram

Whole-Home Backup

For a whole-home backup, there are no significant loads between the inverter grid ports and the meter. The standard CT configuration as shown in figures 1, 2, 3, and 4 may be used.

If it is more convenient, CTs may be placed at each inverter. Each inverter has its own set of CTs plugged into its own CT port. In settings, “Common Grid CT” must be disabled when each inverter uses its own set of CTs. **Figure 5** shows each inverter with its own set of CTs.

If there are any loads added between the inverter grid port and the meter, the CTs can’t measure those loads and they will be powered by the grid unless solar is selling back to the grid at the same time.

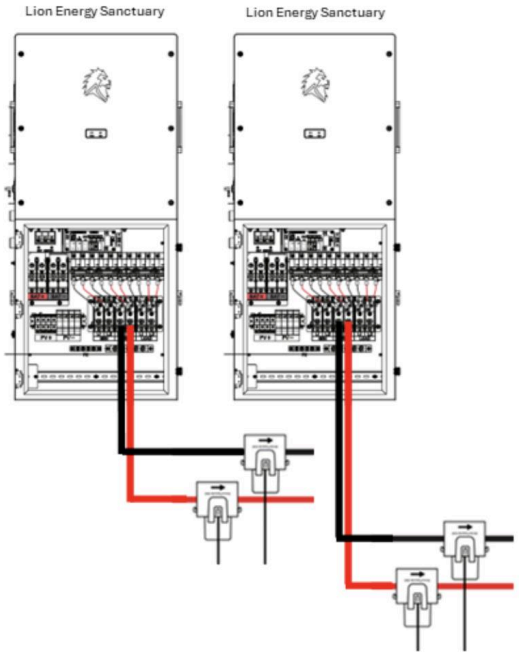

Figure 5. Whole Home Back-up, Alternative CT Placement

In settings, “Common Grid CT” must be disabled when each inverter uses its own set of CTs.

When Proper CT Placement Is Not Accessible

Sometimes the proper CT location is not accessible and is upstream of a location that is accessible, but has separate lines that can’t be forced through a single CT. The CT signal may be added using a splitter if both sets of CTs are the same type. This connects the signals for both CTs in parallel. This example shows two sets of Lion Energy two-in-one CTs being added. Note that the Y in the cable does not connect the L1 CT signal to the L2 CT signal. Both signals remain separate. CT1 is on pins 3 & 6, while CT2 is on pins 1 & 2.

For earlier Sanctuary 2 models that use separate CTs, group the L1 CTs into one splitter and group the L2 CTs into another splitter. Plug the L1 splitter into the L1 CT port. Plug the L2 splitter into the L2 CT port.

Extreme care must be taken to ensure that each CT is on the correct line and in the correct orientation. The possibilities for mistakes exponentially increase when attempting this configuration.

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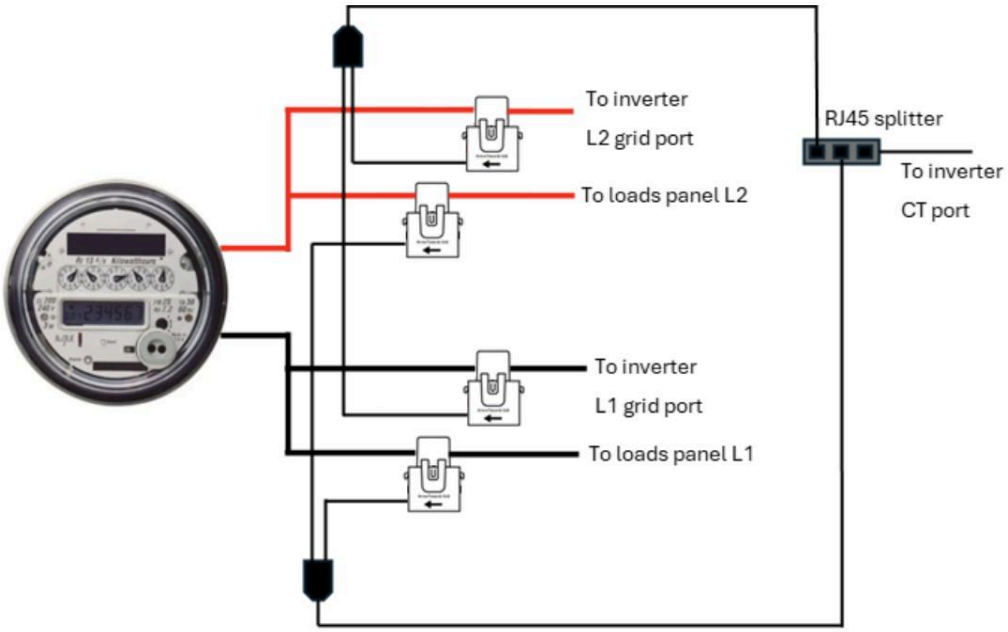

Figure 6. Adding CT Signals

CT Data

AC Power Convention

With the exception of MPPT power, all power into the inverter is reported as negative power, while all power out of the inverter is reported as positive. When the grid power data is negative, the home is buying power from the grid. When the grid power data is positive, the inverter is selling power to the grid. This polarity convention may be different from other inverter brands.

Good Data Example

The graph in **Figure 7** shows proper CT orientation. Starting at 12:00 AM, the graph shows that the loads are being powered by the battery until the battery reaches 20%, after which the loads are powered from the grid. When solar starts producing, the loads use solar power first, and then the battery is charged from solar. When the battery is fully charged, the excess solar power is sold to the grid (positive). As solar power diminishes at the end of the day, load power transitions to battery power.

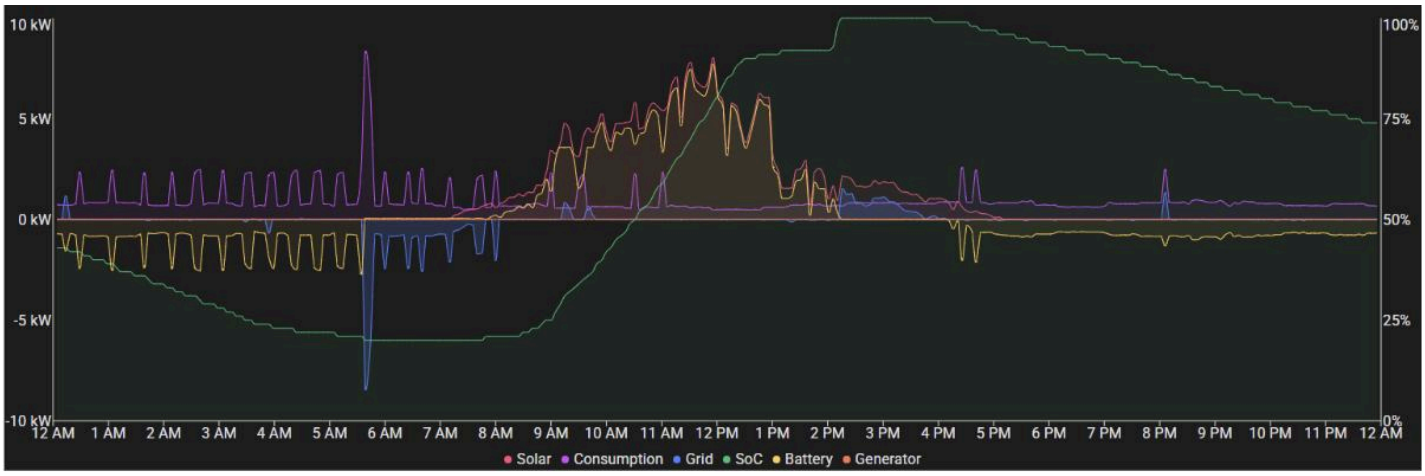

Figure 7. Example of good CT Data

Bad CT examples

Figure 8 shows CTs backwards or L1/L2 swapped. Notice that the grid power shows sell-back for 24 hours.

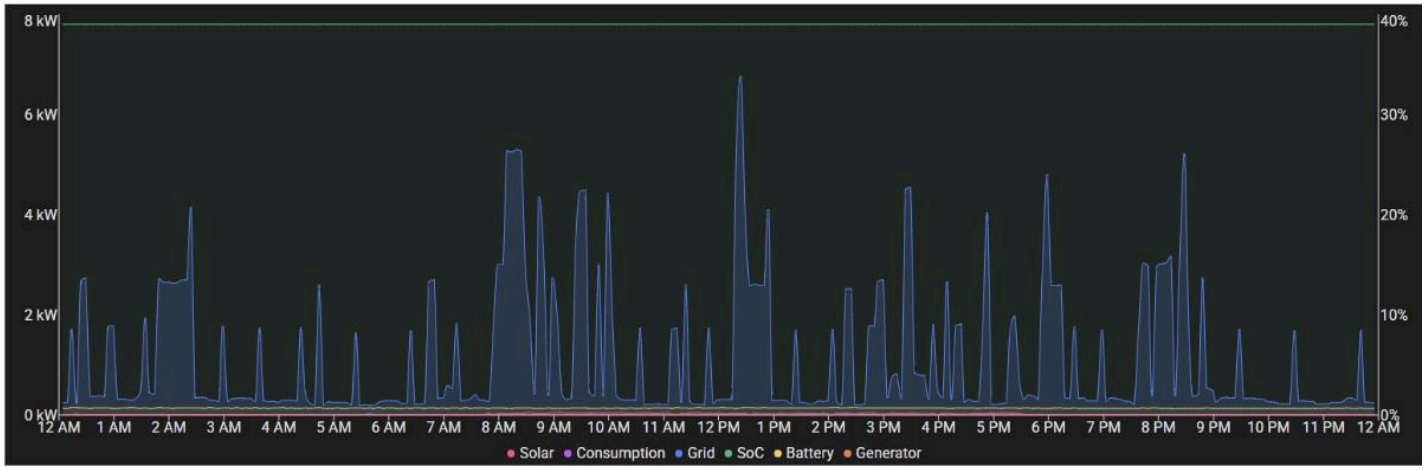

Figure 8. Example of backwards CTs or L1/L2 swapped CTs

Figure 9 shows the CTs backwards or L1/L2 swapped and the system has an external solar inverter, not connected to the Sanctuary's grid port. Notice that the load power calculations follow solar sell-back.

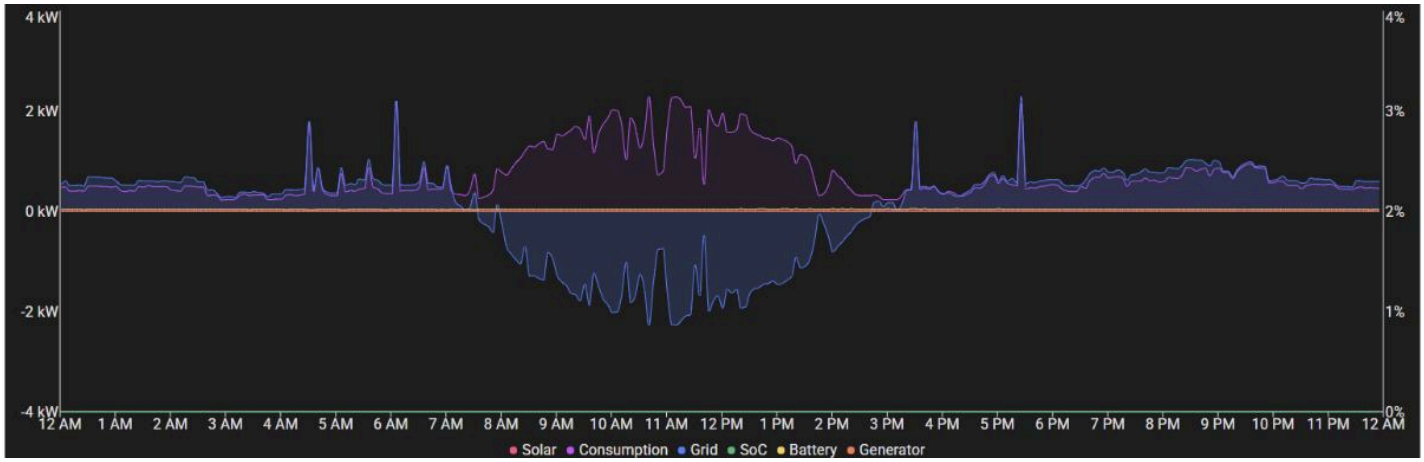

Figure 9: Backwards or swapped CTs with solar power, no battery contribution

Figure 10 shows that the CTs are backwards or L1/L2 swapped. The inverter alternates between charging from the grid and selling to the grid. When the batteries are charging, the CTs show power selling back to the grid. When the batteries are discharging, it shows power consumption equal to charging power plus grid power plus loads. The math doesn't add up.

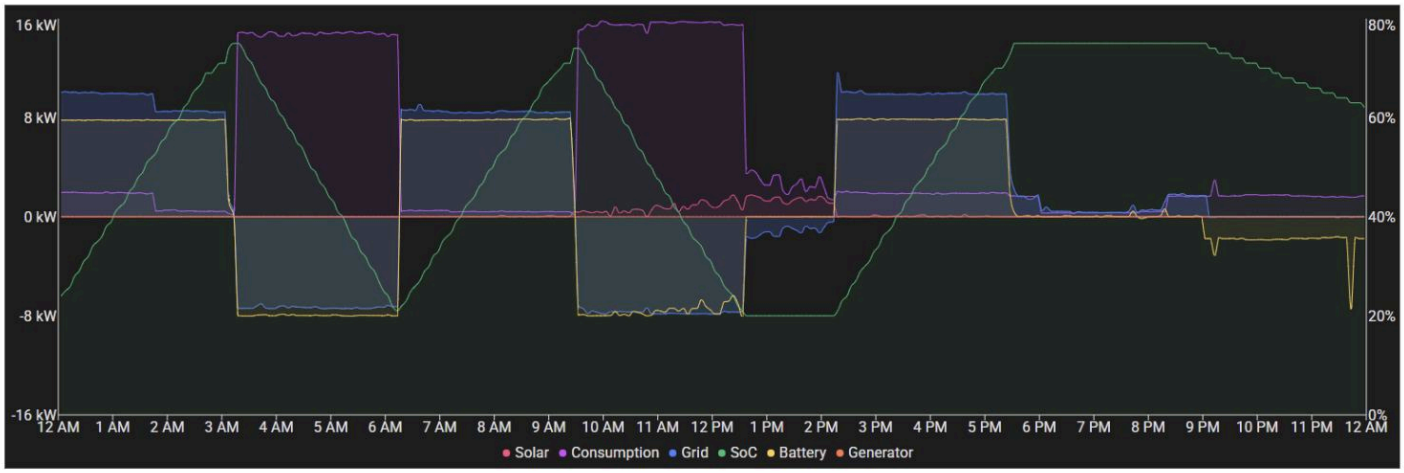

Figure 10: Backwards or swapped CTs

Figure 11 shows a system where the CTs are not installed and there are no loads on the load port. Calculated load power follows solar. Battery charging from the grid shows no power drawn from the grid. The inverter might randomly start charging the battery from the grid or discharging to the grid.

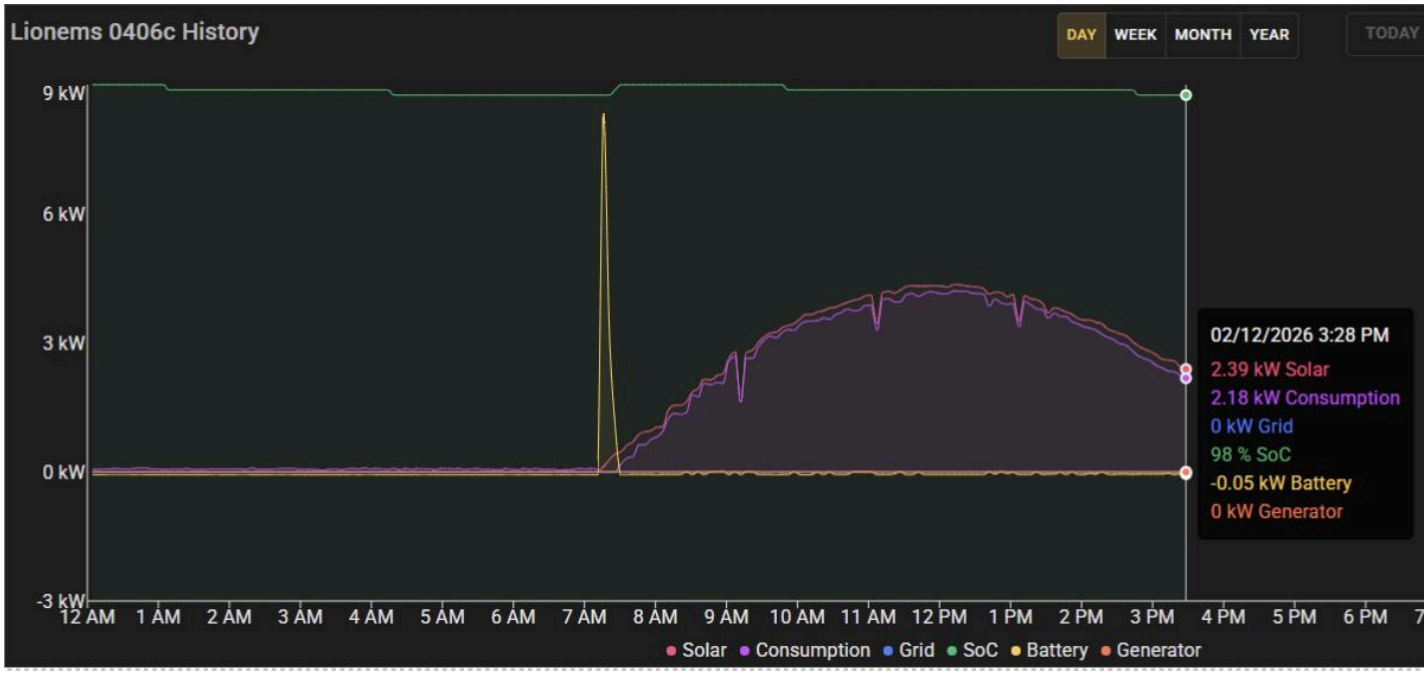

Figure 11: CTs not installed or not connected equals zero grid power.

Mistakes

What happens if the CTs are installed at the inverter's grid port?

If there are any home loads between the inverter's grid port and the utility meter, the inverter won't send battery power to those loads. The inverter will use solar power first to cover the load port power, then to charge the battery, and lastly sell back to the grid. Only when the inverter is selling solar power to the grid will the home loads between the grid port and meter receive power from the solar panels.

What happens if the CTs are in the wrong location?

The inverter will get the wrong signals about how much grid current is flowing. This can cause the inverter to discharge the battery power into the grid and unnecessarily charge the battery from the grid. This cycle can happen repeatedly.

What happens if the CTs are not installed?

The inverter will get the signal that grid current is zero. It may charge the battery from the grid and discharge the battery power to the grid repeatedly. If there is no grid connection (off-grid), then the CTs are not needed unless there is a generator connected to the grid port.

What happens if the CT direction is reversed?

The inverter will discharge the battery at full power until the TOU set-point. Then it might start charging the battery at full power. At any point, it may charge the battery at full power from the grid and repeat the cycle. The inverter will get reversed signals and think it's selling power to the grid when it's actually using grid power. It will think it's using power from the grid when it's selling power to the grid and will try to inject as much power as possible to decrease grid consumption.

What happens if the CTs are swapped between L1 and L2?

This is similar to having the CTs facing the wrong direction. Since the phases are opposite, the inverter will get the wrong direction signals for current.

Three-Phase

Three-phase common grid CT

Inverter #1 L1 CT port gets the phase A CT signal.

Inverter #1 L2 CT port gets the phase B CT signal.

Inverter #2 L1 CT port is not used.

Inverter #2 L2 CT port gets the phase C CT signal.

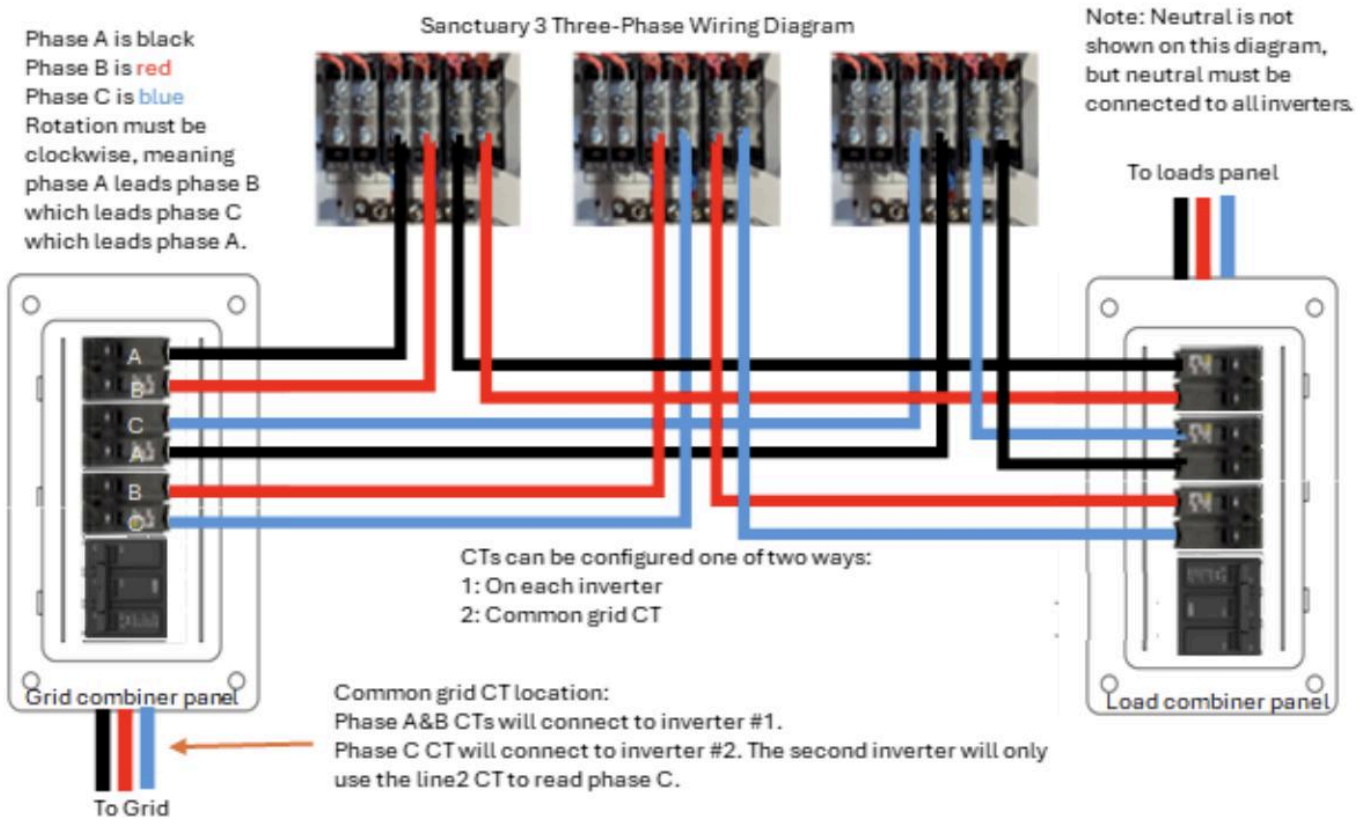

Figure 12: Sanctuary 3 Three-Phase