Design, Acquisition, Construction, Configuration and Operation of a Paralleled Hybrid Grid-Tied 22KW PV System Powered by SRNE HEBP Inverters

Table of Contents

This document is about installing a set of solar panels to make electricity. It presents the scoping, design, purvey, fabrication, installation, configuration and operation of a photovoltaic (PV) panel powered electrical service. A survey of hardware and software is followed by the big ticket choices: the inverters and panels. The electrical reticulation and inspection requirements section details the layout and installation of the inverters, batteries, grid, breaker box/Main Lug Only (MLO) service feeders and PV direct current (DC) leads. The roof preparation, rails, conduits, PV installation and maintenance are covered in the next section. The final sections cover the configuration and performance of the system. The spreadsheet of items and costs is found at the end of this document.

Design and Overview

Net Metering

The work described here was done in Kentucky in 2025. Net metering in Kentucky usually works by rolling the electric meter backwards. No dollars are ever paid to the typical homeowner based service. The homeowner's account is credited for generated electricity and those credits are perpetual. For example, the overproduction of electricity in August will credit against use in January.

Staying on the electrical grid while producing the year's KW buffers well. Any instantaneous load is met by the utility line plus batteries and the solar inverters. This works well for old already installed electrical services as well as new. In the event of the mains going down, a dearth of electrical current will happen and the homeowner will be limited for the duration to that current available from batteries, generators (if any) and solar panels. Old service installations have already met this familiar grid failure scenario and have accommodated the event. The payoff for staying on a net metered grid is a reduction in the scale of the system: it takes fewer panels, fewer batteries, and less constraint on instantaneous loads if you stay on the grid.

Demand Inventory

A simple inventory of some years of electrical usage will give a good measure of the average annual KW demand. Because net metering here buffers the highs and lows of electrical production and consumption, the average annual demand will inform the scale of the system for a given locale. This is not how many solar systems work, but being on the grid in Kentucky with the perpetual credit net metering works.

Once the annual KW demand has been calculated, use several of the web based calculators to estimate the size of the system: the inverter capacity and the panels needed to provide that capacity. For example, the National Renewable Energy Lab's pvwatts calculator, is one such calculator:
https://pvwatts.nrel.gov/pvwatts.php

Documentation and Reference Materials

There is an excellent web forum, **https://diysolarforum.com** that offers a wide range of experience and support. It is required reading.

Many online guides to the design, installation and operation are available, for example:

https://diysolarforum.com/threads/commonly-used-forum-acronyms-abbreviations.882/

https://www.homedepot.com/c/ab/a-pro-guide-to-installing-solar-panels/9ba683603be9fa5395fab90194d945a5

https://www.unizsolar.com/news/industry-news/gridtie-solar-inverters-a-comprehensive-guide-to-ongrid-solar-power.html

https://www.solar-electric.com/lib/wind-sun/CS_Installation-Manual_PV-Modules.pdf

Location

Choosing the exact location for the panel array provides the required parameters to the calculation that yields an estimate of the number of panels needed to meet the annual KW demand. There are several constraints to consider: the orientation and aspect of the panels relative to your latitude and shading are the primary concerns. Some local ordinances may also limit your choices. The state's Public Service Commission requires utilities to report their net metering and grid connection rules. Look those up to better understand how your local utility handles your hybrid grid/solar installation. Here is an example:

https://psc.ky.gov/tariffs/electric/licking%20valley%20recc/Tariff.pdf

https://psc.ky.gov/agencies/psc/Industry/Electric/Final%20Net%20Metering-Interconnection%20Guidelines%201-8-09.pdf

After working out the number of panels and where they will be installed, the rest of the system will derive from calculations based on the number and KW yield of the panels.

Solar Panel Characteristics

Solar panels are not a fixed source of current or voltage, those vary with incident sunlight and temperature. A critical value is the panel voltage at low temperature. The voltage is higher when cold and that higher voltage cannot exceed the limits of the hybrid inverter without damage to the inverter, so it is an imperative design feature to assure that cold temperatures don't get you in trouble. Solar panels have "design specification sheets" that detail the exact characteristics of the panel. The solar panel Open Circuit Voltage (Voc), once corrected for the absolute lowest temperature you might encounter defines the critical voltage that must never be exceeded for a given inverter.

However, like batteries or any other voltage source, panels can be wired in series to add each panel's voltage to a grand sum, the "string voltage", and or they can be wired in parallel too. Parallel adds up the current (amperage) while keeping the voltage constant. Series wiring keeps the current constant and adds up the voltage. Mixing and matching the wiring patterns of serial and parallel will keep both the voltage and amperage within the inverter's limits even in extreme cold.

It's a good idea to expect the panels to under perform, they will rarely provide the advertised wattage: shade, temperature, haze, fog, clouds, dust on the panels, and other factors will knock back the wattage. Adding 20% more panels than the annual demand estimates call for is a start, even more might be better. However, post installation, the operation of the system described here has shown it can make 19KW of an ideal 22KW. Given time and grime, the 19KW

Hybrid Grid Tied Split Phase Inverters

Hybrid Grid Tied Split Phase All-In-One (AIO) inverters come in many flavors and brands. SRNE is just one of several OEM manufacturers. AIO inverters can simultaneously source or sink current from or to the grid, from or to batteries, from a generator (if you have one), and from the PV panel's MPPT circuits. The master/slave set detailed here can contribute 100A from the PV and batteries. The grid makes up any power demand not being provided by the PV or batteries. PV energy not being consumed by the UPS load is pushed to the grid to roll the meter backwards and earn KW credits from the utility.

Running the inverter at 60-80% of it's design load will extend it's life. It will run cooler, a good thing, and handle instantaneous loads better. Study the web forum, **https://diysolarforum.com** extensively to better appreciate the reliability, technical support and features offered by the different inverters.

NB: there are only a handful of OEM producers of inverters, most inverters on the market are just rebranded derivatives. Nigh all are designed and built in China, so it is worth the effort to sort out the original manufacturer and take measure of their products. In many cases, albeit much more difficult to actually buy, purchasing from China is significantly cheaper. In some cases, technical support is offered by the original manufacturer or a national service center, not a smaller re-branding vendor.

Safety Equipment

The hybrid grid tied inverters and solar panels require safety equipment that include breakers, spike protection, conduits, battery management systems and solar panel string disconnection switches. They will require Rapid Shutdown Devices (RSD) if they are on a residence. The RSD devices are largely made for the residential scale PV panels, not the "commercial" scale panels detailed here. You may need to alter your design to conform to RSD technologies that require smaller sized panels, more rails, or more strings. Careful design and installation is required to make a grid ready and safe system. **Of greatest concern is the protection of the utility workers that manage the main lines, you can kill them if you get this wrong.** Modern inverters in the USA use a pair of "current transformers", small induction coils or the like that monitor the phase, frequency and voltage of the grid lines. They trigger the inverter to stop sourcing current to the utility, by law, within 2 minutes, but as a practical matter, within a few milliseconds. See **https://www.nrel.gov/grid/ieee-standard-1547/** for the National Electric Code (NEC) requirements for disconnecting the inverter from the grid. Have a good discussion with your utility company about their specific requirements. There will be an inspection before the utility will connect the inverter to the grid.

Lithium (LiFePo) batteries can burn down your house (it's happened). Box them in drywall/concrete hearthboard/fire brick so if they do ignite, they don't take the building with them. They also must be only charged at very low rates or kept above 0C. Frozen LiFePo batteries will suffer damage if not managed properly.

Power Production and Management

Some inverters can be wired in parallel. In a Master/Slave design, each inverter in the set will manage strings of panels specific to that inverter. Strings are not shared between inverters. The Master/Slave shared inverters will make a coherent, collimated, unified power source that matches the phase, frequency and voltage of the grid when the grid is up, and when down, the master inverter will harmonize with the slave outputs to make a pure sine wave that combines the power from each inverter to make 120/240 V 60 Hz split phase (US standard) electricity.

There is a methodology that the inverters use to maximize the power yield from the solar panel strings called "Maximum Point Power Tracking" (MPPT). It tailors the voltage of a string of panels to a local wattage maximum while allowing other strings to choose a different mix. If the inverter wants to limit the energy from the PV panels (for example, if the grid is down and you cannot use all the energy on offer) the MPPT controller will raise the input voltage. The PV panel's data sheet will include a power curve of available wattage vs voltage (see Jinko Specifications: 635W Solar Panels, below). Shading is the most common issue that MPPT offers to work around. Strings made with different makes of panels (different power curves) are also well managed by MPPT technologies. Inverters support a fixed number of panel strings, typically two to four, and offer MPPT management to each string. It's one of the design attributes that determine the inverter to use.

More About Wiring Strings of Solar Panels

Panels are commonly interconnected using a M/F coupling called an "MC4". The couplings should be interchangeable, but it's a good idea to stick with the make used by the panel manufacturer. Look around for a reliable stock of well reputed MC4 connectors, Staubli (tm) is the most common brand. Try not to mix brands.

There is an art to the MC4 connectors-they want a specific torque on the wire to connector seal, they want a <u>very very good crimp connection</u>, and they benefit from using an anti-oxidant on the wire to MC4 crimp (the anti-oxidant makes the wire slippery, so the crimp needs yet more perfection if you use the anti-oxidants. The crimp needs to pass a strong "tug" test, if the MC4 doesn't withstand a strong pull, chuck it and try again. Do Not fail to make a good crimp. The MC4 connector is officially water proof.

Do not make taut connections wiring one panel to the next in the string. Wire cladding can shrink over time, and temperature changes will affect the overall length of the wires and the panels. Recognize that as you string panels together in series, the voltage increases and you can be hurt or killed by mismanaging the wires on a panel string. As you assemble the system of strings, start by installing the disconnection and breakers at the inverter end of the panel string wires. Have those breakers and disconnects off so the circuit from the panels is is incomplete. Wear safety gear: insulated gloves, insulated tools, etc. Connect the panels in small groups to keep the combined voltage down as long as possible. Make the final completed circuit in a panel string with caution as the voltage or amperage is likely to double (depending on how you link and assemble the panels). It's reasonable to do dangerous connections at night or after covering the panels with 6 mil black polyethylene sheet to block light to make the handling of the hot leads safer.

Panels are mounted on rails. The rails accept a nut, bolt, and clamp that tie down the panel edges to the rail. The rail system shouldn't offer any galvanic incompatible bi-metal junction issues. Panels are usually an aluminum frame, so the nuts, bolts, clamps and rails must be made of compatible metals, typically aluminum or galvanized steel. Hot dipped galvanized steel is a better choice, but electro-galvanized steel and aluminum have a small voltage potential difference and won't corrode quickly. The panels and rails should be bonded and WEEB grounded. In most cases this only needs a protective earth lead across the rails, as the rails should make a ground circuit with the solar panel frames. Check for continuity between the rails, if they are not connected, run a protective earth lead to each rail.

The amperage and voltage of a panel string will determine the minimum wire gauge needed to handle the current generated by the panels. 10 AWG or 6mm THHN wire are common choices as they can usually carry more current than the inverters can handle and as the design already limits the panels in a string to conform to the inverter, the wire gauge is within amperage limits. The system described here operates at a maximum of 29A 300V, which conforms to the National Electric Code for 10AWG THHN with 4 pairs in a 1" conduit. Your local inspector has the final say, so discuss this with them before you start. MC4 connectors accommodate 6mm wire well and are a tad less snug with #10AWG. While the panels are pre-fit with MC4 male and female connections, two additional connections are needed on the leads that conduct the current from the panel string to the disconnect & breaker near the inverter, and another pair may be needed at the disconnect/breaker end.

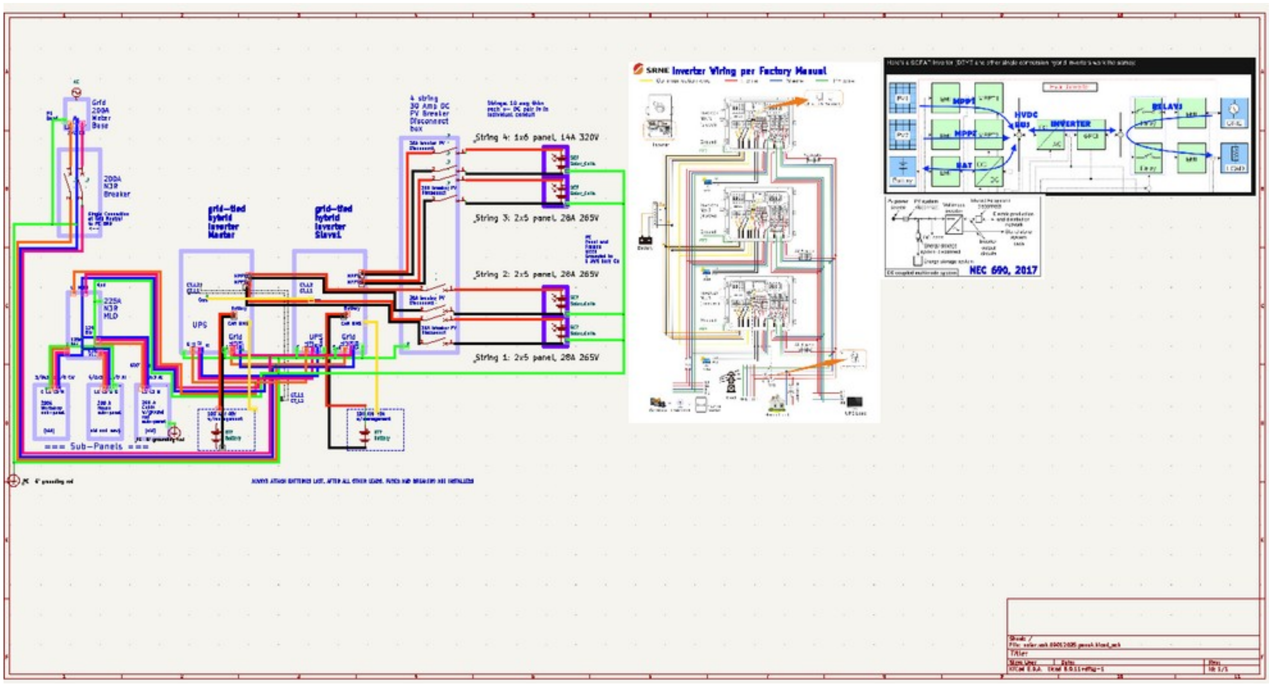
All the wiring in the entire system, once it leaves the panels, should be in conduit.

In addition to solar panels, All-In-One (AIO) hybrid inverters can accept source current from batteries and generators. Generators come in many flavors, they vary by voltage, wattage, fuel, and how they start (automatically, electric start, or manual pull start). The inverters have an upper limit to the current they can draw from a generator. No generators were used here, so there's no further discussion about them in this document.

Batteries, like solar panels, can be wired in series or parallel. The typical LiFePo4 is a 48v device, but they can be 12v, 32v (or other) devices. The LiFePo4 batteries are usually wired in parallel to increase the available amperage. They need large cross section copper wires to handle that amperage. LiFePo4 batteries must be managed to prevent fire. Commonly, commercial batteries are sold with an embedded Battery Management System (BMS) that limits sourcing and sinking current to a safe non-incendiary rate. The batteries used here are enclosed in a fire resistant box, should they catch fire, the box will endure about an hour of ignition before fire can escape.

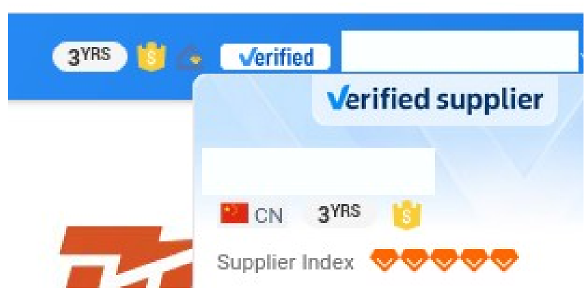
A Big Picture

Develop a schematic wiring diagram. Budgeting and hiring licensed electricians becomes more tractable with one. Construct a Bill of Materials and a spreadsheet for the costs. Plan the purchase schedule, many items will take time to deliver. Pre-authorize the charges that will go on a credit card. It may be best to pre-pay the card as well, as the credit card company will be more confident about large charges accruing to the card.



Acquiring The Inverters and Panels Directly From China

Most solar inverters and panels are made in China. It is often much cheaper to buy the gear directly from a broker or manufacturer there. That often means using Alibaba and using it carefully. The Alibaba web platform is difficult and enigmatic, it will take some time and practice to use. There are some fundamental practices that you must abide: Alibaba brands each vendor with some badges if they've earned them. Only consider vendors that have badges like the ones shown here:

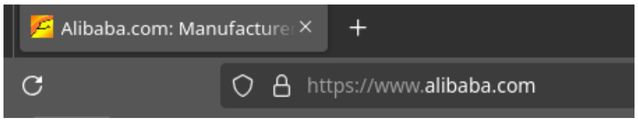


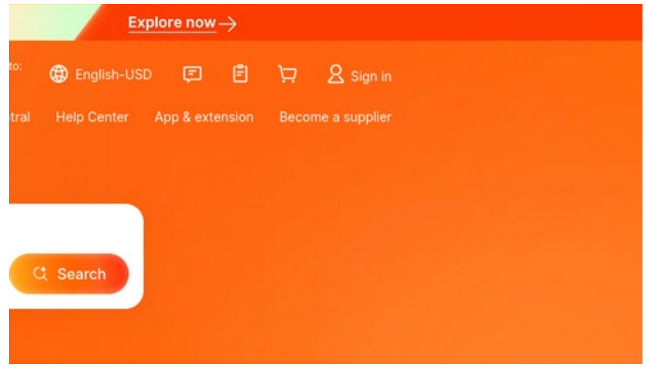
From the left, the vendor has been on Alibaba for 3 years, has Trade Assurance, the verifier was TrustPass, and the vendor is a Verified Supplier. The bottom array, Supplier Index, is a measure of transactions done on Alibaba, the 5 icons shown here are the max, meaning a lot of business has been done. Any listing for a product will have a link to the vendor that will show you the badges and company information. Also review the Company Profile, and Ratings & Reviews.

Often when searching, filters for each badged attribute will be offered so you can better locate vendors you might consider.

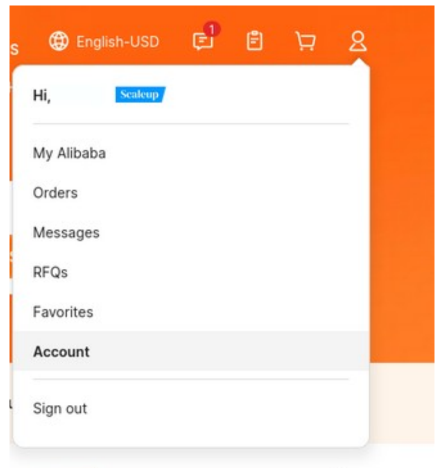
Create an Alibaba login ID.

Create an account and sign in. *Be precise, the name on the account should match the name on the credit card you'll use.*



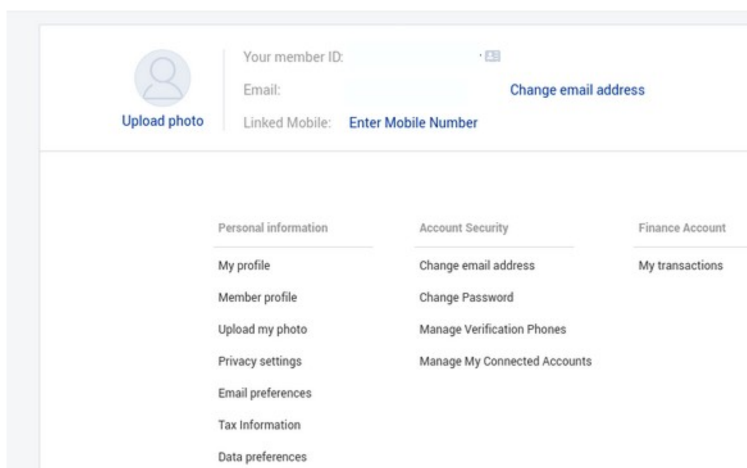


Register Your Credit Cards



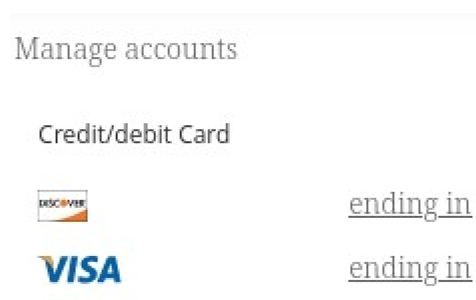
The credit card(s) will need vetting by the Trade Assurance staff, so create the account and login and then from the main page, select the "Account" option from the drop down menu.

From the next page that shows up when you click on "Account", click on "My Transactions"

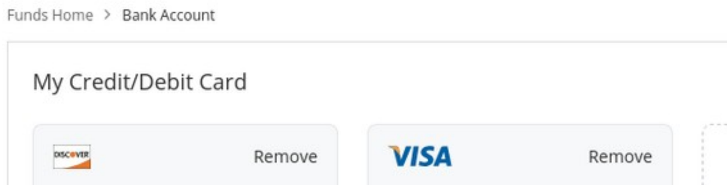


From the "Transactions" page, find the "Manage Accounts" section in the upper right and add the credit card(s) you'll use.

When you click on Manage or a current card, you will see the



https://myfinance.alibaba.com/buyer/wallet/accountManage.html page and can add a new card or revise existing records.



If Alibaba Chokes On A Payment

Paying for the second inverter appeared to have worked from my end, I got a page that said that the payment "is under review." That should have been completed quickly. Instead, the card company accepted the transaction **but Alibaba rejected it:** "Payment Failure. You have not successfully completed your 3D authentication. Try again or use another card or payment method." NB: That message was only offered after some days and a couple of attempts to use the offending credit card. 3D Authentication pertains to the first card I used, the one that I had to clear a block set at my end, but was then rejected at the Alibaba end after the block was cleared. I went back to the first card that had worked, but it too was now rejected.

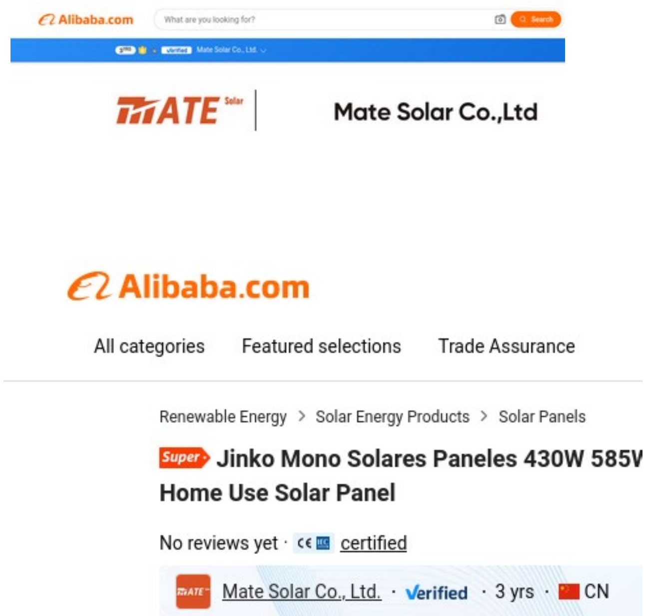
Waiting until the first sale was fully processed (c. 3 days) and then trying to make the payment again was part of the trick that made the sale finally work. The other part was vetting the card by appealing the rejection. First, try to make the rejected sale again. That offers an "Appeal", then click on the Appeal. The card needs photos for validation, likely three images- of the card, a utility bill at the billing address, and a photo id. Send the validations, and wait a couple of days while the card gets validated and bound to your account. Getting that done up front prevents a prolonged security review when a sale is rejected, so try to add and bind the card(s) to the account before making the purchase, but don't be surprised if it has gotcha's and features. Technical support is marginal to nil on Alibaba Expect to use email and for 3+ days before response.

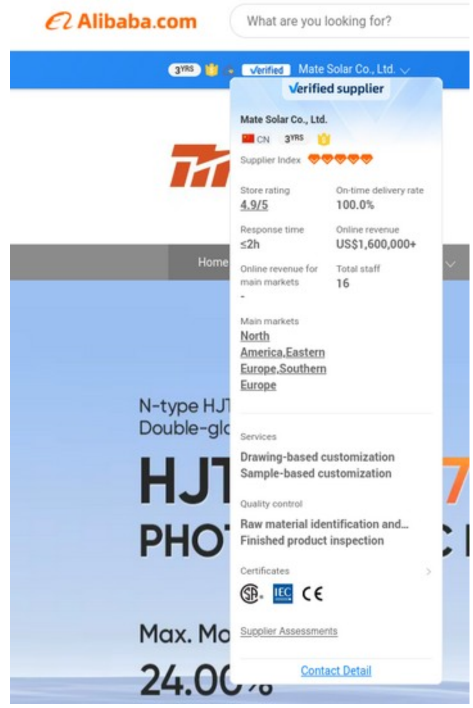
Finding What You Want

Construct the solicitation precisely. Work hard to have an exact, ready to buy, description of what you are trying to get. There are buzzwords associated with international commerce: DDP is an important one. The Direct Delivery Price (DDP) is a fixed price quote for delivering the product to your delivery address, home, workplace, etc, vs some port where you hire your own trucking company to fetch the product.

For Example:
I am interested in the Jinko 78HL4-BDV 635w. Please quote the DDP with post-delivery coverage, shipping and packaging details and delivery date for a pallet (36 ct panels) delivered to 123 Main St, Anytown, YZ, USA.

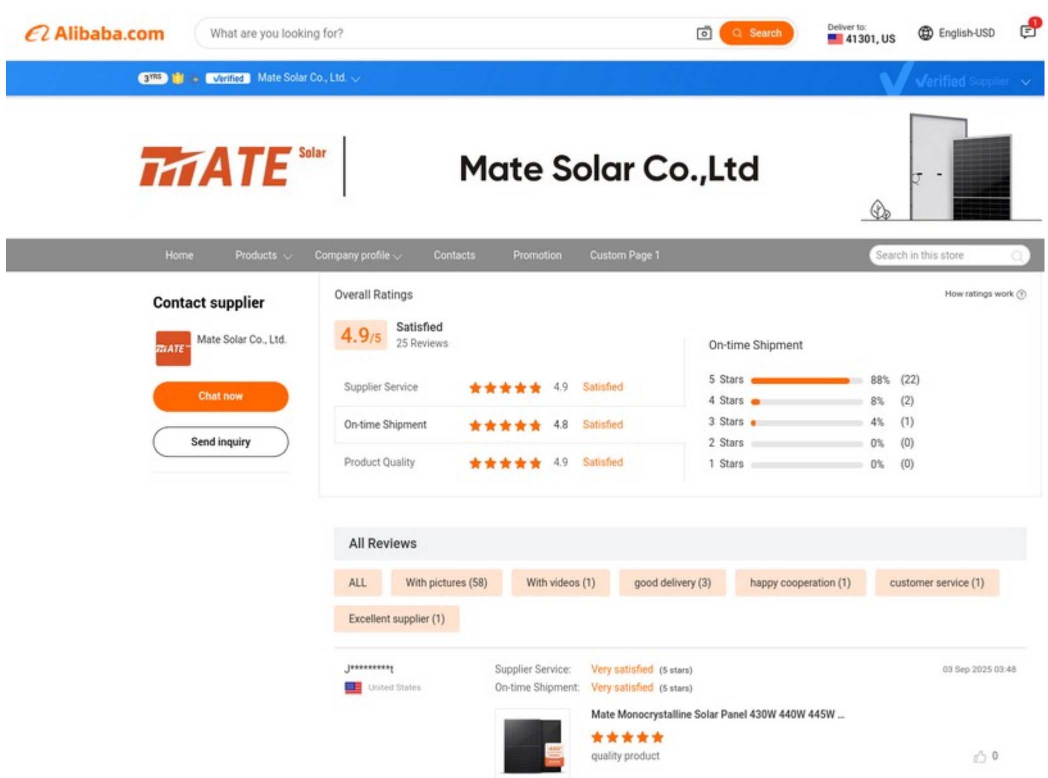
Search for the product,





Negotiate

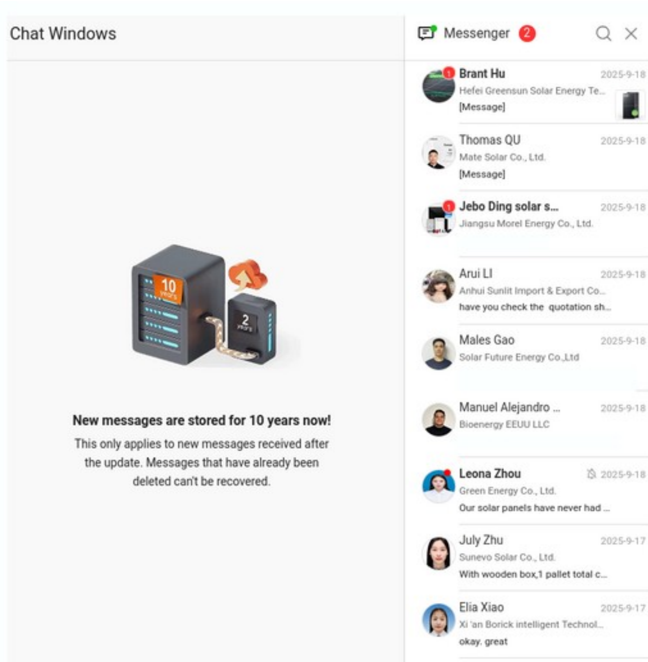
Once you find the list of plausible vendors or they find you based on some query you made. Alibaba will post your request, so you may get a lot of offers, including many from long after you've made your purchase, it's time to chat and dicker via the Alibaba Messages service. Usually that means being awake during China's business hours, so get ready for that. Re-assert the quote specifications with each new vendor. The international commerce lingo has meaning, always ask for DDP, the direct delivery price that includes everything like shipping, taxes, tariffs as well as the product itself. The language " Please quote the DDP with post-delivery coverage, shipping and packaging details and delivery date for a…" should suffice.



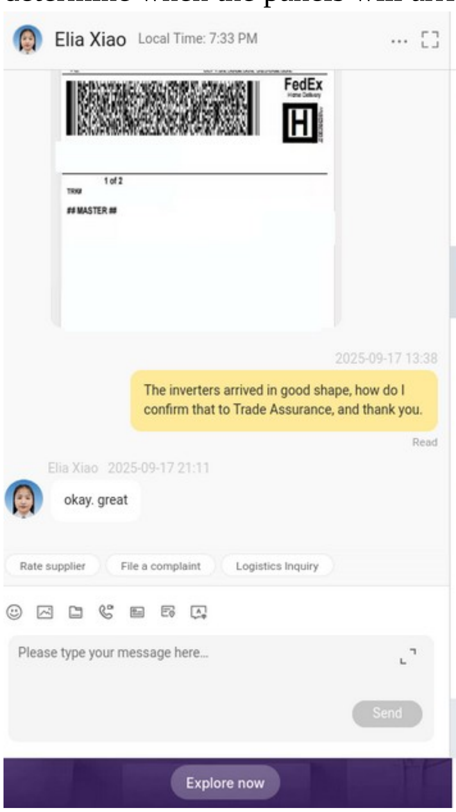
How To Order

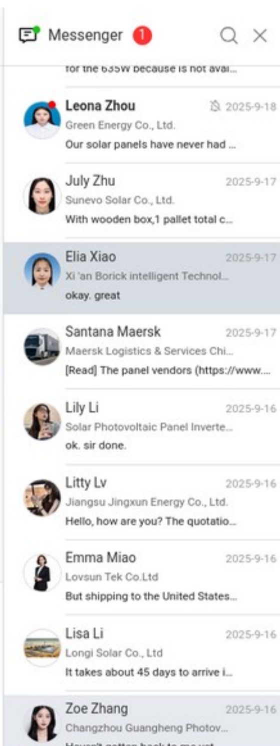
When things sort out right, and you are ready to place the order you've negotiated, you must get that order offered through the Alibaba system, usually as a dialog posted into the chat with the vendor titled "Order". It must show up in your Alibaba Trade Assurance Orders or Transactions list.

Only pay with a credit card, never anything else like a bank transfer. Folks who know and trust their vendor can take the risk, but one-offs and small customers need the credit card company and Alibaba's Trade Assurance escrow and oversight. Expect to pay state taxes. Expect to pay a 3% card fee for the full cost of the transaction.



Include in your order request that you require the Bill of Lading showing the shipping vessel and departure date of the panels. Be clear with the vendor that you will complain to Alibaba (more below) if you are not promptly given the Bill of Lading (BOL). The BOL is how you can track the vessel and determine when the panels will arrive.

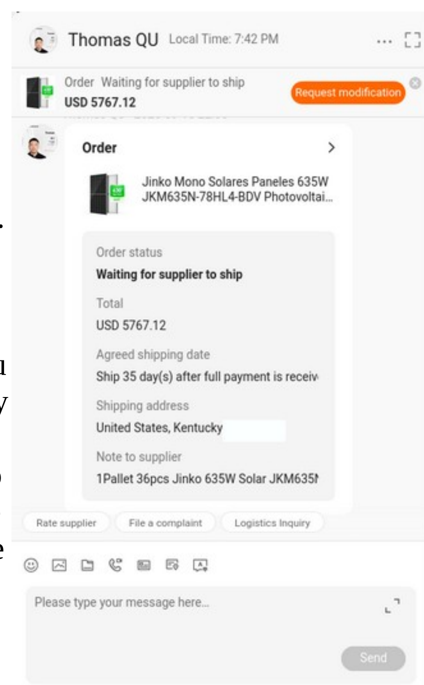




Slow Boats

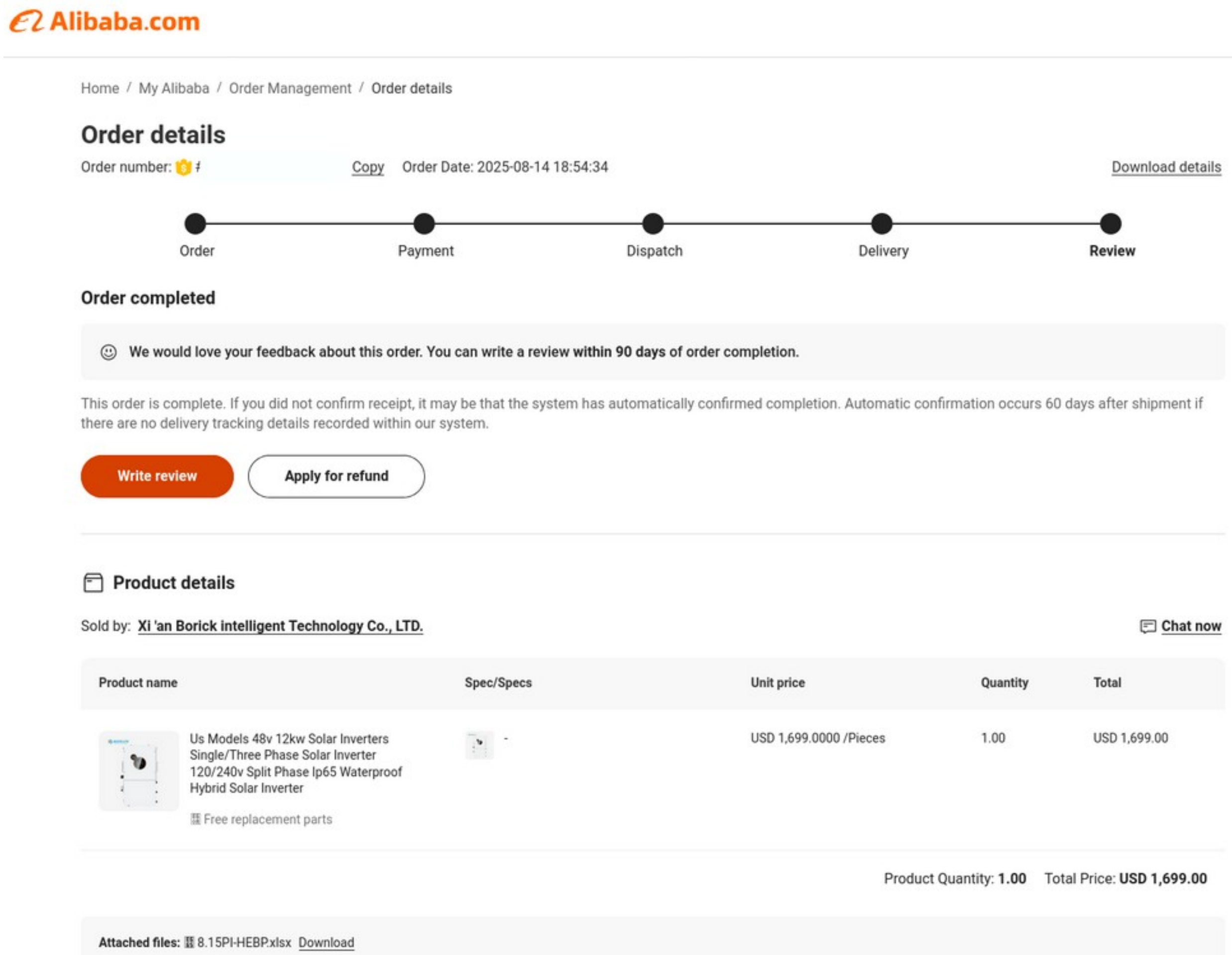
Now wait 30-45 days.

And when stuff arrives, you may or may not be expected to sign for the order, so be vigilant about the delivery so you can inspect it with the carrier there in case you have damaged goods.



Success, the Order is Delivered

Once the order arrives, the Alibaba Order will be marked complete. If there's a basis to complain, do it immediately.



Should the vendor misbehave, like not posting the Bill of Lading for a shipment, ask persistently and should that fail, invite the Alibaba support folks into the dialog. That too may initially fail, so after some days, ask them to escalate the inquiry. This is not the same as filing a dispute or complaint, but it puts the vendor on notice that the Trade Assurance and Alibaba platform folks are now getting involved. Tell the vendor that you've invited them into the dialog and point out that posting the Bill of Lading (a standard practice) will make it all go away. The vendor is in control of the order process, and can mark the order shipped without any real evidence, so getting a Bill of Lading is the proof that the order has been shipped.

The Bill of Lading may include things like the "ocean vessel/voyage number" and with that you can look up the date of departure and scheduled arrival of the vessel. Websites like "myshiptracking.com" or "vesselfinder.com" will report those. Knowing the arrival date allows you to plan for and schedule the arrival.

The Pallet of Panels delivery

Once the pallet has arrived at the destination port, it still needs to be trucked to the delivery site. In spite of having negotiated and paid for the pallet delivery to place the pallet on on a local flatbed truck, my stateside shipping company declared that all they can do is put the pallet on the ground and drive off. In spite of that negotiation and the trucking company's assurance, when the pallet arrived, the delivery truck quite literally did not have a way to move the pallet around on their own truck much less offload it to the ground. After some careful measuring, and relocating the delivery truck to elevate the tailgate to meet the height of a handy flatbed truck, the pallet was chained at the base below the panels and a slow but effective chain hoist tow pulled the pallet from the delivery truck onto the flatbed. It took three hours to set up the trucks, chains and move the pallet! Once on the flatbed, the pallet was unmovable without the chainhoist. Your panels may need to come out of the pallet to get offloaded, and that may take several people.

To unpack the pallet, a wooden cage made of plywood and 2x4s was built around the pallet and fixed to the deck of the flatbed truck so the panels could not topple and could be restrained upright while individual panels were lifted out by hand and set on a forklift. The forklift had 50" (the panels are 44") tall 2x4s as an upright backrest so the frame of the panel lay against the uprights and the forks. They could be restrained to the uprights with rope and transported to temporary storage adjacent to the crane that will loft them to the roof.

Panels need to be stored with care to keep the MC4 connections pristine. The 36 panels are upright, sandwiched between sheets of plywood and surrounded by the cardboard they came in and covered with a plastic sheet.

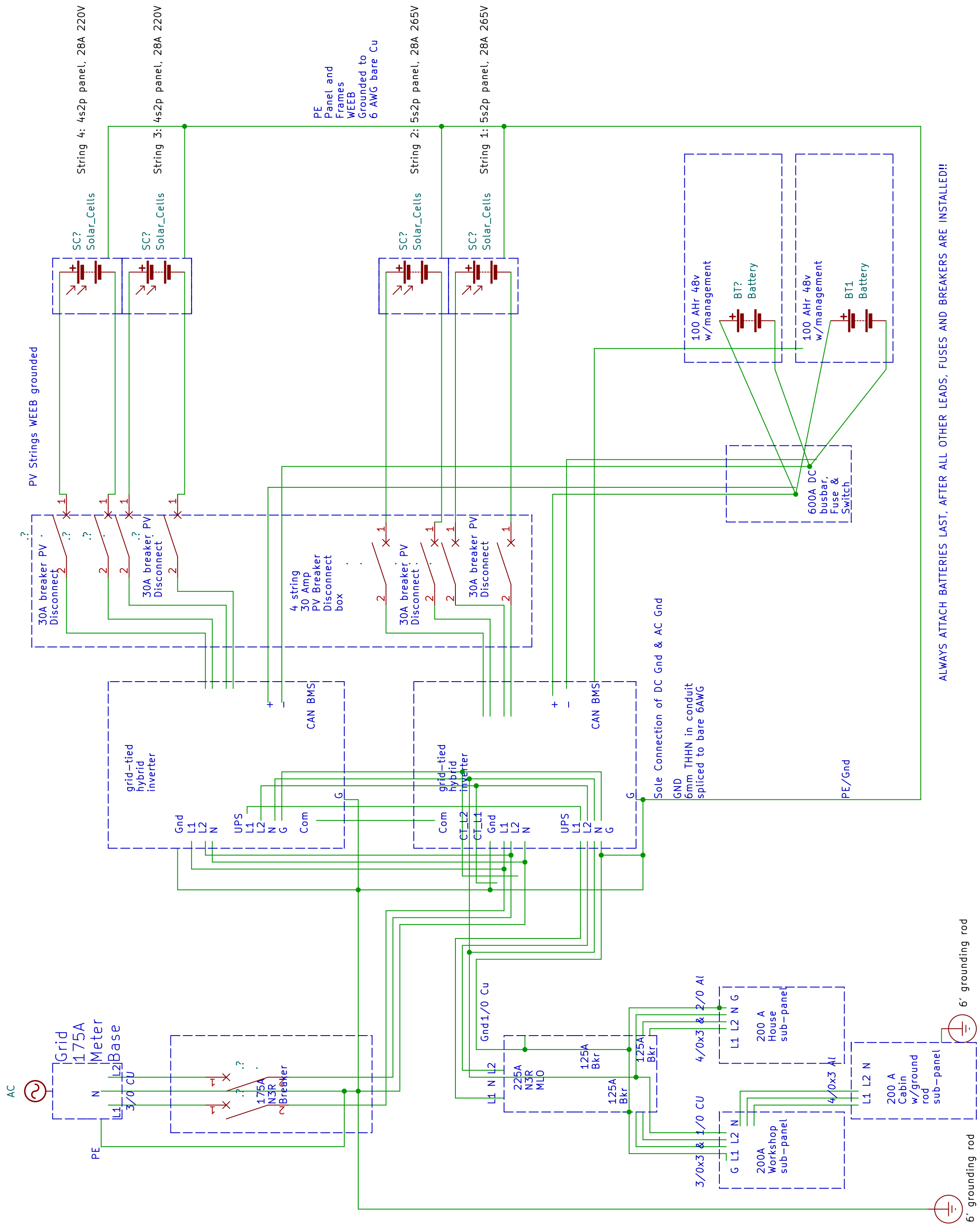
System Design, NEC, & Passing Inspection

All the electrical aspects of the job need approval from your local Electrical Inspector, the authority on what can be permitted where you are. There is little to characterize, as the local rules may vary from the National Electric Codes a lot. Hiring an electrician may spare you the learning and failure curves, mostly. The costs are also hard to characterize.

Broadly, because the PV energy is being pushed to the grid to roll back the meter, the system's wiring has to be calibrated to the total amperage that might ever occur, and then get de-rated by some rules mostly only known to electricians and electrical inspectors, the 80%, 120% and 125% rules. These ratios are applied to some of the circuits and they will disqualify some of the wiring standards that usually apply. Your local inspector will describe what will pass and what won't. It may take a couple of passes and you'll be billed for each pass. It's money well spent.

The inverters must be certified by a Nationally Recognized Testing Lab (like UL, CE, etc) to conform to safety regulations. The inverters must sense a grid failure and stop pushing current to the grid, by law within 2 minutes, in practice a few milliseconds. If they inverters don't stop pushing current to the Grid, you can kill utility line workers, so that one is a Primary Concern. Other similar rules apply for the quality of the energy being pushed to the Grid to assure that the phase, and voltages are within specification.

Solar System Wiring Schematic



Unless told otherwise by your inspector, adhere to the NEC. Make good records. Keep a log of torques applied to all the lugs and fittings, documentation and photos of the work Label the wiring in situ and document the labels. Solar systems require explicit visible external labeling. For old installations, the inspector is constrained to the new work, any hazards, and any "significantly impacted" circuits.

Designing to Comply With the NEC

What follows is how to de-rate and wire a standard 200A utility meter base to a 175A circuit breaker that feeds the Grid lugs of a dual master/slave paralleled interactive hybrid grid-tied pass-through SRNE brand inverter pair, including the NEC codes that apply.

Each SRNE inverter used here can make 50 A of 240V split phase current. All the home load is on an inverter circuit called "UPS" that is powered by PV panels, the Grid, and batteries.   Many installations will use both the UPS and the "Home" load circuits especially with new structures that can run independent wiring for uninterruptible circuits versus those that are OK with being powered off should the grid be down.

The intent of this installation is to limit the effective available Grid contribution to the inverter pair by placing the 175 A OCPD (a 175 A breaker in an outdoor N3R box) in the supply path to the inverter's Grid lugs. The protective device (the 175 A breaker) limits the Grid contribution to the inverter to a maximum of 175 A. The meter socket itself (the box the meter is plugged into) is physically unchanged but because of the 175A breaker, it is electrically limited to 175 amps from the grid.

Design Summary

* Show the NEC calculations (705.12, 705.28, 110.3(B), 240.4, 310.16, 250.24) and demonstrate how the de-rate to 175 A is sized, protected, and wired.
* Meter socket: mechanically rated 200 A (that equipment remains unchanged).
* Intent: de-rate the electrical service feeding the inverters by installing a 175 A main overcurrent device (breaker) ahead of the inverter Grid lugs so the inverter pair receives service through a 175 A protected supply conductor rather than a full 200 A main. This effectively limits the upstream protected bus contribution and keeps the installation compliant when checked against NEC Article 705 requirements.
* Inverters: two identical interactive hybrid inverters, each rated 50 A @ 240 V split-phase Combined maximum continuous interactive current = 100 A.

With the 175 A OCPD feeding the inverter GRID lugs, and with properly sized conductors and labeling, the NEC bus/current calculations and conductor protection can be satisfied and the inspector has the documentation to approve the proposed configuration. <u>NB: The inspector can request alternate options (supply-side tap, service upgrade, or reduced export)</u>. What is described here is common though.

Technical Narrative and Rationale for a 175 A OCPD (breaker)

Inverter A nameplate: **50 A @ 240 V split-phase → 12.0 kVA (approx), continuous current 50 A.
Inverter B nameplate: **50 A @ 240 V split-phase → 12.0 kVA.
Combined inverter output (parallel): 50 A + 50 A = 100 A continuous at 240 V split-phase.

NEC Requirements

For Article 705 bus checks and conductor sizing, the inverter (power production) output is considered when calculating bus and conductor ampacities; 125% of inverter output current is used where continuous-style sizing is required (NEC 705.12 and 705.28 for conductor/OCPD calculations and the busbar sum rule).

The meter socket is a mechanical device rated to 200 A; rating alone is not a substitute for ampacity calculations on conductors and busbars. NB: The meter socket and associated hardware remain unmodified mechanically; the field change is *electrical* (smaller OCPD) not a physical de-rate of the meter can.

NEC Article 705.12 requires that the sum of the inverter source contribution (adjusted per Code) plus the rating of the OCPD protecting the bus not exceed bus ampacity (or meet the alternate 120% end-of-bus rule when applicable). So a 175 A main breaker that protects the conductors feeding the inverter Grid lugs will reduce the value that appears in the bus-sum calculation (the OCPD rating protecting the bus) to present a compliant 705.12(B)(3) bus sum calculation.

Conductor sizing, OCPD selection, and grounding

OCPD: 175 A breaker (listed for service equipment) is selected to protect the conductors feeding the inverter grid lugs. The Square-D 175A breaker fits.

Conductors (meter to 175 A breaker): Size per NEC Table 310.16 based on conductor type and insulation. For copper THHN single- or 3-conductor run in conduit, 2/0 Cu or larger is typically used for 175 A continuous duty if allowed by temperature rating and correction factors. Verify with Table 310.16 and applicable derating factors. The system actually built here used 3/0 wire, well over capacity for the design and harder to bend and fit, but it will run cooler.

Inverter GRID lug feeders (175 A breaker to inverter pair Grid input): Size conductors to carry the 175 A OCPD rating per 310.16 and protect per 240.4(B) rounding rules. If the inverter input is split into two feeders, ensure each is protected and sized to meet the inverter manufacturer instructions and 705.28 conductor sizing rules. Again, oversized 3/0 copper L1,L2,N,and 1/0 copper PE are used here.

Grounding & Bonding: Follow NEC 250.24 for service bonding and grounding. Ensure grounding electrode conductor (GEC) and enclosure bonding are continuous and properly sized; provide an equipment grounding conductor sized per 250.122 for the OCPD selected and the inverter equipment instruction. Maintain a single main bonding jumper at the first connect from the service, so PE & N are bifurcated at the 175A breaker box where the meter base service lines enter.

Inverter interconnection and disconnection

The inverter's grid lugs must be connected using the manufacturer-provided lugs and wiring method; follow NEC 110.3(B) and the inverter instructions (UL 1741 / UL 1741 SA listing). The 175A breaker provides the external listed disconnecting means for the inverters per 705.22 and per the inverter manufacturer's instructions.

Labeling Enclosures and Equipment

Label all equipment with the required markings per 705.30 and 110.22. NEC has specific colors (generally red) and locations for the labels.

Load Separation (UPS) and Anti-islanding

This system's work is served from the separate inverter output circuit labeled "UPS". The UPS circuit is not directly tied into the same bus that the Grid lugs feed (this matters to the design and to the inspector; ensure physical and electrical separation is clear in the documentation and that transfer, pass-through, and anti-islanding schemes abide the inverter manufacturer instructions and NEC 705 series requirements.

NEC References

NEC 705.12 — Interconnected electric power production sources: busbar and conductor calculations for parallel operation and the 125%/120% sum rules. Use when evaluating load-side interconnections.
NEC 705.28 — Power production conductor and overcurrent device sizing (treat inverter outputs as power production sources for conductor and OCPD calculations).
NEC 110.3(B) — Equipment must be installed per manufacturer instructions and listing (apply to inverters and service equipment).
NEC 240.4(B) and related sections — Rules for standard breaker sizing and conductor protection.
NEC 310.16 — Conductor ampacity tables for conductor sizing.
NEC 250.24 — Service grounding and bonding rules.
NEC 705.22 / 705.30 — Disconnecting means and labeling for distributed resources.

```
        Utility
          |
      [Meter]  (meter socket rated 200 A)
          |  Service Conductors (sized per 310.16)
          |
      ┌──────────────────┐
      | 175 A Breaker |   <-- Installed in listed enclosure
      └──────────────────┘
          |  (Protected supply to inverter GRID lugs)
          |
   ------------------------ Bus / Conductor run -------------------
    |                                      |
 Inverter Pair GRID Lugs (paralleled master/slave)          Other service circuits
 Inverter A GRID IN  -----|                            (main load side)
 Inverter B GRID IN  -----|                            (separate UPS inverter outputs)
               [Inverter Enclosure(s)]
```

Note: ALL HOME LOADS are fed from the separate UPS inverter output circuit;
the 175 A breaker only feeds the inverter GRID lugs (not the UPS distribution panel).

One-Page Worksheet— Bus & Conductor Check

Project:** 200 A Meter Base — De-rate to 175 A breaker feeding inverter GRID lugs

Inverter nameplate data:**

Inverter A = 50 A @ 240 V
Inverter B = 50 A @ 240 V
Combined = 100 A @ 240 V

Code factor for bus check: NEC 705.12 & 705.28 use 125% of power-production output for bus/conductor checks where continuous-current sizing applies.

Step 1 — Inverter adjusted current:

1.25 × (combined inverter output) = 1.25 × 100 A = 125 A

Step 2 — OCPD rating protecting the bus (we are proposing a 175 A breaker):

OCPD rating = 175 A

Step 3 — Bus sum check (as required by NEC 705.12(B)(3))

Required: (125% inverter adjusted) + (OCPD rating protecting the bus) ≤ Bus ampacity OR meet the 120% opposite-end allowance when applicable.

Calculation: 125 A + 175 A = 300 A

Step 4 — Compare to bus ampacity / 120% rule

Mechanical meter socket rating = 200 A (bus nominal)
120% of 200 A = 240 A (alternate if sources at opposite ends)

Result:

125 + 175 = 300 A > 200 A and > 240 A → Does NOT meet direct bus test for a 200 A bus.

Required inspector checkpoints (initial each):

[ ] 175 A protective device is listed for this use and installed in a listed enclosure adjacent to meter.
[ ] Conductor sizes from meter to 175 A device are sized per NEC 310.16 for the chosen conductor material and temperature rating.
[ ] Inverter manufacturer wiring followed (110.3(B)) and inverter disconnects present per 705.22.
[ ] Labels per 705.30 placed: multiple sources, inverter info, emergency instructions.
[ ] Utility notification / permission or local AHJ written acceptance (as required by local practice)

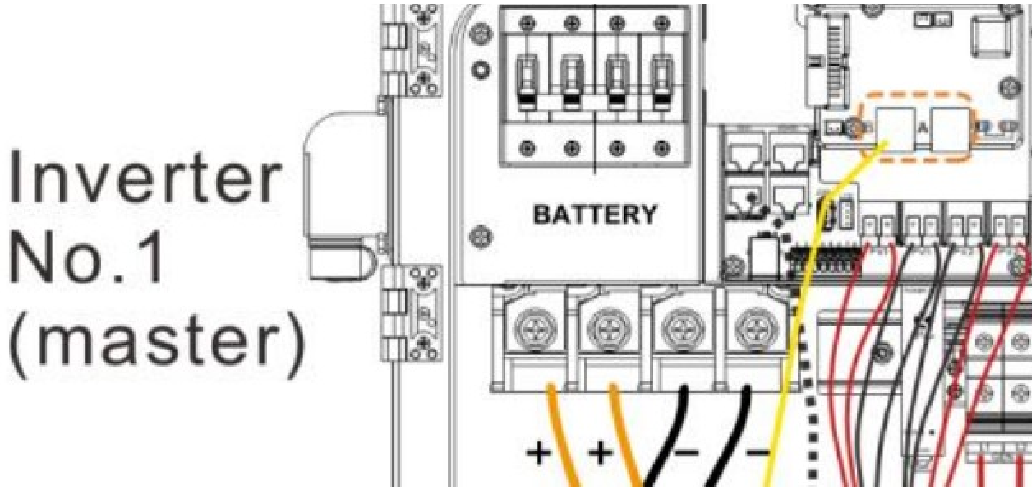
Inspector signature: Date:

Recommended Documentation

1. One-line diagram (this page).
2. One-page worksheet (this page) with inspector checklist and signature.
3. Inverter manufacturer installation instructions and nameplate pages (copies).
4. Panelboard / breaker listing pages showing the 175 A device suitability.
5. Conductor sizing sheet: show 2/0 Cu or selected conductor and reference to NEC Table 310.16 with temp rating and correction/derating if needed.
6. Grounding electrode and bonding schematic per NEC 250.24.

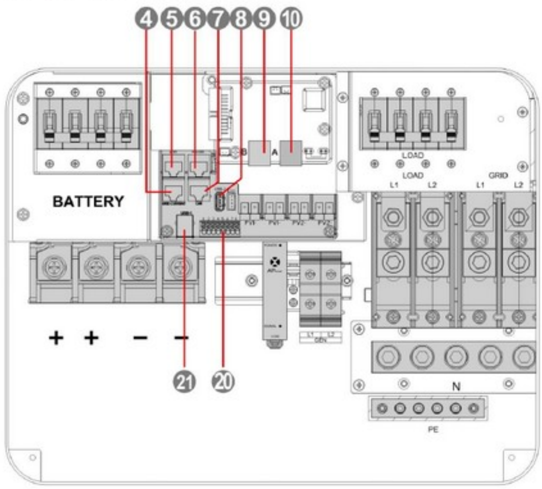
Explain that the meter can remains physically rated 200 A but the effective electrical protection for the inverter grid lugs is 175 A, which is the protective limit used in the conductor/OCPD checks.

Excerpts from the SRNE Inverter Manual



7. Communication

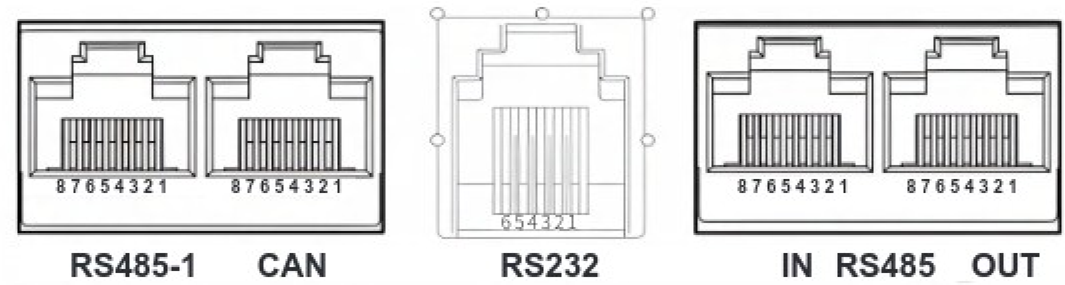
7.1 Overview



4	External CT port
5	WiFi port
6	BMS RS485 port
7	BMS CAN port
8	USB-2 port
9	Parallel port B
10	Parallel port A
20	Dry contact
21	USB-1 port

The Battery Management System cable looks to be a standard Ethernet cable. The LiFePo 100AH EcoWorthy batteries can use either CAN or RS485. Use the RS485 ports.

3.3.3.2 Communication Interface Pin Diagram



Communication Port	RS485-1		CAN		RS232		IN RS485 OUT	
Functional Description	Connect to host computer/inverter		Connect to host computer/inverter		Connect to host computer		Parallel communication	
Pin Description	PIN	Description	PIN	Description	PIN	Description	PIN	Description
	1,8	RS485-B1	1,8	NC	1,2	NC	1,8	RS485-B2
	2,7	RS485-A1	2,7	NC	3	TX	2,7	RS485-A2
	4	NC	4	CANH1	4	RX	4	NC
	5	NC	5	CANL1	5	GND	5	NC
	3,6	GND	3,6	GND	6	14V	3,6	GND

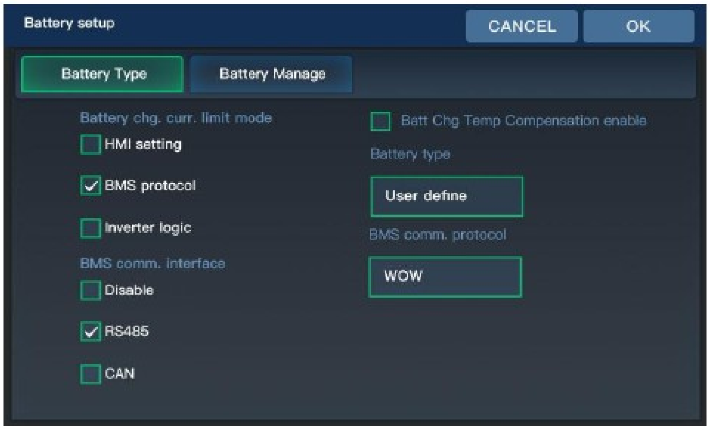
The communication protocols/devices/software supported by each ports

PORT	RS485-1	CAN	RS232
USAGE	Connect to the inverter or upper computer	Connect to the inverter	Connect to the upper computer
SUPPORT	PYLON-LV RS485 V3.5 2019/08/07 (9600)-(Default)	Pylon CAN bus protocol V2.0.6_220510-(Default)	JBD-UP
	Growatt Low voltage battery BMS V1.09(1) -20201022	Growatt BMS CAN-Bus-protocol-low-voltage-V1.04	Solar Assistant
	VOLTRONIC-485-V1.0.3-200325	Goodwe-CAN-V1.7-220228	Overkill
	LXP-485-V1.0.0-210625	Sofar-CAN-V1.00-211117-Rev6	
	Deye-485 Modbus Protocol(4)-deye-V1.30-20160801	Victron-CAN-V1.00-210107	
	SRNE_WOW_PACE_BMS_Modbus Protocol_for_RS485_V1.3(2020-11-24)	Luxpowertek Battery CAN Protocol-V1.0-20200211	
	Lithium Battery Protocol GT	Deye-Low voltage battery	

The Ecoworthy batteries' management system defaults to the PYLON protocol (#9).

6.2.3 Battery Parameter Setting

6.2.3.1 Battery basic setting



- **Battery type:** This parameter selects the type of battery, please choose the parameters consistent with your battery.
  ① **User define:** All parameters can be set
  ② **SLD:** sealed lead acid battery
  ③ **FLD:** Open lead-acid battery
  ④ **GEL:** Colloidal lead acid battery
  ⑤ **LFP14/15/16:** Lithium iron phosphate battery with 14/15/16 cells
  ⑥ **N13/ N14:** Ternary lithium battery with 13/14 cells
  ⑦ **No battery:** No battery connected

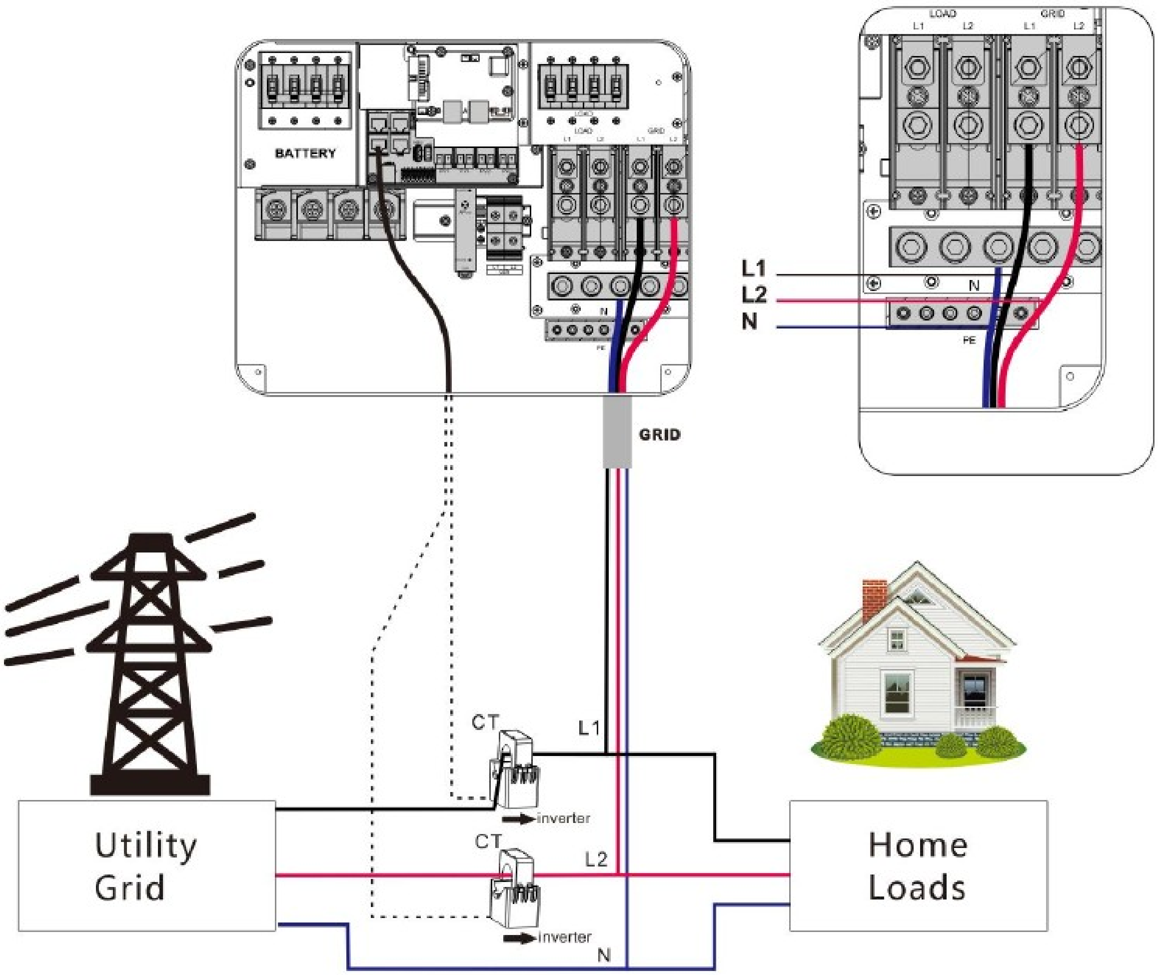
- **BMS comm. Interface:** Choose BMS communication interface, according to the actual battery BMS interface to choose RS485 interface or CAN interface.
- **BMS comm. protocol:** Choose the communication protocol that matches your battery BMS.

NO.	Brand	Protocol name	Type
1	PACEEX	PACE	485 protocol
2	RADAR	RUDA	485 protocol
3	AUTOONE	AOGUAN	485 protocol

NO.	Brand	Protocol name	Type
4	OLITER	OULITE	485 protocol
5	CFGE	CEF	485 protocol
6	Sunwoda	XINWANGDA	485 protocol
7	Dyness	DAQIN	485 protocol
8	SRNE	WOW	485 protocol
9	Pylon tech	PYL	485 protocol

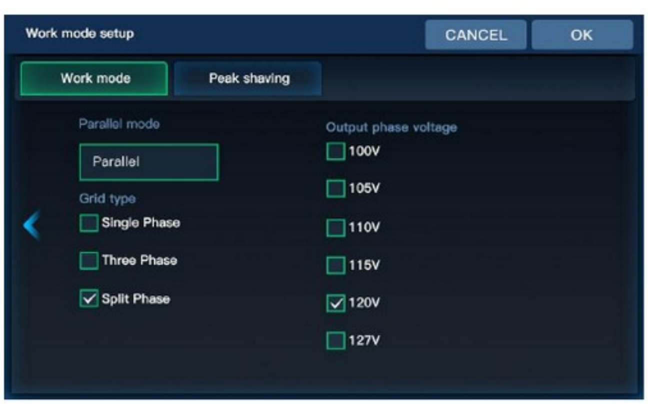
7.7 External CT Port

Length of CT Output Line Wrap : 4m;   Normally The CT direction is “to inverter”



The Master inverter monitors the Grid current with the CT coils on the L1 & L2 lines from the grid.

5.2 Split-phase parallel wiring



Setting for each inverter: Select "Parallel" for parallel mode, select "Split Phase" for grid type, when "120V" is selected for output phase voltage, the output L1-L2 voltage is 240V, L1-N voltage is 120V, L2-N voltage is 120V.

SRNE

10.Datasheet

MODEL	HEBP4880U240-Pro	HEBP48100U240-Pro	HEBP48120U240-Pro	Settable
Inverter output				
Rated Output Power	8800W	10,000W	@240V 12000W @208V 10400W	
Max. Peak Power	1.5 times rated power (10s)			
Rated Output Voltage	120/240Vac (Split-phase) 120/208V(Three-phase)			√
Output voltage error	@240V 36.6A @208V 42.3A	@240V 41.7A @208V 48.1A	50A	
Load Capacity of Motors	5HP	6HP	6HP	
Rated AC Frequency	50/60Hz			√
Waveform	Pure Sine Wave			
Parallel capacity	6			
Battery				
Battery Type	Li-ion / Lead-Acid / User Defined			√
Rated Battery Voltage	48Vdc			
Voltage Range	40-60Vdc			√
Max. Grid Charging Current	200A			√
Max. Generator Charging Current	90A			√
Max. Hybrid Charging Current	240A			√
PV input				
Num. of MPPT Trackers	2			
Max. PV array power	6600W/6600W	7500W/7500W	9000W/9000W	
Max. input current	32A+32A			
Short current Isc	40A+40A			
Max. Voltage of Open Circuit	550Vdc+550Vdc			
MPPT Voltage Range	125-450Vdc/125-450Vdc			
Grid / Generator input				
Input Voltage Range	90-140Vac			
Frequency Range	50/60Hz			
Continuous Grid Passthrough Current	200A			
Efficiency				
MPPT Tracking Efficiency	99.9%			
Max Efficiency	97.5%			
CEC Efficiency	96.5%			
Basic data				
Reverse polarity protection	YES			
DC switch rating for each	YES			

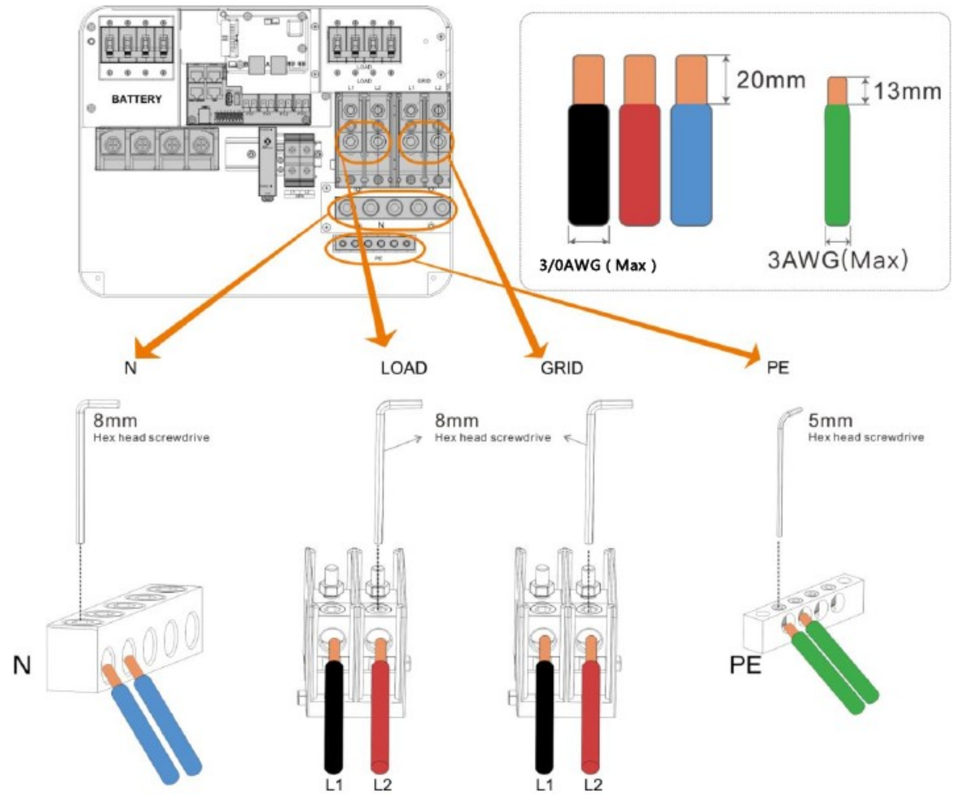
MPPT		
Output over-voltage protection varistor	YES	
Output over current protection	YES	
Ground fault monitoring	YES	
Grid monitoring	YES	
Pole sensitive leakage current monitoring unit	YES	
AFCI	YES	
RSD	YES	
Dimensions	840*440*260mm	
Weight	48kg	
Protection Degree	IP65	
Operating Temperature Range	-25~60℃,>45℃ derated	
Noise	<60dB	
Self-comsumption	<100W	
Cooling Method	Heat sink + intelligent fan cooling	
Communication		
Communication port	RS485 / CAN / USB / Dry contact	√
External Modules (Optional)	Wi-Fi / GPRS	√
Certified specifications		
Safety standards	UL1741&IEEE1547.1-2020,CEC, RULE 21, HECO	
EMC	FCC 15 class B	
RoHS	Yes	

4. Connection

4.1 GRID & LOAD connection

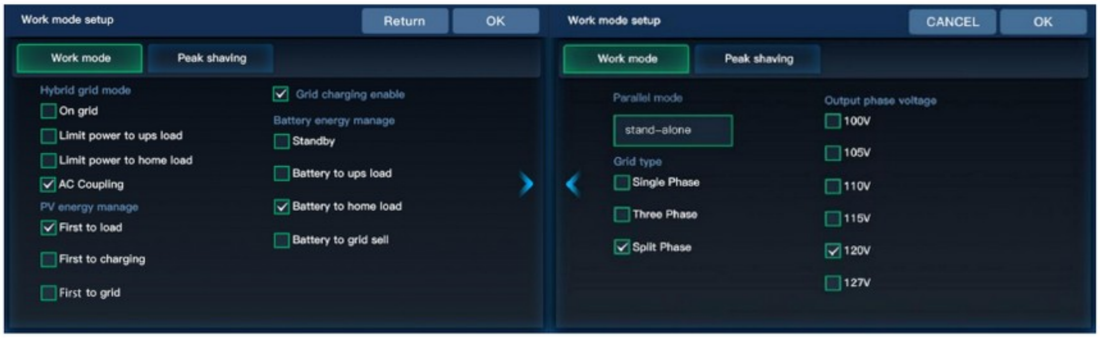
All wiring must be performed by a qualified personnal. It is very important for system safety and efficient operation to use appropritate cable for AC input connection.To reduce risk of injury, please use the proper recommended cable as below

Model	Cable Diameter	Circuit Breaker Spec	Torque
8.8/10/12KW	70mm²/ 0～000AWG (L1/L2/N)	2P-200A	13N.M



6.2.2 Operating mode setting

6.2.2.1Basic mode of operation



1. Hybrid grid mode:

Select the device to work in grid-connected power generation mode or anti-flow mode.

- **"on grid"** means PV energy can be connected to the grid to sell electricity,
- **"limit to ups load"** means PV or battery power is only provided to the ups load, no electricity is sold,
- **" limit to home load"** means PV or battery power is only provided to the ups load and home load, no electricity is sold.
- **"AC coupling"** means the on-grid inverter connect to the hybrid inverter

Notice:

"UPS load" refers to the load connected to the "load" port of the device. "Home load" refers to the load connected to the "Grid" port side of the device.

2. PV energy manage:

This parameter is used to select the priority of PV energy.

- **"First to load"** means that the photovoltaic energy is supplied to the load first, the battery is charged after the load power is satisfied, and the remaining power will be feed into grid.
- **"First to charging"** means that the photovoltaic energy is supplied to battery first, and then supplied to load after the charging power is satisfied, and the remaining power will be feed into grid.
- **"First to grid"** means that the PV energy is preferentially supplied to the load, and then feed into the grid after meeting the load power, and finally the remaining power is used to charge the battery.

Notice:

When "Hybrid grid mode" is set to "limit power to ups load", the above "load" refers to the ups load. When "Hybrid grid mode" is set to "limit power to home load" and CT function is enabled, the above "load" refers toUPS load and home load.

3. Grid charging enable:

Choose whether to enable the grid charging function. If enabled, the PV function is charged preferentially and the grid power is used as a supplement.

4. Battery energy manage:

This parameter is used to select the battery discharge option.

- **"Standby"** means that the battery is not discharged in the hybrid mode, but only discharged in the off-grid mode.
- **"Battery to ups load"** means that the battery discharge power is only supplied to the ups load, and the discharge power is less than or equal to the ups load power.

NB: The Work Mode page needs a value entered into the “Sell Power Max” field to put any energy onto the grid. This field defaults to 0 to accommodate locations that do not permit net metering. Enter the maximum wattage the inverter can make to push all the energy you can to the grid for net metering. The hybrid inverter will first deliver current to the USP load and to charge the batteries, then the remainder will be put on the grid.

<u>If left at 0, the system will generally appear broken and not making much electricity.</u>

6. Parallel mode:

This parameter is used to set the device parallel mode and is associated with the Grid type parameter. When the Grid type is set to "single phase" or "split phase", the parallel mode parameters can be selected as "stand-alone" or "parallel".

When the AC wiring type is set to "three phases", the parallel mode parameters can be set to "Three phase A" or "Three phase B" or "Three phase C".

6.2.4 Grid parameter setting:

You will need to enter a password to access this page, the default password is "0000". The parameter page has grid-connected basic function Settings, grid enter service Settings, grid protection Settings and other function Settings.

6.2.4.1 grid basic function Settings

- **Grid standard :** Choose the local grid-connected standard.

Grid standard	Region
RULE21	California
HECO	Hawaii
UL1741&IEEE1547.1-2020	The rest of the United States
GNL	Areas without on-grid standards

SRNE

9.Protection and Maintenance

9.1 Protection features

No.	Protection Feature	Instruction
1	PV current limiting protection	When the charging current or power of the PV array configured exceeds the PV input rated value, the inverter will limit the input power and charge at the rated.
2	PV input over-voltage	If the PV voltage exceeds the maximum value allowed by the hardware, the machine will report a fault and stop the PV boost to output a sinusoidal AC wave.
3	PV night reverse current protection	At night, the battery is prevented from discharging through the PV module because the battery voltage is greater than the voltage of PV module.
4	Utility input overvoltage protection	When the mains voltage exceeds 140Vac, the mains charging will be stopped and the output will be inverted.
5	AC input under-voltage protection	When the mains voltage falls below 90Vac, the mains charging will be stopped and the output will be inverted.
6	Battery over-voltage protection	When the battery voltage reaches the over-voltage cut-off point, the PV and the utility will automatically stop charging to prevent the battery from being overcharged and damaged.
7	Battery under-voltage protection	When the battery voltage reaches the under-voltage cut-off point, the inverter will automatically stop the battery discharge to prevent damage from over-discharging the battery
8	Battery over-current protection	After a period when the battery current exceeds that allowed by the hardware, the machine will switch off the output and stop discharging the battery.
9	AC output short-circuit protection	When a short-circuit fault occurs at the load output for more than 200ms, the output AC voltage will be turned off immediately, and then manually re-powered and turned on before normal output can be restored. (Non-utility bypass condition)
10	Heat sink over-temperature protection	When the internal temperature of the inverter is too high, the inverter will stop charging and discharging; when the temperature returns to normal, the inverter will resume charging and discharging.
11	Inverter over-load protection	After triggering the overload protection the inverter will resume output after 3 minutes, 5 consecutive overloads will switch off the output until the inverter is restarted.
12	AC output reverse	Prevents AC back flow from the battery inverter to the bypass AC input.
13	Bypass over-current protection	Built-in AC input over-current protection circuit breaker
14	Bypass phase inconsistency protection	When the phase of the bypass input and the phase of the inverter split do not match, the inverter disables switching to the bypass output to prevent the load from dropping out or short-circuiting when switching to the bypass.

An Example "Spec sheet"--Jinko Specifications: 635W Solar Panels

78HL4-BDV 615-635 Watt

Mechanical Characteristics

Cell Type	N- type Mono-crystalline
No. of cells	156 (78×2)
Dimensions	2465×1134×30 mm
Weight	34.0 kg
Front Glass	2.0 mm, Anti-Reflection Coating
Back Glass	2.0 mm, Heat Strengthened Glass
Frame	Anodized Aluminium Alloy
Junction Box	IP68 Rated
Protection Class	Class II
IEC Fire Type	Class C
Output Cables	4.0 mm^2 (+): 400 mm , (-): 200 mm or Customized Length

Packaging Configuration

Pallet Dimentions	2525×1140×1251 mm
Packing Detail (Two pallets = One stack)	36 pcs/pallets, 72 pcs/stack, 576 pcs/ 40'HQ Container

Specifications (STC)

Maximum Power - Pmax [Wp]	615	620	625	630	635
Maximum Power Voltage - Vmp [V]	47.20	47.37	47.54	47.70	47.86
Maximum Power Current - Imp [A]	13.03	13.09	13.15	13.21	13.27
Open-circuit Voltage - Voc [V]	56.69	56.82	56.95	57.08	57.21
Short-circuit Current - Isc [A]	13.68	13.74	13.80	13.86	13.92
Module Efficiency STC [%]	22.00	22.18	22.36	22.54	22.72
Power Tolerance	0 ~ + 3 %				
Temperature Coefficients of Pmax	-0.29 %/°C				
Temperature Coefficients of Voc	-0.25 %/°C				
Temperature Coefficients of Isc	0.045 %/°C				

STC: Irradiance 1000W/m^2, Cell Temperature 25°C, AM=1.5

Specifications (NOCT)

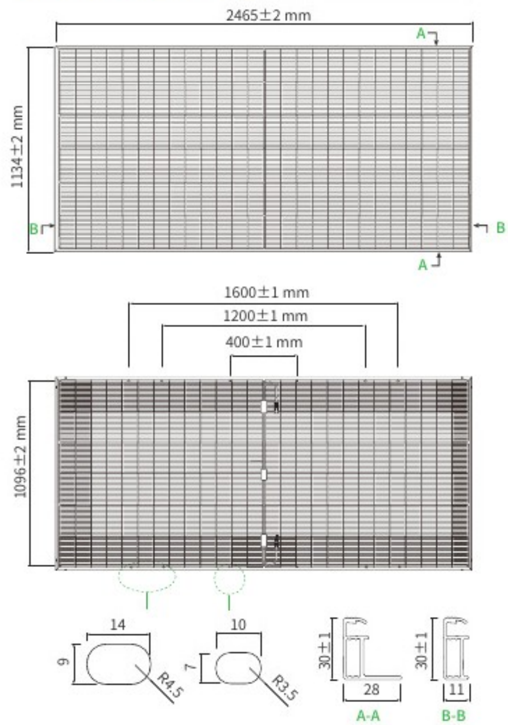
Maximum Power - Pmax [Wp]	463	467	471	475	479
Maximum Power Voltage - Vmp [V]	44.39	44.54	44.69	44.83	44.98
Maximum Power Current - Imp [A]	10.44	10.49	10.54	10.59	10.64
Open-circuit Voltage - Voc [V]	53.85	53.97	54.10	54.22	54.34
Short-circuit Current - Isc [A]	11.04	11.09	11.14	11.19	11.24

NOCT: Irradiance 800W/m^2, Ambient Temperature 20°C, AM=1.5, Wind Speed 1m/s

Application Conditions

Operating Temperature	-40 °C ~ +85 °C
Maximum System Voltage	1500 VDC (IEC)
Maximum Series Fuse Rating	30 A
Nominal Operating Cell Temperature - NOCT	45±2 °C
Refer. Bifacial Factor	80±5 %

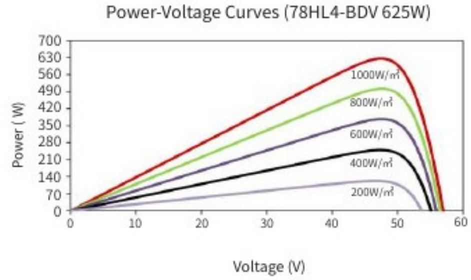
Engineering Drawings



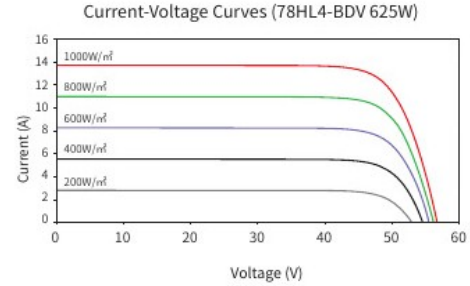
Note: For specific dimensions and tolerance ranges, please refer to the corresponding detailed module drawings.

Electrical Performance

Power-Voltage Curves (78HL4-BDV 625W)



Current-Voltage Curves (78HL4-BDV 625W)



TigerNeo

78HL4-BDV

615-635 Watt

BIFACIAL MODULE WITH DUAL GLASS

N-type

N-type Technology

N-Type modules with Tunnel Oxide Passivating Contacts (TOPCon) technology offer lower LID/LeTID degradation and better low light performance.

HOT 2.0 Technology

N-type modules with JinkoSolar's HOT 2.0 technology offer better reliability and efficiency.

12 Year Product Warranty | **30** Year Linear Power Warranty | **1**% First-year Degradation | **0.4**% Annual Degradatio Over 30 Years

Dual-Sided Power Generation

Dual-sided power generation gain increases with backside exposure to light, significantly reducing LCOE.

Mechanical Load Enhanced

Certified to withstand:

5400 Pa front side max static test load

2400 Pa rear side max static test load

- IEC61215 (2016) / IEC61730 (2016)
- IEC61701 / IEC62716 / IEC60068 / IEC62804
- ISO9001:2015: Quality Management System
- ISO14001:2015: Environment Management System
- ISO45001:2018: Occupational health and safety management systems

SMBB Technology

Better light trapping and current collection to improve module power output and reliability.

Anti-PID Guarantee

Minimizes the chance of degradation caused by PID phenomena through optimization of cell production technology and material control.

JKM615-635N-78HL4-BDV-F8-EN

Grid Related Construction Details

The Electrical Work

A good set of wire bending tools and a lug torque gauge are essential. Use a conduit lubricant to make the wires slide readily in the pipe and not bind in the conduit. Keep a log of all the torques. Use a UL listed anti-oxident on each lug connection. Expect to show the torque logs to the Electrical Inspector.

Each component requires explicit labels to conform to the NEC.

This installation is overbuilt. The copper wire gauges are relatively large. All the sub-panels are derated from 200A to 125A. Each circuit, except for the 175A grid feed that has a single breaker disconnect, has redundant disconnect devices. Both batteries have builtin breakers, a fuse, a disconnect switch at the busbars and a factory 200A breaker at the inverters. The Load circuit has breakers at the inverters and breakers in the MLO, the fed circuits each have breakers in their sub-panels.

Inverter Installation

The inverters are a hybrid grid-tied pair of 12KW devices that have an automatic transfer switch that will pass through the Grid current when the demand on the Load exceeds the PV provided current. NB: the master slave pairing between inverters requires a 10 pin cable between the two inverters. That factory cable is short. The manual says to space the inverters 22" apart, but that is right at the limit of the 10 pin cable. Place the inverters slightly closer together so that cable fits without strain.

The SRNE HEBP inverters come pre-equipped with RSD transmitters, however two or more RSD transmitters will lead to a system failure unless they and the strings they manage are segregated by 24" or more. *This only applies to Master/Slave installations where there is more than one RSD transmitter.* If the leads are all in one conduit, the cross-talk between the two transmitter's signals will trigger shutdowns. The workaround in this all in one conduit case is to not use the the built-in RSD transmitters but instead, buy a single RSD transmitter and pass all the leads through the core of that transmitter. Disconnect the 12V power connected to the built in transmitters and either use a switched labeled 12V supply for the transmitter, or wire it to one of the SRNE HEBP 12 V RSD transmitter leads.

The pair of inverters (Master/Slave parallelized) are mounted on a concrete block wall. The wall is under a shed roof but otherwise is an open unoccupied structure. This puts it in a specific class of NEC rules that mostly apply to the roof panel layout.

The physical and electrical needs of a parallelized (master/slave) array of inverters that generate current demands that the impedance of all the leads between the master and slave(s) inverters are all identical. As a practical matter that means that the leads between them are identical length and gauge. This matters a lot and good care needs to be taken to assure the matched impedance between the Grid, Load, and Battery leads.

The inverters weigh a lot. They are hung on a rack tied with 5/16" all thread bolted through the 8" concrete block. The manual requires them to be at least 22" apart to permit good air flow and be set so the control panel is at a good height for ease of sight. NB: the 22” is right at the limit of the factory supplied 10 pin Master/Slave communication cable , make a careful measure of that cable and span the inverters to fit. A 10 pin cable is not common, and standard Ethernet cable tools cannot make one.

The bottom of the inverter has all the ports for wire entry. These ports stand some 6-9” from the wall so all the attendant conduits and leads need to handle being the set out from the wall.

Raceway Installation

There are a lot of 3/0 copper wires. The manual suggests one could use a smaller gauge but I chose the larger wire because it will never have any ampacity limitation. It is a difficult gauge to place, expect to struggle fitting it to the inverters, conduit and raceway.

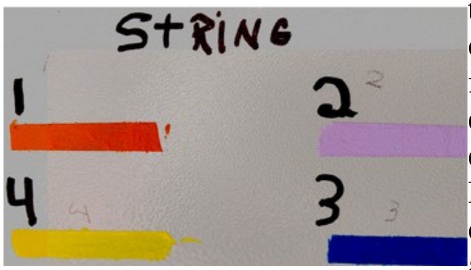
The raceway I chose is a 6”x6”x 48” UL listed steel box that opens in the front. The raceway is set with blocks to space it from the wall and align it under the inverter. To assure the impedance matching of the Load and Grid circuits, each lead from an inverter runs to a dual entry three port 3/0 gauge UL listed insulated splice connector. There is a splice for the Protective Earth, Line 1, Line 2, and Neutral leads on both the Load and Grid wires, a total of eight splices that need to fit within the raceway. To manage this, one set of leads, Load or Grid, needs to be longer so the splices are offset in the raceway and can fit within the enclosure.

MLO Installation

The Main Lug Only N3R 225A rated breaker box is wired to the inverters' output. The inverter's UPS leads power the box. The breakers in the MLO reticulate the power to the various buildings. Six port dual entry splices are needed for the Neutral and Protective Earth leads. The only lead that uses the Neutral bus built into the MLO runs to the spike protection device, all the rest are large gauge leads that run to the splices. NB: the Aluminum 4/0 leads needs splices to 3/0 Cu that can fit the 125A breaker, the 4/0 is too big for the breaker. 3/0 is a real challenge but it works.

PV Breaker Box Installation

The leads from the PV panel strings run to a four pole disconnect switch connect and then to four 30A DC breakers. The output side of the breakers run to the inverters. The manual specifies using 10AWG wire terminated with crimped "boot lace ferrules" at the inverter end. The inverters each support two MPPT PV string circuits. The ferrules are inserted into the inverters at the orange flip clamps. The SRNE manual is not clear, but the orange flip connector levers lift up 90 degrees. The levers appear frail, but they will lift. Insert the 10AWG crimped ferrule all the way up into the connector and flip down the orange lever. The wire should be well clamped-test the fit and iterate until it is all the way up and held tight.



The plastic DC breaker box is contained within a steel enclosure and factory fit with MC4 M/F connectors. NB:, the outer enclosure must vent heat, as the breakers may throw at 29A when too warm. Use 10AWG leads crimped connected to the MC4 connectors.PV

Four Pole Disconnect Switch Installation

In addition to the upstream Rapid Shutdown Devices that are directly wired to each panel (if any), a four pole single throw (4PST) switch is wired to the positive leads from the PV four strings. That 4PST runs to the 30A breakers. The inverter can also internally disconnect the PV by turning the black knob on the left side of the SRNE HEBP inverter.

Busbar, Fuse, Battery Disconnect Installation

The busbar for the two 100AH 48V LiFePo4 batteries is a set of 1/2”x1”x6” copper bar, good for some 600A. The busbars are fed by impedance matched wires of plus and minus 2/0 copper leads attached to 250A MRBFs (Marine Rated Battery Fuse). The breakers at the inverters are 200A, the breaker built into each Ecoworthy battery is 125A. The marine rated UL listed disconnect switch is rated to 300A. Unload the circuit before flipping that switch. The switch is fed by a 4/0 copper lead attached to a 250A MRBF at the busbar. The output side of the disconnect switch is wired with a 4/0 copper lead to the batteries. The two batteries are wired together in parallel with 4/0 leads. The design here is limited to two batteries.

The inverters can be set to use batteries when the grid has failed. In general, the batteries only purpose is to self heat to stay above 0F and to carry the well houses small heating load in frigid weather. The overheating issues should be minimized since the batteries are rarely used. Should the grid fail during hard freezing conditions, after dark try to cut off all circuits but the well houses and the battery heater.

Fire Resistant Battery Box Construction and Installation

The two LiFePo4 100AH batteries are contained in an insulated forced air flow box. The box has ½” of concrete hearthboard on the inside face then ½” drywall, 2” of foam insulation, and a ½” plywood exterior.

175A Meter Disconnection OCPD

The 175A breaker box is located immediately below the meter on the north side of the workshop next to the large door. The N3R box is rated at 225A, the breaker is the 175A part.

There is a pass through circuit from the MLO that uses 4/0 dual entry two port splices on the L1, L2 & N leads from a MLO 125A breaker to the leads running to the shop sub-panel. The PE 1/0 copper THHN lead is a new and continuous run from the MLO to the old sub-panel inside the shop.

The leads from the meter to the 175A breaker are 3/0 copper. The ground rod is original.

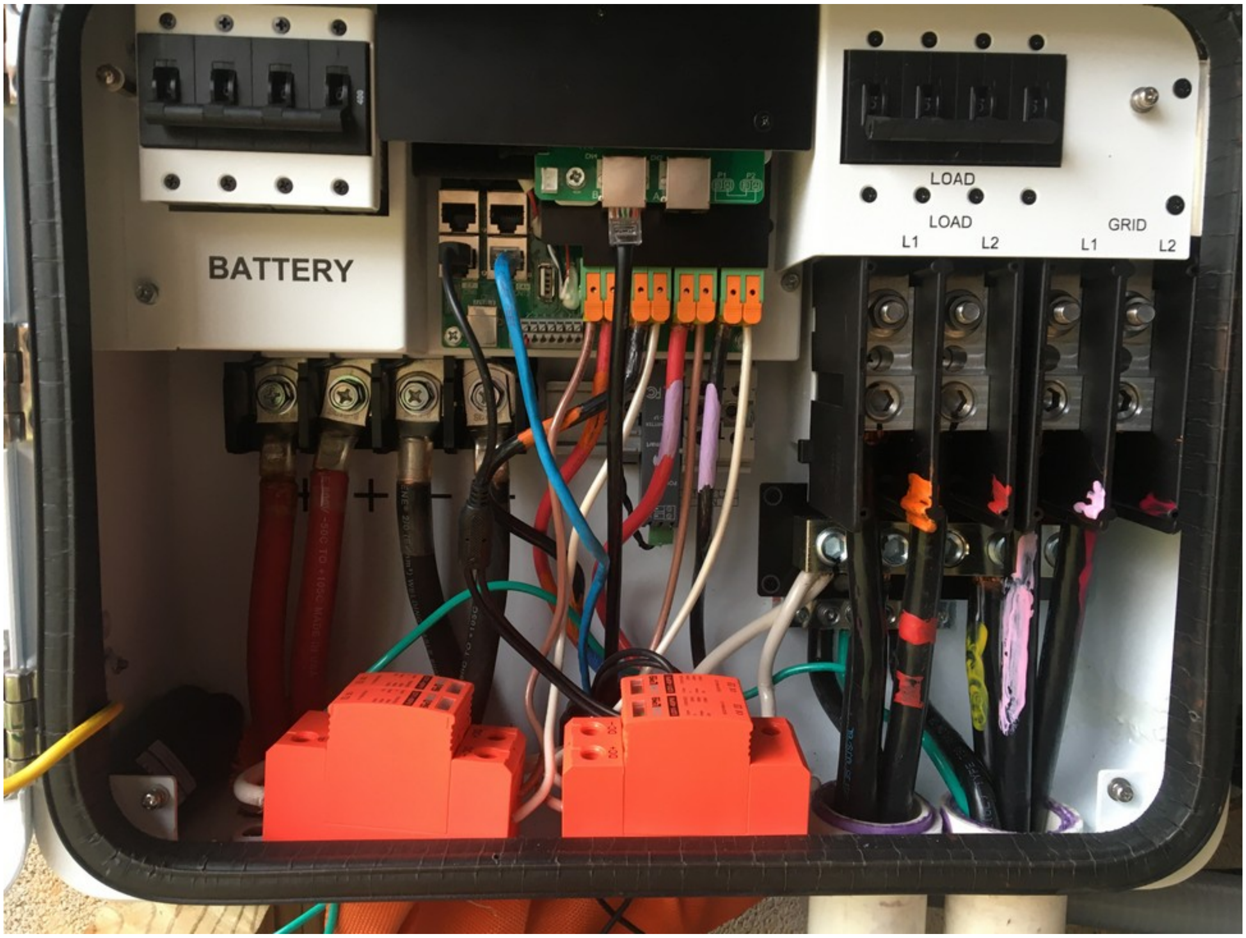
100AH LiFePo4 Batteries

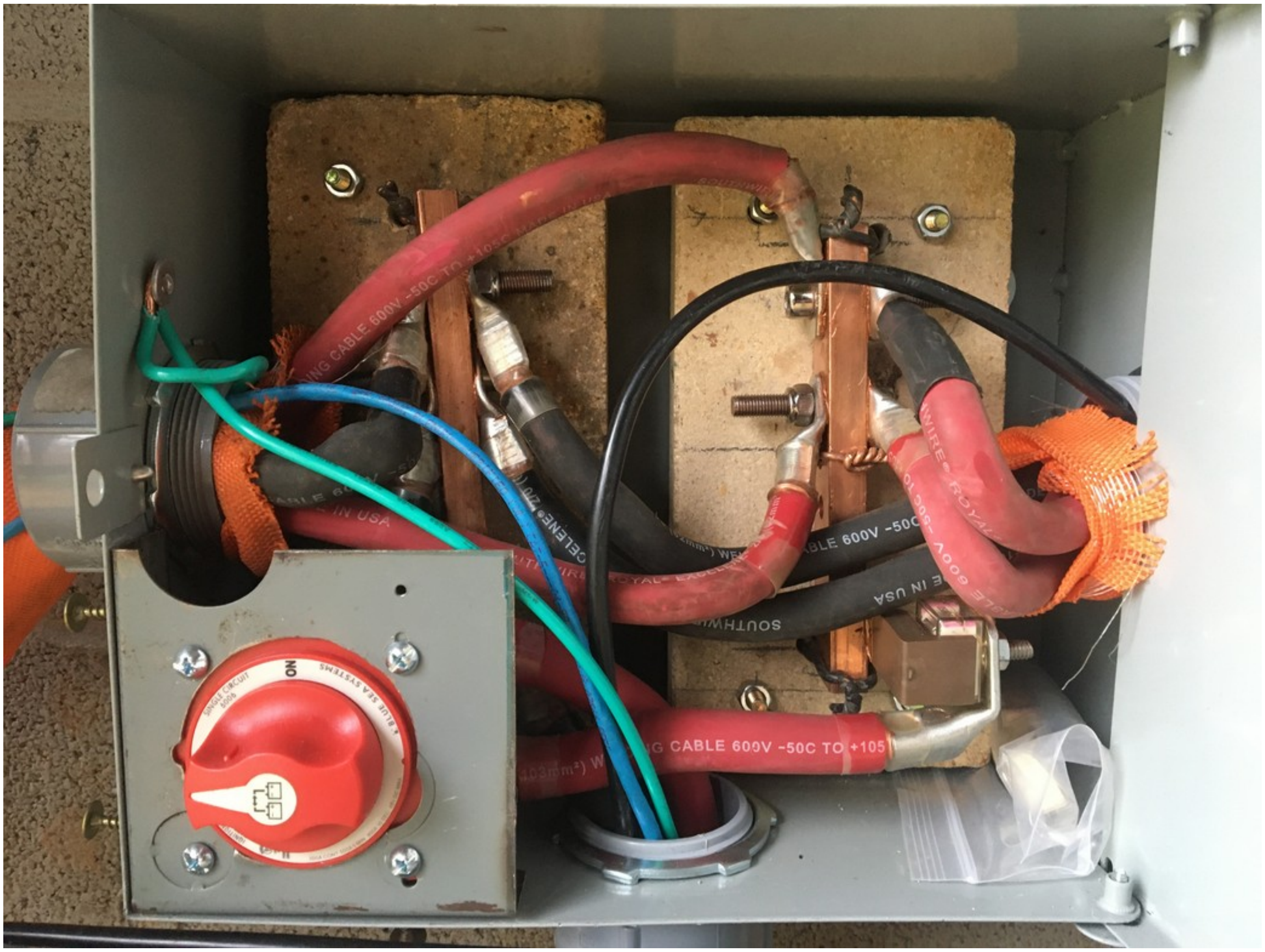
The batteries fit in the box with inches of clearance. The box is heated with a 60 watt 120v “RV Tank” heater pad with a 44F-65F on/off thermostat and a circulation fan that runs at 50F and below. The fan circulates the cooling box air before the heating pad warms up, and when the pad starts to heat, the batteries will heat evenly from 44F to 50F then both fan and heater will quit.

The MLO to House 4/0 Al Feeder

The solar/grid feeder lines from the MLO to the house are in a 32" deep trench. The 175' run is aluminum 4/0 L1, L2, N 1/0 PE direct burial cable. The MLO end has splices connecting the 4/0 Al to 3/0 Cu that fit the 125 A breakers (4/0 cannot fit).

The Finished Work Below the Roof




CABLE 600V -50C TO +105
ON

Communication Cabling

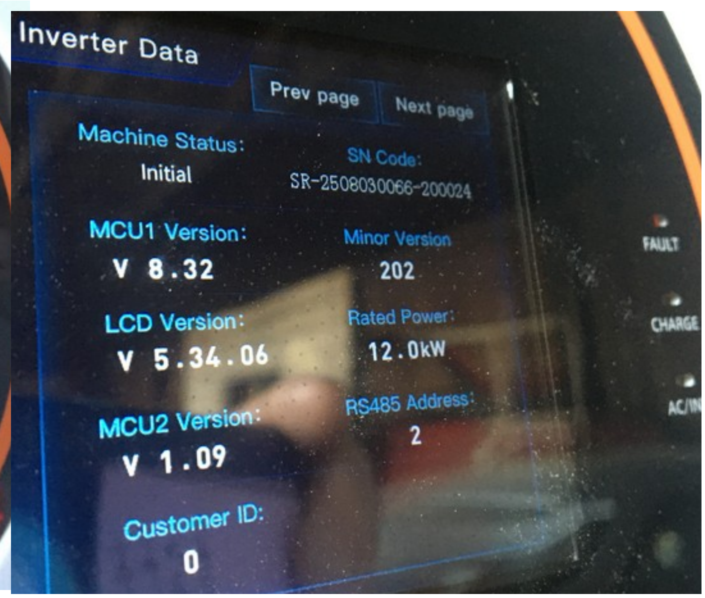
The master/slave paralleled inverters need a 10 pin cable connecting them. As mentioned above, the 22" span between inverters is just at the limit of the factory cable, so be sure to not span them too far apart. The Master inverter uses the B socket, the slave uses the A.

The SRNE HEBP Inverters Startup

Previously both inverters had started on battery power without any grid connection. It would have been best to fully configure the inverters before adding the grid.
Once the inspection passed, the covers were fit on the 175A disconnect, the MLO, the Shop sub-panel and the Office sub-panel. The 175A breaker was ready to be closed and conduct grid current to the inverters. Next the 175A breaker was closed and the grid current was conducted to the inverters. Both woke up even though they were "off" and threw a B3 error. That simply meant that the batteries were not connected, which they weren't. Turning on the batteries, the 300A busbar disconnect switch and the battery breakers in the inverters made the B3 error clear. Both inverters were then powered off by their on/off buttons and restarted. The Master came up perfectly, the second inverter had some issues, but they cleared right up when the work mode "parallel" settings were applied to both inverters and the 10 pin cable plugged in correctly. The manual section 4.9 is not clear about how to attach the 10 pin communications cable needed for parallel operation. The associated graphic is specific though, the master has the cable in the "A" port, and the slave in "B".

The virtue of a redundant design was made immediately apparent, as the grid pass through has worked well and the entire campus was back in service on just one inverter. Once the Parallel settings were fixed, both inverters came on line.

The LAN cable connecting the two Eco-Worthy 100AH batteries needed to be replaced, once that was sorted, both batteries were visible to the app software. Setting the inverters to permit grid charging the batteries brought both batteries to full charge.



Note the “Master” listed above the green Inverter icon in the image below. Paralleling is active.

The “slave” inverter does not show the “Master” tag above the green Inverter icon.

Starting and stopping a PV string

The four PV strings are wired to the two inverters via 30A breakers and a 4PST switch that connects to the #10 AWG THHN leads run in conduit from the roof. When the Rapid Shutdown System Transmitter-PLC controller (via the big black switch on the side of the inverter) is on, an AC signal is put on the string’s DC + lead that stops the RSD interrupters and current begins to flow.

Ultimately, the only string using RSDs is #4, the westmost 4s2p set (due to crostalk & “Commercial” sized panels).

In order to start a string, it’s best to turn off all strings on both inverters with their big black switches and turn the 4PST switch off, set the 30A breakers as wanted, then turn on the 4PST switch and finally, the big black switch on the string’s inverter. Strings 1 & 2 are wired to inverter 1 (the north-most) and 3 & 4 are wired to inverter 2. A working string should report under the PV panel icon on the main screen. NB: until the inverters have been set to deliver wattage to the grid, the MPPTs will limit the wattage to nil and the system will appear to fail!

Shutdown sequence to stop all current to the inverters

Current to the inverters is supplied from three sources: the utility grid, the batteries, and the PV panels. To do maintenance or innovation on the pair of inverters both inverters must be disconnected from all those sources.

The PV panels are disconnected by the RSD Shutdown " PV Switch", the combiner box 30 A DC circuit breakers and the 4PST switch.

Next throw the 175A breaker below the utility meter to shut off the grid.

Turn off the batteries from the inverter's menu. Do both inverters. Stop the inverters- press the on/off button below the PV Switch. Once both inverters are shut down, switch off the red dial switch on the bus bar/fuse box (between the two inverters). If the batteries themselves need to be turned off, open the battery box and power them down from their front panel's on/off.

Test the inverter source leads for voltage, they should all be disconnected and work safe.

As a list:

- Throw the 175A OCPD breaker below the utility meter.
- Switch the RSDs on String 4 off by turning off both large black knobs on the inverters.
- Open the PV combiner/breaker enclosure and switch off the breaker and 4PST connections.
- Press the power switch on the slave inverter, then the master inverter to shut them off.
- Turn the batteries off at the busbar box by turning the red switch to the off position.

This shuts off all power generation and pass-through and safes the system for maintenance. Test the leads for voltage to be certain.

NB: the PV panels are still generating current in sunlight and the 10AWG THHN leads are still hot up to the combiner box. The RSDs, if present, arrest that current at the panel but the panels themselves are still dangerous.

If an Inverter Fails

In the event that the Master inverter fails, turn off both the Master and Slave inverters. Use the battery and PV physical disconnect switches to disconnect the PV and batteries, and throw the main 175 A Grid breaker below the meter base. Disconnect the Master/Slave B:A communications cable and if the master inverter has failed disconnect the RS485 BMS cable then plug in the CT leads to the ex-slave (now master) inverter and plug in the BMS cable to the inverter and open the battery box and swap out the BMS cable from the failed Master inverter, replace it with the BMS cable from the ex-slave (now master).   Next physically remove the L1, L2, & N leads, the battery leads and the PV string leads from the failed inverter and once the inverter has been physically removed, thoroughly tape or cap them off so they cannot electrocute anyone as they will be dangerously hot until reconnected to a working inverter. Reconnect the grid with the 175A breaker and power up the remaining inverter.   Reconnect the PV strings by switching the physical 4PST disconnect switch back on. Leave the breakers off for the PV strings that are no longer attached to an inverter.

Install the replacement in the reverse of the above: be absolutely certain that all current from the remaining inverter, the grid, batteries and and PV panels is off. Test each lead for current before starting the replacement, failing to get that right could be fatal.

Above the Roof: PV Panel related construction details

Panel Design

The virtue of this particular PV panel is the amperage. The short circuit and maximum amperage are below 14A. When run in parallel, the 28A is below the breaker rating of 30A, below the inverter's maximum of 32A, and below the NEC permitted ampacity on a 10AWG THHN wire. The other big reasons for choosing this panel include the total wattage in a pallet (36 ct) matches well with the annual KW usage and Jinko has a solid reputation for making good panels. Also, the panels are a great fit for the available roof space. The warranty on workmanship is 12 years with a 30 warranty on the rate the panel loses wattage due to age.

The panels are broken into four strings. Two strings, each with ten panels, are arranged as a two by five array. Five panels are wired in series, adding the per panel voltages (c. 48V) to a total of c. 240V , and the pair of five panel strings are wired in parallel. The total amperage of the 10 panels is 26.5A, with a short circuit amperage (from broken panels) of 28A. The pallet's remaining sixteen panels are set as two strings, each string is a 4x2 set that makes c. 200V 28A.

Each inverter has two MPPT circuits, the four strings of solar panels are divided between the two inverters. By keeping the amperage on the strings below 28A, 10AWG THHN wire is used to connect the strings to the MPPTs. All the leads in the entire reticulation are in conduit. The 10AWG string leads are together in 1" conduit, the 125A and 175A 3/0 Cu leads are in 2" conduit, and the wiring adjacent to the inverters is in a 6" square conduit raceway.The 36 Jinko PV panels are set up in series. In Strings 1 & 2 a 5 panel series is connected in parallel with another 5 panel series, in sets, 3 & 4, two 4 panel series are paired. The parallelized series double the current to 28 A. The doubling is done with a MC4 "Y" connector. That connector is wired to 10AWG THHN that is run in 1" PVC conduit to the inverter. The long axis conduit is attached to the rail above the walkway. Conduits tee off the main axis to carry 10 AWG THHN leads to the series in the lower array.

The two wires that run a series (+|-) need MC4 connectors at both ends according to the panel lead or "Y" combiner they connect to. The string leads need MC4s too. The 4 DC +- pairs that make up strings 1-4 run in conduit to enter the top right rear of the combiner box. The + leads are wired to the 4PST switch, the – leads run directly to the DC breakers.

Examine the diagram shown below that presents the position and orientation of each PV panel, the rails, conduit and wiring. The strings that run to the inverters are shown as "String 1" through "String 4". The series that make up the strings are numbered 1 through 8.

The Pallet of PV panels.

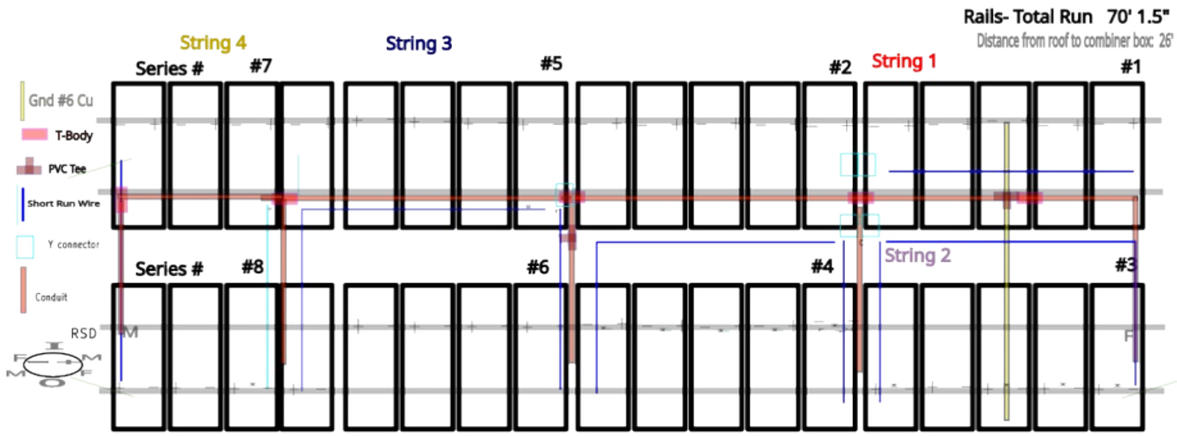
Physical Positions: the Panel Layout on the Roof

	PV Panel mm	Inches	Width w/clamp
L	2465	97.0472440944882	
W	1134	44.6456692913386	45.3156692913386
D	30	1.18110236220472	

Panel Run #	Decimal Inches	feet	inches
1	45.3156692913386	3	9.31566929133859
2	90.6313385826772	7	6.63133858267717
3	135.947007874016	11	3.94700787401575
4	181.262677165354	15	1.26267716535435
5	226.578346456693	18	10.5783464566929
6	271.894015748032	22	7.89401574803151
7	317.20968503937	26	5.20968503937013
8	362.525354330709	30	2.52535433070869
9	407.841023622047	33	11.8410236220473
10	453.156692913386	37	9.15669291338588
11	498.472362204724	41	6.47236220472445
12	543.788031496063	45	3.78803149606301
13	589.103700787402	49	1.10370078740164
14	634.41937007874	52	10.4193700787403
15	679.735039370079	56	7.73503937007877
16	725.050708661417	60	5.05070866141739
17	770.366377952756	64	2.36637795275601
18	815.682047244095	67	11.6820472440945

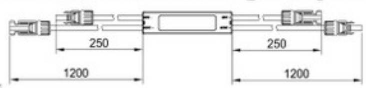
Final panel string & series wiring layout

The wiring in the image below shows the layout of the leads to the strings.



Only Jinko PV panels in string 4 have an APSmart RSD-S isolator.. The 2 RDS Xmitters have a cross talk bug, so only 1 can work

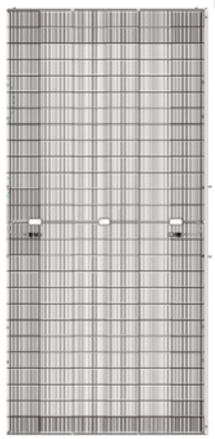
The runs shown above are symbolic.
All wires lie in conduit



2465 x 1134 x 30 mm.

	PV Panel mm	Inches	Width w/clamp
L	2465	97.047244094	
W	1134	44.645669291	45.3156692913386
D	30	1.1811023622	

Panel Run #	Decimal Inches	feet	inches
1	45.3156692913386	3	9.32
2	90.6313385826772	7	6.63
3	135.947007874016	11	3.95
4	181.262677165354	15	1.26
5	226.578346456693	18	10.6
6	271.894015748032	22	7.89
7	317.20968503937	26	5.21
8	362.525354330709	30	2.53
9	407.841023622047	33	11.8
10	453.156692913386	37	9.16
11	498.472362204724	41	6.47
12	543.788031496063	45	3.79
13	589.103700787402	49	1.1
14	634.41937007874	52	10.4
15	679.735039370079	56	7.74
16	725.050708661417	60	5.05
17	770.366377952756	64	2.37
18	815.682047244095	67	11.7



Note: Series #5,#6,#8 & #3 have M/F order reversed.

The RDS transmitter cross talk bug is poorly documented, it requires DC leads from a transmitter to be at least 20" from any adjacent leads connected to a 2nd transmitter. I failed to do that. However, NEC does not require RDS on an unoccupied detatched unenclosed dry structure "like a car port" So, it has all those attributes, including the cars, hence strings 1-3 have NO RSD.

The 10AWG THHN wires actually lay inside the 1” conduit, not outside as shown in the image. The conduit has Tee’s and L-bodys where the leads from the panels enter the conduit. The wiring works as follows:

Each 5 panel string (1 &2) is wired in parallel to the string above/below it with its + end connected to a Y-Combiner. The output of the combiner is a 28A 250V lead that is contained in the conduit.

The four by two panel strings (3 & 4) are wired in parallel to make a 28A A 200V lead. Only String 4 has RSDs due to the poorly documented cross talk problem and the poorly documented fact that commercial panels don’t use RSDs so there is no market for commercial sized RSD. Both MPPTs on each inverter have the same voltage and amperage and that works well.

Roof Preparation

Roof preparation is not available to the 30% tax credit. Account for the cost in its own budget.

The rails need a reliable connection to the roof. The metal sheets on the roof are decent, but the purlin lathes that lay under the rails need to be replaced or more added. The roofing needs to be briefly removed to add the 1" x 6" white oak purlin that lays directly under the rails and are fixed to the 2x6" rafters, and to add the new 8' tin roofing.

To start, the PV panel vendor provides a data sheet and an installation guide. Examine those to determine the exact dimensions of the panel and the recommended position of the rails under the panel. Examine the roof and commit to the exact position of the panels on the roof. Attach baton boards to the roof beyond the extreme edges of the rails and carefully measure the position of the purlins and rails then set screws into the batons to hold strings. String the run across the roof for each purlin for reference during construction.

The purlin stock used here is 16' long that lays under 8 roofing tin sheets. The strings needed to be removed to lift the roofing tin, so use paint or tape to mark string location at the start and finish and on the 8^{th} & 9^{th} sheets across the roof to align the purlin once the 8 sheets have been removed.

The purlins and new tin got craned to the roof and staged near the 8' tin sheet set to be removed, the purlins added, and the tin restored. The 8x2 set of roofing tin sheets were removed with minimal damage. The new purlins were both nailed twice and screwed down twice at each rafter. They added a lot to the structural integrity of the building to resist wind loads when reliably attached. Restore the tin-replace any tin that doesn't have 30 years left in it's working life. Use a gutter sealing compound to fill any piercings that don't have roofing screws to seal them. Repeat this for the rest of the PV paneled roof.

A 2' wide walkway between the upper and lower panels has 1" oak under it. Additional cross stock was installed in some places. Once the oak was down, the tin was put back on the top row and replaced on the bottom row. White paint guide lines mark the walkway.

Installing the Rails

The rails lay over the new oak purlins. String the layout to properly and exactly align the rails to the purlin. The rails are supported by pipe "post" sections and are screwed through the roofing tin to the oak purlins. Initially, just the ends are screwed down. Once the panels are ready to install, each rail will get more posts screwed down that lie directly below the clamps at the junction of two panels.

Before setting the PV panels

Testing Gear

Use a proven multimeter that can measure 0-400v DC, continuity, and resistance.

Make test cables and MC4 connectors. Trim off the vertical stubs on the female connector so it won't latch and need the hand tool to release the connection. Trim off the slots on the male MC4 connector that accept and latch the female stubs so the two test MC4s can be connected and disconnected without the hand tools. Fix those modified connectors to runs of 10AWG. Make at least one test cable run long enough to test the full length of a series, the rest can just be short stubs for testing with a voltmeter. Test the test cable for continuity and low resistance.

MC4 Connector Crimping & Faults

The hand made MC4 connections are the usual failure. The connectors must be properly constructed or the string will fail. Strip the wire and place the nut and gasket onto the wire. Anoint the bare wire with anti-oxidant. When making the crimp and assembling the connector, very carefully orient the metal unit to the crimper. Hold it on the stripped wire with slight finger pressure from the tip and only crimp the small metal wings. Orient the wings to the crimper so they fit into the crimper's slot with the wings facing the crimp die with the high middle (where two smaller circles meet). Make the crimp and carefully inspect the work. The crimp should fold the two wings onto the bare wire and not deform any of the rest of the metal unit. Check that the anode/cathode is straight and none of the barbs or sleeves are damaged. Push the MC4 front sleeve onto the crimped anode/cathode until you feel it latch. Assure that the crimped M/F anodes/cathodes are fully driven to the tip of the connector and are secure there. Next screw the tail end cap & seal onto the MC4 connector torque it to the manufacturer specifications (usually the cap does not thread up tight to the MC4 connector, but the correct torque depends on the wire gauge (10 AWG or 6mm, etc). Tug HARD on the wire- if the anode/cathode shifts or the wire pulls loose from the crimp, re-install the connection.

Setting alignment strings

Use a pair of panel clamps to fit on the extreme ends of a rail. Set them on the bottom rail of the upper and the lower rail set. Screw them down to the rail and fix a string to the clamp so it runs the full length of the rail. Use the string to align the panels

Test the leads and connectors

Test the +-MC4 connectors and leads that run to the inverter. The +- pairs were color labeled at the conduit as String 1: Red, 2: Purple (PVC pipe primer), 3: Blue, 4: Yellow. The positive wire is the tan colored lead. The white lead is DC -.

Each series in a string has a + & a – lead that runs to the MC4 combiners, 4PST switch and 30A DC breaker, and finally to the inverter. Test that wire and it's MC4 connectors for continuity before setting any panels in the series.

Crane up the panels

The panels move from the stack to the caddy without trouble. Two panels in the caddy lift readily and the crane clears the roof with inches to spare. The caddy lays on the roof well but extracting the panels is a bit tough. Hauling hard on the lift line gets a panel up enough to fit a wedge/crowbar under an edge and then the panel lifts well. It's expedient to hoist and store some 4-10 panels briefly, then turn off the crane and place the panels.

Plan where to put a panel

Check the position of the right clamp to see if it collides with a screw and standoff. If the screw is going to interfere with the clamp nut, move the screw. Before placing a panel on the rail, locate the + & - leads and orient the panel to place the + at the correct side. Before screwing down the panel and clamp, use a working voltmeter to show that there is voltage and that the panel is good. NB: the Jinko MC4 connector blocks the standard MC4 release tool, two bits of plastic need to be cut out/clipped before the tool can release the MF pair. Try to never need to separate Jinko MF connectors by testing and inspecting all the leads before connecting. The test connectors won't latch, so they are not a problem.

Position the clamps and panels

Set the clamps onto the rail. Be certain that the clamp nut is almost off the bolt to leave lots of room to lift the panel over the grounding washer. Fetch and place the panel. Use the strings to position the panel. Only tighten the left clamps. At the right side, add a pipe and screw stand. Position it to not interfere with the clamp nuts. Anoint the pipe stand with gutter seal.

If possible, plug the test cable into the left end of the panel series and check the series voltage as the panels are added, but most series must plug in the 10AWG/conduit lead that will lay under the panels which may or may not offer a way to test the string voltage. Check the string voltage at the inputs to the RSD.

APSmart RSD-S

NB: a rarely documented problem with the RSD technology is crosstalk between two transmitters that makes them unreliable. To eliminate the problem, the DC leads on one RSD transmitter must be segregated by at least 24" from any other. Further, there seems to only be RSDs for the "residential" size panels, not the "commercial." These bugs are the only significant design flaw I made, but because the system is in an uninhabited, unenclosed, carport like structure, RSDs are not required by NEC. String four has them although I may take them off because they don't fit and are laying on the roof surface (enclosed in PVC pipe, but still not right), but none of the others do because of the crosstalk bug that makes them fail reliably.

690.12 Rapid Shutdown of PV Systems on Buildings

690.12 Rapid Shutdown of PV Systems on Buildings. PV system circuits installed on or in buildings shall include a rapid shutdown function to reduce shock hazard for firefighters in accordance with 690.12(A) through (D).

Exception No. 1: Ground-mounted PV system circuits that enter buildings, of which the sole purpose is to house PV system equipment, shall not be required to comply with 690.12.

Exception No. 2: PV equipment and circuits installed on nonenclosed detached structures including but not limited to parking shade structures, carports, solar trellises, and similar structures shall not be required to comply with 690.12.

Wiring and bolting the panels

Rail clamps that hold PV panels need pipe and screw support near the clamp. Add supports near each clamp as part of the panel installation sequence. The stronger the supports the better, so multiple screws per pipe are OK.

PV panels are first hand carried to near their installation location. First assure the WEEB grounding washer is unbent then carefully align the panel to the string and put the PV panel hard against the left hand clamps. Next, place two rail clamps on the right hand side of the panel but don't screw them down. Leave the clamps slack so the panel can be aligned. After the panel is aligned and set, screw down the socket head bolt on the left two clamps. Jinko says to never deform the frame, and the WEEB ground washers have a bite, so the bolt is not real tight.

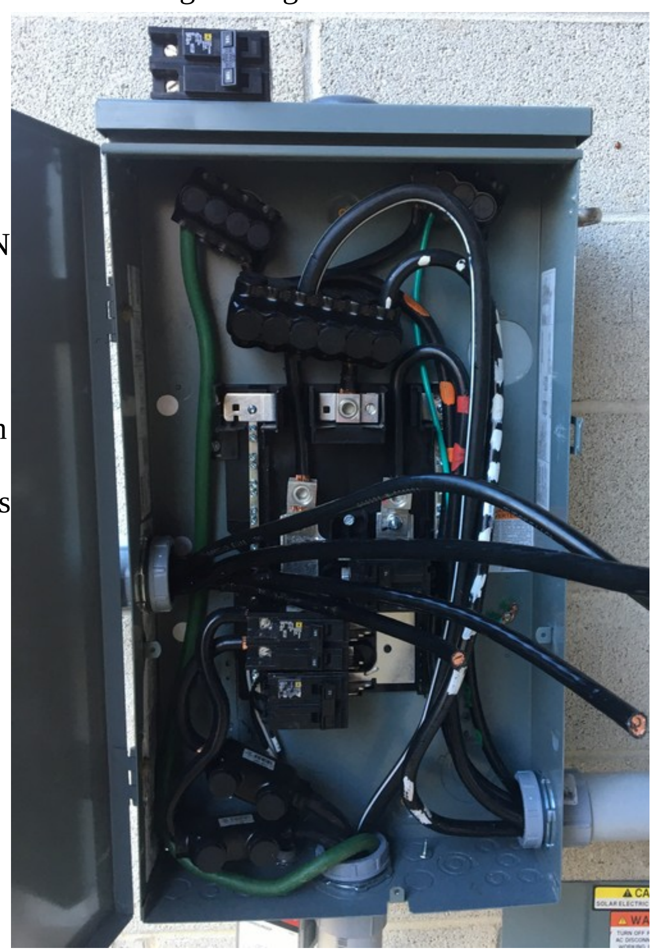
Proceed to the next panel and repeat the above. When a series of panels is complete, attach the 14A +- leads to the 10 AWG THHN leads and for Strings 1,2 & 3, to the MC4 "Y" combiners, then attach the 28A end of the "Y" combiner to the main 10 AWG THHN leads that carry the 28A to the Breaker and Switch box. String 4 is a 14A run without a "Y" combiner.

The PV Panels Installation is Complete

The panels now deliver current to the switch, breakers and inverters in the daylight hours.

Successful Electrical Inspections

Once all the new work but for the grid connections and PV panels is completed, the installation can benefit from a preliminary inspection. Any needed work or changes can get sorted out before the meters are pulled.



My preliminary inspection found no issues, a single decal had the wrong color and will be replaced with the same decal but with a red border, not a yellow.   The inspector specifically accepted running four DC circuits of 28A on 10AWG THHN in 1" conduit on the roof, using 6 AWG Cu to ground the rails and panels and a 6mm PE lead from the 6awg ground line to the breaker/combiner/switch box and through to the single busbar connection with the 1/0 Cu PE line in the slave inverter. The WEEB disc grounding the panels to the rails and 6 AWG & 6mm ground leads were also okay. The inspector also accepted the work on the 125A feeder to the office. The trenching, the 4/0 Al, the Al < - > Cu splices and adding the PE lead to the sub-panel were all accepted as is.

The meters on the office and the shop were pulled and the fuses at the can were removed as well so the feed to the meter base was cut and the base made electrically cold.

Two days were spent installing the 4/0 Al L1, L2, N & 1/0 Al PE at the office, installing and connecting the 175A OCPD disconnect below the shop meter and putting in the 125A breaker the feeds the shop.

At the suggestion of the LVRECC lineman, the office was directly wired with the 4/0 Al L1,L2,N, 1/0 Al PE (instead of spicing to 3/0 Cu). This was faster and the Al wire bends more easily than the 3/0 Cu. Most remarkably, the Al leads were exactly the right length: the original purchased length and all the slack in the trench & conduit feeds worked out to the inch! The original notion had slack, but by not splicing the 3/0 Cu, that slack was consumed.

The 3/0 Cu & 1/0 Cu wire lengths also worked out very well with almost no scrap or leftover wire. This is bad planning. Don't try to skimp on the extra slack , you'll need the extra length in nearly all cases.

The 175A breaker box also fit very well, all the access holes were well positioned and the conduits met up precisely. The through wall conduit that passed through the MLO 125A feed was graceful enough, the original L-Body needed the sawsall to cut the 2" nipple from the meter base after the original 3/0 leads were removed. The 175A box was fixed to the concrete block with molly bolts and all the leads attached. The Inverter-Grid leads were a perfect fit and the splices that wired the shop sub-panel to the 125A breaker in the MLO fit well in the enclosure.

The 125A breaker at the MLO was a little challenging. A slight taper needed to be ground on the 3/0 L1 L2 leads to fit the breaker. Once all the breakers were fit, the new work was inspected. The LVRECC repair crew showed up 45 minutes after the inspection and restored the meter and fuses and the new work was in service.

The final inspection was completed after all the work was done and the system tested and debugged. The inspection found no issues and the full installation certified.

The last thing to do was to apply to the utility company to enable the Net Metering and start accruing energy credits.

System Operation

Inverter Configuration

To maximize PV production and net metering the value for "Sell Power Max" on the "On Grid Setup/Basic" page needs to set near the inverter's upper limit wattage, 12000W, and the work setup "Work Mode" page set the "Hybrid grid mode" to "On Grid" and the "PV energy manage." Setting "First to grid" or "First to load" will drive PV wattage to the grid. Uncheck the "Grid charging enable" if you want to only charge the batteries with PV power (not grid too). Set the "Battery energy manage" to "Standby" to preserve all battery capacity to only serve when the grid is down and the PV panels are not producing.   With these settings, the inverters will push energy to keep the batteries at 100% (available for UPS support when the grid is down), push energy to the UPS when the PV panels are illuminated, and send all the remaining energy to the grid for net metering.

Caution: Inverter Settings Can Defeat PV Production

The inverter factory default settings inhibit all PV to grid production! The MPPT logic will escalate the voltage to minimize PV production and the inverters will appear to be broken. Because many states and individuals don't accept net metering or current backfed to the grid, those defaults are sane. However the inverter manual and prompts are not well labeled or documented, so some trial and error is warranted.

Optional: Solarman Smart WIFI Web Reporting

Should the MPPT on an inverter perform poorly and required technical support from SRNE (see above), to inform the details of the issue, the Solarman Stick Loggers that came with the inverters can be installed and their serial numbers passed to SRNE support.

Update all the routers in the chain from the inverters to the WAN gateway to the latest firmware. To start, a new 2.4 GHz AP was set up, "PickAName" on the WIFI router closest to the inverters. The PickAName zone accepts input and output but rejects intra-zone forwarding and has explicit firewall traffic rules to isolate its net from everything but the gateway so it can reach the internet.

Use both a laptop and a cell phone to complete the wifi stick installation. The cellphone should have a mock location tool up and running that assigns the Lat/Long to some not too far off location (privacy matters when enabling a persistent offsite connection). You'll **require** a web based email service that you have immediate access to, so bring that up in a browser tab alongside the home.solarmanPV.com site (see below).

The sequence is arcane and difficult.

Have the stick's serial number and password written down and have a pen/pencil on hand as you'll have a much too short an interval (60 seconds) to receive and enter an authorization code.

Attach both the laptop and cell to the PickAName ap. Use the laptop to log into https://home.solarmanpv.com after reading and accepting the super intrusive terms of service (hence all the isolation listed above), register a new account. You'll be prompted for a name and an email address.

Next create a "plant". There is a 60 second timeout – first, enter a the authorization code sent to the email address. It takes about 30 seconds to arrive, leaving about 30 seconds to write down the code and switch between the web email page showing the code and the home.solarmanpv.com create and register the plant dialog. Create a "plant" for each inverter, one at a time (so the 60 second timeout authoization code stuff happens twice). Make them a non-residential industrial site located at some arbitrary Lat/Long (deny the web site's "location" request) that you enter by hand. It should be close enough to fairly represent the insolation energy and weather.

Name the first “plant” as HEBP1 Master and enter the timezone, type,KW capacity and the date the inverter was put in service (when the system passed inspection and went on grid).

Next, on the laptop, when prompted add the wifi stick logger manually. You’ll be prompted for the stick’s serial # and password. Next use the cell phone. You’ll be prompted to find the stick’s AP, attach to that AP (WPA2 TKIP) and go the ip address that you’re given in the laptop web dialog (http 10.100.100.244 or such). The wifi stick’s web page asks for a an ID & PW, those are “admin” & “admin” (those are shown on the laptop’s attach wifi stick dialog). When all that works, the laptop webpage will report that the wifi stick was successfully bound to the plant.

Create a second plant for the slave inverter, “HEBP2 slave”, and do all same timezone, type,KW capacity and the date the inverter was put in service stuff that was done for the HEBP1 plant. Add the second wifi stick, it’s the same sequence as above.

Once the two plants have been constructed and the home.solarmanpv.com site reports both are working, log out of the site and disconnect from the PickAName ap, then logoff and power down the laptop. Do the same with the cell phone.

Now if you need support, SRNE should then be able to observe the system and sort out the MPPTs.

Once the technical support get what they need from the wifi sticks, disable the PickAName AP at the wifi router to re-isolate the inverters from the web.

Warranty Support

SRNE’s US Warranty Service Center is HYSOLIS.COM (support@hysolis.com), they’ve been great.

Maintenance and Testing

Little maintenance is required. Most weather conditions like snow or ice make roof work too hazardous. Panels can be washed when the weather permits.

Dead PV panels

Should issues arise, the inverters will show the offending PV MPPT & string. Do an RSD shutdown (if there are any RSDs) on the offended inverter then expect to pull some PV panel clamps to expose the “Y” connectors and conduit ports. Isolate the series by removing one leg from the Y, and checking the inverter’s report. Once the series is located use an opaque sheet to sequentially cover the PV panels, one panel at a time. The one that makes no change at the inverter is the likely dead one.

Battery Fuses

The battery bus bar and disconnect box has a marine rated battery fuse on the + leg from the battery to the bus bar. Spare fuses are in the box. To replace a fuse, open the battery box and power down both batteries, then at the inverters, throw the DC circuit breakers to disconnect the batteries. Test the bus bar to be certain no current is present, then unbolt the fused lead and replace the fuse. Turn everything back on and re-seal the battery box.

The Spreadsheet

Component	Count	Price per w/tax	Total	Purchased on	URLs	Notes
Solar Panel Rails, WEEBs and Clamps						
rail screws	1	53	53	08/04/25	https://www.lowes.com/pd/Deck-Plus-8-x-1-5-8-in-Wood-To-Wood-Deck-Screws-1700-Per-Box/5014169861	
3" roofing screws to tie rail thru roof and stringer to joist	1	36	36	08/05/25	https://www.amazon.com/Roofing-Screws-Washer-Corrugated-250Pcs/dp/B0C1GZPPXV	Metal Roofing Screws 10 x 2-1/2 inch, Hex Head Sheet Metal Roof Screw with EPDM Washer f
1-5/8 in x 13/16 in Channel Strut, Slotted, Aluminum, Plain 1/16 in thick	64	12.2	780.8	08/22/25	https://www.zoro.com/zoro-select-single-channel-strut-slotted-aluminum-plain-916-in-x-1-18-in-hole-size-silver-fs-500ss-al-6000/i/G3345478/	
panel to rail clamps 5/16 hole. .6" deep 20 pack	5	28.8	144	08/22/25	https://a.co/d/0RfrO8K	Solar mid clamp Panel 5/8 (Pack of 20)
rail nuts, galvanized 100	1	63.59	63.59	09/13/25	https://www.ebay.com/itm/201923889131	
Full Thread Hex Tap Bolts, 5/16-18 x 1-1/2, Piece-100, zinc	1	17	17		https://www.amazon.com/Hard-Find-Fastener-014973244033-Piece-100/dp/B00L1L8KSQ?crid=13A41NM1Z6G8&dib=eyJ2Ij	(Qty 100) 3/8-16 x 1" Hex Bolt Zinc Plated Grade 5 Full Thread Cap Screw
Plastic Cable Clips (30 ct)	1	13.77	13.77	09/07/25	https://www.ebay.com/itm/376321217886?_skw=Trailer+Frame+Wire+Plastic+Clip&itmmeta=01K4J0RSDF975FVBSN7PR5KK20&hash=item579e7e155e:g:r-0AAOSwYD1oRftR&itmprp=enc%3AAQAKAAABAFkggFvd1G	
panel installation labor		400	0			
qty 5 Strut Channel Nuts 5/16-18 Short Spring Zinc Plated Unistrut Nut	1	13	13	08/22/25	https://www.zoro.com/superstrut-100-spring-nut-steel-galvanized-za10014eg-10/i/G313767840/	
6" eye hook safety top rope anchor		1.59	0		https://www.lowes.com/pd/Hillman-Steel-Screw-Eye-Hook/3036085	Twice failed to deliver correct part, will need to go to Lowes and fetch from shelf.
electric screwdriver	1	79	79	09/07/25	ebay	
caulking to seal rail/roof holes	1	85.27	85.27	08/12/25	https://www.homedepot.com/p/DAP-Butyl-Flex-10-1-oz-Aluminum-Gray-Gutter-and-Flashing-Sealant-12-Pack-7079818188/2	case of 12, gutter/metal seal
High solar reflective index paint for under bifacial panels	1	101	101	08/22/25	https://www.zoro.com/valspar-exterior-paint-metal-steel-wood-white-0090029048008/i/G915487467/	400 ft sq /gallon
25' #6 bare cu grounding wire	1	26.5	26.5	09/07/25	https://www.ebay.com/itm/226641462840?_skw=6+awg+bare+cu+grounding+wire+20%27&epid=25004761258&itmmeta=01K4HZXTWDTNE87DS9AVRQKCPQ&hash=item34c4e24638:g:EUwAAeSwSPBn0G~9&itmprp:	
36" 1.5" square al tubing, w/ .328" hole @1.5" center, cut to 3"	3	27.5	82.5	09/11/25	https://www.amazon.com/80-20-Smooth-Square-Profile/dp/B00J4SW764?crid=2Q1WP11EKBNO1&dib=eyJ2IjoiMSJ9.eTzFU5y19MXfH2fSozDxpXm4xzIG2iCU3xNz2J0nTvBbP0Divz8fM6TD8vvT3gG48Lpb7aNbzAe3uW	
50Pcs Solar Panel Grounding Lug discs	2	11.7	23.4	09/11/25	https://www.amazon.com/Grounding-Washer-Spacer-Photovoltaic-Ground/dp/B0BJ8RV9QZ	
MC4 Parallel Connect Panels (2Pairs M/FF+F/MM, T-Branch)	3	13.7	41.1	09/11/25	https://www.amazon.com/TOMSHIELE-Connector-Parallel-Connection-Between/dp/B0CYLNBPYR?crid=A7BDL8R90CTL&dib=eyJ2IjoiMSJ9.l_qOxG_dTjQJddiRYyQYBMj5yccPWU_1NYThiJ2BQ7WZ6jiNlGe7xEgb3jejtG	
Ground Bracket Aluminum Rail, lugs,4 ct	1	12.4	12.4	09/11/25	https://www.amazon.com/dp/B0BHWCMXT1?ref=ive_vftp_hero_cx_pfo_vse-cards-ingress0&th=1	
10 " Al saw blade			0	09/11/25		
NEC Rqd labels	1	10.6	10.6	09/11/25	https://www.amazon.com/CDXHOME-Install-Photovoltaic-Stickers-Electrical/dp/B0C6LRKDCH?dib=eyJ2IjoiMSJ9.Dat7PuiRay-0yIC2xfdrdEA4kQi4SFNoWBcArK9mat9JVrAzcnmENRkY13ONReG38z2X9Mw6-AXgnewLZ	
mc2 mf connectors 22 pairs	1	28.5	28.5	09/11/25	https://www.amazon.com/BougeRV-22PCS-Solar-Connectors-Female/dp/B07875Y7N9?crid=3H0VWY2KLSBDH&dib=eyJ2IjoiMSJ9.XbsXUMNjdkcj_c8l7rayQ4KVue6ZVNz7oi_xwiBivtqOndZnUd-fafnaYeEip4bK-LrbPHKp	
1" fender washer-ties rails to roof (600 ct, but cheapest @>120ct)	1	42.39	42.39	09/13/25	https://www.ebay.com/itm/200987578608?_trksid=p4481478.c101875.m1851&itmprp=cksum%3A2009875786089cdf466cc10e452fa99bd03b1bb36526%7Cenc%3AAQAKAAABgG96wQ16jds4VFcrhy1F3d4mbwZUJI9Fs	
			0			
PV Panels			0			
635w Jinko pallet (36 ct)	1	5939.56	5939.56	09/19/25	mate solar, alibaba	
			0			
			0			
MC4 & Panel Wiring			0			
mc4 crimping tool	1	24	24	08/05/25	https://www.amazon.com/haisstronica-Crimping-Tool-Solar-Connectors/dp/B0BGL9SMR5	
mc4 connectors M/F 6 pair w/ disconnect tool	1	10.6	10.6	08/05/25	https://www.amazon.com/BougeRV-Pairs-Solar-Connectors-Female/dp/B073TX1N5Q/ref=sr_1_3	CHECK FIT FOR 6MM WIRE !!
electrician's gloves, lightweight	2	9.5	19	08/05/25	https://www.lowes.com/pd/Blue-Hawk-Large-3-Pack-Mens-Polyester-Polyurethane-Dipped-Multipurpose-Gloves/50061517	3 pack
electrician's gloves 12kv lineman grade	1	16	16	08/05/25	https://www.amazon.com/Electrical-Electrician-Waterproof-Protective-Insulating/dp/B07LDDDGHB	
6 mil black poly sheet, to cover panels during construction	1	74	74	2024	https://www.lowes.com/pd/BARRICADE-10-ft-x-100-ft-Black-6-mil-Plastic-Sheeting/1000158147	10' x 100'
			0			
			0			
Panel Disconnect, Surge and Overcurrent Protection			0			
Solar Panel Disconnect Switch/combiner box	1	89	89	08/19/25	https://www.amazon.com/DIHOOL-Disconnect-Circuit-Breaker-Combiner/dp/B0D9NJQ1JN/138-3272722-5899328?th=1	arc xtinguish/overload/overcurrent/short circuit
Enclosure for DiHool combiner box	1	60.88	60.88	09/13/25	https://www.ebay.com/itm/177318100261	
Surge protection device GE	1	51	51	08/19/25	https://www.amazon.com/THOMESURGEP-ABB-SurgeProTM-Protective-Residential/dp/B0CXHZ9JXY	Thru breaker from solar panels wire both + & - , and a #8 to protective earth
Midnite Solar-MNDC-GFP63	0	77.38	0		https://www.amazon.com/MidNite-Solar-CECOMINOD046558-Midnite-Solar-MNDC-GFP63/dp/B007IAIQ9W	NEC Ground Fault Protection – 690.5 BUILT INTO INVERTER
			0			
Grid-Tied Hybrid Inverter & battery support			0			
SRNE-Inverter-HEBP4880U200-Pro + shipping (qty 2)	1	4298.19	4298.19	08/14/25	https://www.alibaba.com/product-detail/Hot-Sale-SRNE-Inverter-HEBP4880U200-Pro_1601385137191.html	Elia @ borick via alibaba verified transaction, on discover, shipped 09/11/2025
elia@boricksolar.com posts on DIYSolar			0			
			0			
Batteries and Management			0			
qty 2, 48V 100Ah LiFePO4 Lithium Battery,	1	1792.45	1792.45	10/14/25	https://www.amazon.com/dp/B0DP4LTRMG or https://www.amazon.com/dp/B0DR8JK97W	Ecoworthy 100 AH lfp
	1	0	0			
	0	0	0			
Anker f3800			0	06/01/24		
raspberry pi zero for SolarAssistant, case and PS, not pi 0	1	12	12	08/08/25	ebay	
			0			
Solar Service to House			0			@ house, Feeder cable in 2" conduit to nema 4x box 4 leads spliced to existing cu, add ground
Caution tape, in trench	1	10.94	10.94	08/14/25	amazon order # 112-2012629-5429031	
Outdoor Electrical Junction Box, 12 X 10 X 6	3	43.4	130.2	08/22/25	https://www.amazon.com/Electrical-Junction-Waterproof-Mounting-Lockable/dp/B0FCYGF41Y?dib=eyJ2IjoiMSJ9.bK-qHcLyoKOCttj8xwl4Sf6LlijCgZKOR6LUMNIFMY7gsIsoa4_EbUeJLpKcekLmSg_6XO1RU99FyN1p5m8	
2 Port Insulated Multi Tap Connector 2/0 6 pack	1	45.55	45.55	08/14/25	https://www.amazon.com/Joinfworld-Insulated-Connector-Connectors-Electrical/dp/B0DLW5RQGX?crid=3IBWHG3	ground line from feeder to sub-panel
			0			
Wire			0			
200 Amp 4/0 4/0 4/0 2/0 AL service line to house	205	9.24	1894.2	08/23/25	https://www.lowes.com/pd/Southwire-Southwire-4-0-4-0-4-0-2-0-Aluminum-Mobile-Home-Feeder-Service-Entrance-Cable-By-the-Foot/3129329?idProductFound=false&idExtracted=false	
3/0 Black Stranded CU SIMpull THHN Wire	30	9.51	285.3	08/23/25	https://www.homedepot.com/p/Southwire-By-the-Foot-3-0-Black-Stranded-CU-SIMpull-THHN-Wire-20507099/204632783	
1/0 stranded Cu wire	15	6.76	101.4	08/23/25	https://www.lowes.com/pd/Southwire-SIMpull-1-0-AWG-Stranded-Black-Copper-THHN-Wire-By-the-Foot/50101588	
THHN #6 RED, WHITE, 120 (2),#8 Green 50'	1	208.22	208.22	08/02/25	https://www.ebay.com/str/bungolawing?_trksid=p4429486.m3561.l161211	
Southwire 65179640 SPL4/0-6AD Dual Rated, 1PK Splicer, Grey x 6	1	23.65	23.65	08/23/25	amazon/ebay	rectangular butt 2 wire 4/0
Southwire #2 to #4/0 Parallel Groove Clamp	6	7.19	43.14	08/05/25		3 wire clamp
cable bending tool	1	10.6	10.6	08/24/25	https://www.amazon.com/Bending-Ratchet-Connection-Convenient-Upgraded/dp/B0DCRJH7WF?crid=PR9D1W9EXWFN&dib=eyJ2IjoiMSJ9.t-zvftSiOzT1w8M18NAYQUW-oj_yWVd7cWFXg6TUlEEd_5-Dl8K0Rmg_W6yF	
4 0z Noalox (ebay)	1	11.97	11.97	08/05/25	ebay	
Kopr-shield 8 oz	1	64	64	08/05/25	amazon/ebay	
exterior latex paint to label wires	1	26.49	26.49	08/14/25	Amazon	
Thhn 10awg brown (the new red)	1	111.3	111.3	09/07/25	https://www.ebay.com/itm/256859049945?_skw=thhn+wire+10awg+red+250&itmmeta=01K4FDTXR5SQ8CXSAMEYCR26FX&hash=item3bcdfe0fd9:g:zlYAAOSwuGJn1iBP&itmprp=enc%3AAQAKAAAA0FkggFvd1GGDu	
Thhn 500' 10 awg white (the new black)	1	111.3	111.3	09/07/25	https://www.ebay.com/itm/257060199379?_skw=thhn+wire+10awg+red+250&itmmeta=01K4FDTXR5H2MR4YECGEN24GGZ&hash=item3bd9fb5bd3:g:s1MAAeSwBOdodwhQ&itmprp=enc%3AAQAKAAAA8FkggFvd1GG	
2nd cable bending tool	1	10.16	10.16	09/11/25	amazon/timber gamer inc	
Conduit			0			
2" pvc conduit 10'	5	21.18	105.9	08/23/25	https://www.lowes.com/pd/CANTEX-Common-2-in-Actual-2-In-Non-Metallic-Pvc-10-ft-Conduit/50434252	
1" pvc conduit , 10'	12	10.08	120.96	08/23/25	https://www.lowes.com/pd/CANTEX-Common-1-in-Actual-1-In-Non-Metallic-Pvc-10-ft-Conduit/50434246	40', 30', & misc
1" slip coupling	4	0.83	3.32	08/05/25	https://www.lowes.com/pd/CANTEX-1-IN-PVC-Coupling-Conduit-Fittings-Durable-and-Reliable-Solution/5002319889	
1" conduit 90dg elbow	8	2.4	19.2	08/05/25	https://www.lowes.com/pd/CANTEX-1-IN-SCH-40-90-DEG-BLD-ELBOW/5002691557	
2" Conduit Hole Size Knockout Punch	1	45.82	45.82	08/06/25	https://www.ebay.com/itm/383427283990	
1" conduit hole knockout punch	1	22.32	22.32	08/23/25	https://www.amazon.com/THA034-Conduit-Hydraulic-Driver-Thread/dp/B07NJQDJMX?crid=2VEPNJ4YRBKFJ&dib=eyJ2IjoiMSJ9.vN4NYexeMIlo6LLMMB7EuqwLGT1IXjzhJxOFa6R63L_GjHj071QN20LucGBJIEps.P0vt8	
2" elbows, locknuts, bushings, couplngs & brackets	1	88.98	88.98	08/09/25	lowes order #300901221250719044	2" conduit locknut ring to tie close nipple to box, 2 per
2" adapters	4	2.09	8.36	08/12/25	https://www.homedepot.com/p/Carlon-2-in-Electrical-PVC-Male-Adapter-E943J-28-HD-E943J-28-HD/100404004	connect meter base to 200 disconnect
Square D 2-in Hub- conduit to box	1	26	26	09/07/25	https://www.lowes.com/pd/Square-D-2-in-Hub/3129235	
Lube	1	11.65	11.65	08/24/25	https://www.amazon.com/Synthetic-Lubricant-Klein-Tools-51010/dp/B000MKDUSC?crid=CRPDOFK4Y522&dib=eyJ2IjoiMSJ9.as4bU8orycG2ySFC0a6YSuPOPIEyC_Bsobfs1xQlvrw7TIW2Ms_4gJpm4x23vBqIixxhBlpWhij	
1-1/2 in. x 10 ft. PVC Schedule 40 DWV Pipe	2	10.2	20.4	08/23/25	https://www.lowes.com/pd/IPEX-1-1-2-in-x-10-ft-330-Psi-Schedule-40-PVC-Pipe/5016159395	cut to 3/4" to make rail standoffs, need 240 +
1" flexible conduit 25'	1	45.58	45.58	08/23/25	Amazon	
CANTEX Type T Conduit body 1-in Plastic Type T conduit bodies	5	6.23	31.15	09/07/25	https://www.lowes.com/pd/CANTEX-1-in-Combination-Connector-Schedule-40-PVC-Compatible-Schedule-80-PVC-Compatible-Conduit-Fitting/3234068	
CANTEX Type LConduit body 1-in Plastic Type L conduit bodies	2	6.23	12.46	09/07/25	https://www.lowes.com/pd/CANTEX-1-in-Combination-Connector-Schedule-40-PVC-Compatible-Schedule-80-PVC-Compatible-Conduit-Fitting/1000321675	
CANTEX Type L Conduit body 2 iin Plastic Type L conduit bodies	3	19.6		10/02/25	https://www.homedepot.com/p/Cantex-2-in-Type-LB-PVC-Conduit-Body-Conduit-Fitting-for-Cantex-PVC-Conduits-R5133668/202043420	
1.5" panel punch	1	22.25	22.25	10/03/25	amazon	
ODDS AND ENDS			0			
1" gland nuts- conduit t bodies #10 THHN at panel connects Q10	1	20.12	20.12	10/23/25	amazon	
5 pack 1" pvc tee slip for conduit	1	9.88	9.88	09/23/25	https://www.amazon.com/HayEastdor-Connectors-Sprinkler-Irrigation-Extension/dp/B0F2H99C5Z?crid=U6VUOHCGTHDW&dib=eyJ2IjoiMSJ9.frBSOzPFH2a2i7HmXHepFtdY1R4_gtJb46vqnQf9O8FT9F7lNWJB4QpR9ig-	
6 pack 1" pvc m slip to fpt	8	1	8	09/23/25	https://www.lowes.com/pd/CANTEX-1-in-Combination-Connector-Schedule-40-PVC-Compatible-Schedule-80-PVC-Compatible-Conduit-Fitting/1000321669	
1" t body	0	6.23	0		https://www.lowes.com/pd/CANTEX-1-in-Combination-Connector-Schedule-40-PVC-Compatible-Schedule-80-PVC-Compatible-Conduit-Fitting/3234068	
175A breaker	1	115.54	115.54	10/02/25	https://www.homedepot.com/p/Square-D-QO-175-Amp-22k-AIR-QOM2-Frame-Size-Main-Circuit-Breaker-for-QO-and-Homeline-Load-Centers-QOM2175VH/317157048	
36" 1.5" square al tubing, w/ .328" hole @1.5" center, cut to 3"	3	27.5	82.5	09/23/25	https://www.amazon.com/80-20-Smooth-Square-Profile/dp/B00J4SW764?crid=2Q1WP11EKBNO1&dib=eyJ2IjoiMSJ9.eTzFU5y19MXfH2fSozDxpXm4xzIG2iCU3xNz2J0nTvBbP0Divz8fM6TD8vvT3gG48Lpb7aNbzAe3uW	
2" conduit elbow	4	7.82	31.28	09/23/25	https://www.lowes.com/pd/CANTEX-2-in-Combination-Elbow-Conduit-Fitting/1000321657	
2" ring locknut	7	2	14	09/23/25	lowes	
chain for eyes and X wires in "attic" of shed, /ft.		6.6	0		https://www.lowes.com/pd/Blue-Hawk-1-Ft-3-8-in-Welded-Zinc-Plated-Steel-Chain-By-the-Foot/1000830234	
12" 3/8 all thread rod	8	2.31	18.48	09/23/25	https://www.lowes.com/pd/Oatey-3-8-in-X-12-in-Threaded-Rod/1001223378	
1" entrance bushing	4	0.72	2.88	09/23/25	https://www.lowes.com/pd/Sigma-Electric-ProConnex-1-in-Insulated-Bushing-Intermediate-Metal-Conduit-Compatible-Galvanized-Rigid-Conduit-Compatible-Rigid-Metal-Conduit-Compatible-Conduit-Fitting/1092637	
3/8" washers	1	6.38	6.38	09/23/25	lowes	
3/8" nuts	1	6.38	6.38	09/23/25	https://www.lowes.com/pd/Project-Pak-3-8-in-x-16-Galvanized-Steel-Hex-Nut/3033221	
heat shrink tubing for 1/0, 3/0 & 4/0 cables	1	5.59	5.59	10/31/25	https://www.ebay.com/itm/127255727347?var=428359139822	
Lugs, 4/0	1	28.5	28.5	10/24/25	https://www.ebay.com/itm/141627484659?var=442246262624	
fuse block, MRBF for batteries	1	15.72	15.72	10/24/25	https://www.ebay.com/itm/126448858466	
small fans for battery box	1	24.41	24.41	10/23/25	https://www.ebay.com/itm/187503711552	
thermostat for battery box	1	21.33	21.33	10/20/25	https://www.ebay.com/itm/126826757983	
chrome bolts for Cu busbar	1	13.26	13.26	10/20/25	https://www.ebay.com/itm/203882527173	
Splice 4/0 Cu	1	24.69	24.69	10/18/25	https://www.ebay.com/itm/375787935278	
Splice 3/0	1	43.32	43.32	10/18/25	https://www.ebay.com/itm/356793207157	
Lugs 2/0 for inverter to battery busbar	1	16.5	16.5	10/17/25	https://www.ebay.com/itm/255064203743	
lug crimper tool	1	23.24	23.24	10/17/25	https://www.ebay.com/itm/281912922165	
rapid shutdown devices	1	191.27	191.27	10/15/25	https://www.ebay.com/itm/116766759047	
Safety anchor for installing panels	1	40.42	40.42	10/15/25	https://www.ebay.com/itm/336068376767	
30' 1/0 THHN wire	1	95.5	95.5	10/14/25	https://www.ebay.com/itm/365749640560	
90' 3/0 THHN	1	459.1	459.1	10/14/25	https://www.ebay.com/itm/297502413979	
5' red 4/0 cu wire	1	52.42	52.42	10/13/25	https://www.ebay.com/itm/302348773272?var=601185011552	
5' black 4/0 cu wire	1	42.98	42.98	10/13/25	https://www.ebay.com/itm/302348773272?var=601185011560	
13' red 2/0 wire	1	64.99	64.99	10/13/25	https://www.ebay.com/itm/302348773272?var=601185011550	
13' black 2/0 wire	1	64.99	64.99	10/13/25	https://www.ebay.com/itm/302348773272?var=601185011558	
cu battery busbar	1	44.86	44.86	10/10/25	https://www.ebay.com/itm/182711908729	
panel end clamps	1	26.96	26.96	09/30/25	https://www.ebay.com/itm/175203859907	
2" conduit stuff (less $ for poly pipe fitting)	1	95.56	95.56	09/23/25	lowes	
2" conduit stuff, wire lube	1	60.25	60.25	11/11/25	lowes	
(q6) 3/0 splice	1	47.91	47.91	10/01/25	https://www.homedepot.com/p/ASI-6-AWG-250-MCM-600-Volt-6-Ports-Multi-Tap-Connector-Insulated-Dual-Sided-Black-AICD250-6/310236438	
Q6 2/0 splice	1	46.62	46.62	08/14/25	amazon	
hole saw bit, concrete, 175A box thru block	1	22.89	22.89	10/13/25	amazon	
ferrule crimper (PV 10awg leads to inverter)	1	19.06	19.06	10/13/25	amazon	
1" poly block busbar insulation	1	24.14	24.14	10/13/25	amazon	
DC surge protection qty 4	1	57.98	57.98	10/03/25	amazon	
Grid box spike protection	1	51.91	51.91	10/03/25	amazon	
Qty5 3/0 4 port splice	1	63.59	63.59	10/03/25	amazon	
4" DIN rail	1	3.69	3.69	10/03/25	amazon	
3.25" 5/16 hex socket cap screw qty 10	1	12.6	12.6	10/03/25	amazon	
2" cable sleeve conduit 10'	1	19.06	19.06	10/23/25	amazon	
2nd batch of 1.5"al square tubing	1	82.39	82.39	10/23/25	amazon	
60 ml syringe for Kopr-Shield q4	1	7.41	7.41	08/05/25	amazon	
battery fuses q4	1	39.68	39.68	10/20/25	discover/del city	
Q50 3 ¼" 5/16 hex cap screws, panel bolts	1	47.53	47.53	10/06/25	disover/kjljack inc	
Disconnect switches-PV &battery	1	67.84	67.84	10/21/25	amazon	
panel end brackets to group by string, NEC rqd labels	1	46.61	46.61	11/08/25	amazon	
battery box hinges, locks, cvc outlet covers	1	38.22	38.22	10/31/25	amazon	
	1		0			
	1		0			
Mounting Panel for Inverter, Batteries and Associated Hardware			0			
4' x 8' x 3/4 " treated plywood: electrical backwall/cabinet	1	49	49	06/01/25	https://www.lowes.com/pd/Severe-Weather-15-32-CAT-PS1-09-Square-Structural-Plywood-Pressure-Treated-Southern-Yellow-Pine-Application-as-4-x-8/4564604	
4' x 8' x 1/2" (2) drywall: electrical backwall/cabinet	2	14	28	2024	https://www.lowes.com/pd/CertainTeed-Common-1-2-in-x-4-ft-x-8-ft-Actual-0-5-in-x-4-ft-x-8-ft-Drywall-Panel/1002992798	
1/8"x 3" 150 lb rated molly bolts: electrical backwall/cabinet	1	11.7	11.7	08/05/25	https://www.lowes.com/pd/TITAN-150-lb-1-8-in-x-3-in-Toggle-Bolt-Drywall-Anchors-with-Screws-Included-50-Pack/5015146825	
Outdoor Electrical Junction Box, 12 X 10 X 6	1	43.4	43.4	08/22/25	https://www.amazon.com/Electrical-Junction-Waterproof-Mounting-Lockable/dp/B0FCYGF41Y?dib=eyJ2IjoiMS	box for splice connectors between inverters 3/0 cu
			0			
LVRECC 200 A @ Meter			0		Scott Spencer @ LVRECC : old services DO NOT need the disconnect switch 8-8-2025 @11:25am	
AC OC breaker type dpst switch grid cutoff	1	217.21	217.21	08/12/25	https://www.homedepot.com/p/Square-D-QO-200-Amp-2-Pole-Outdoor-Circuit-Breaker-Enclosure-with-QOM2200VH-Breake	WG96217104 <==order #
Wire Connector 3 Port Dual Side Entry for 3/0-6	4	21.2	84.8	08/22/25	https://www.amazon.com/dp/B0CZZM3MR1	
225 Amp 12-Circuit Outdoor Main Lug Neutral Load Center	1	123.47	123.47	08/23/25	https://www.homedepot.com/p/Square-D-Homeline-225-Amp-12-Space-12-Circuit-Outdoor-Main-Lug-Plug-On-Neutral-Loa	powers the subpanels, leads to house, shop
125 A breaker	2	115.54	231.08	08/23/25	https://www.homedepot.com/p/Square-D-Homeline-125-Amp-2-Pole-Circuit-Breaker-HOM2125CP/100146567	house and shop, set in MLO box
14 terminal ground lug bar	3	11.53	34.59	09/07/25	https://www.lowes.com/pd/Eaton-1-in-Ground-Bar-Kit/1000551239	ground bar for house sub-panel
10 terminal ground lug bar	3	11.8	35.4	09/27/25	https://www.lowes.com/pd/Eaton-Load-Center-Ground-Bar-Kit/3370974	ground bar for house sub-panel
Outdoor Electrical Junction Box, 12 X 10 X 6	1	43.4	43.4	08/24/25	https://www.amazon.com/Electrical-Junction-Waterproof-Mounting-Lockable/dp/B0FCYGF41Y?dib=eyJ2IjoiMSJ9.bK-qHcLyoKOCttj8xwl4Sf6LlijCgZKOR6LUMNIFMY7gsIsoa4_EbUeJLpKcekLmSg_6XO1RU99FyN1p5m8	
			0			
			0			
			0			
electrician			0			
ekeli	1	125	125	08/15/25	wsh check #9554	
todd lindon final inspect	1	100	100	11/04/25	wsh check #9348	
			0			
GRAND TOTAL ======>			21311			
30% tax credit		6393.225				
cost after tax credit (excluding roof prep)		14917.525				

Conclusion

The do-it-yourself installation of the 22KW PV system was a lot of work. The good news is that the only design flaws were related to the Rapid Shutdown Devices, and in this case, those were optional.

Caution slowed some of the final stages unnecessarily, but no one was harmed so it was worth the delay.

The SRNE manual is pretty good, but there are a couple of glaring omissions: the “Work Setup” “Sell Power Max” field was never mentioned, but until a non-zero value is entered, the inverters won’t draw power from the PV panels and the system appears broken.

The below the roof work, setting up the inverters, the grid wiring and all the trenching was a lot of effort. However, the roof repair before setting the rails and panels was the most physically onerous part. Installing the panels was pretty straightforward but for debugging the cross-talk problems with the RSDs.

The system has been observed to work at 90% of ideal, better than I had expected. A sunny day near the vernal equinox generated 50+KWH. About ¼ of that served the UPS home loads, the remainder was banked by the power utility for future use (winter, cloudy days, etc). The 22KW ideal design has made 19KW in real conditions.

The effort was well worth the time and money.