EcoSTORE Pole-mounted Community Energy Storage System

November 2021

Overview

The EcoStore is a pole -mounted 30kVA/65kWh three phase Battery Energy Storage System (BESS) ideally suited to a community energy storage application. It consists of three pole mounted cabinets as shown in Figure 1, each containing a 10kVA/21.9kWh BESS coordinated together to operate as a three phase BESS. Having separate inverters per phase allows true unbalanced operation and advanced grid support.

It has full four quadrant power capability able to sink or source any combination of real and reactive power up to 10kVA per phase.

Figure 1: EcoSTORE Pole mounted BESS

Hardware

Figure 2 shows a diagram of the system showing the outer dimensions of each cabinet.

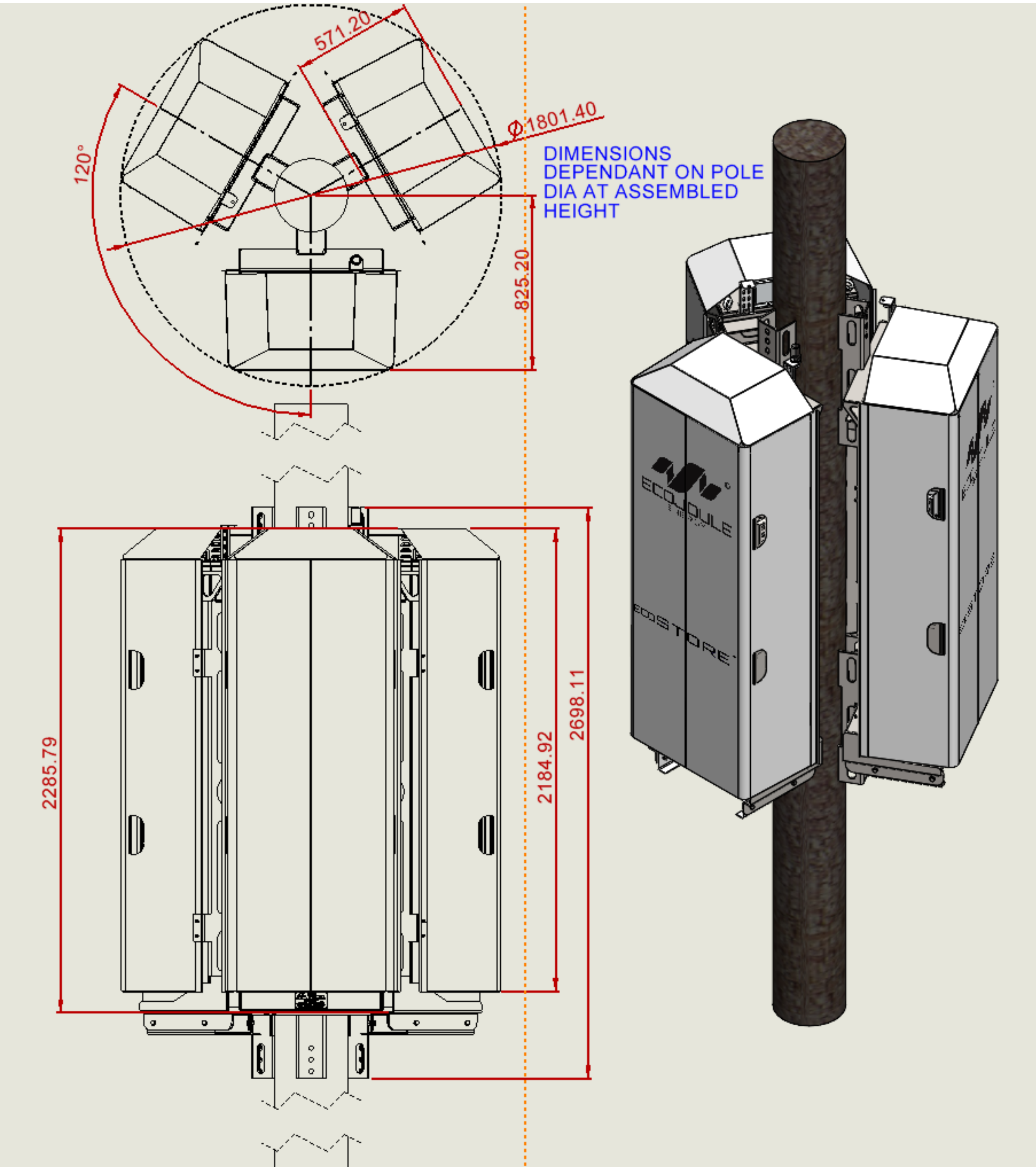

Figure 2: Dimensioned diagram

Each enclosure has an outer sunshield to prevent direct solar radiation on the electronics and battery cabinet, similar to EcoJoule's EcoVAR STATCOM. Figure 3 shows a view with one sunshield removed. Each enclosure is mounted onto its own pole bracket (shown in Figure 4).

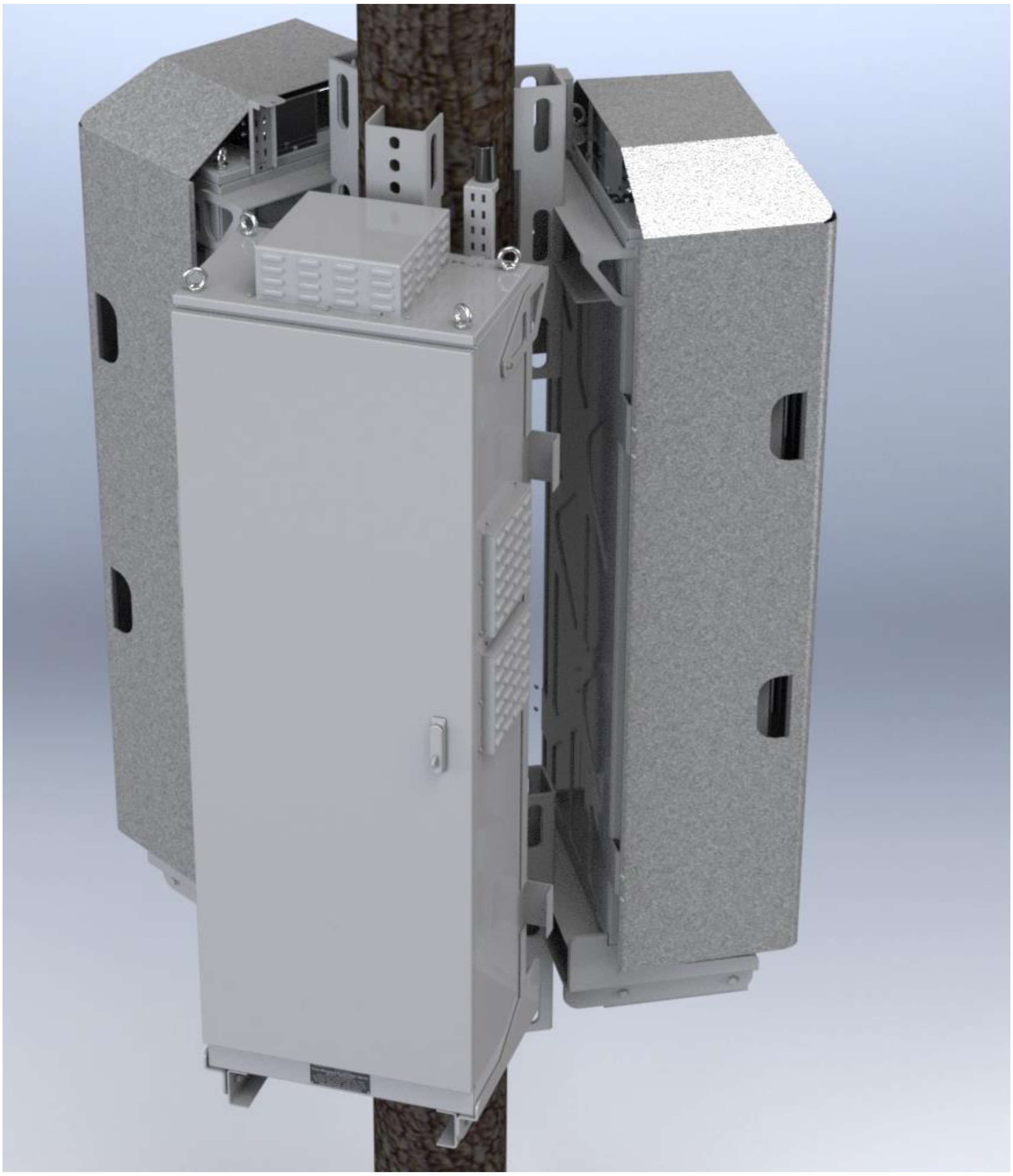

Figure 3: View with one sunshield removed

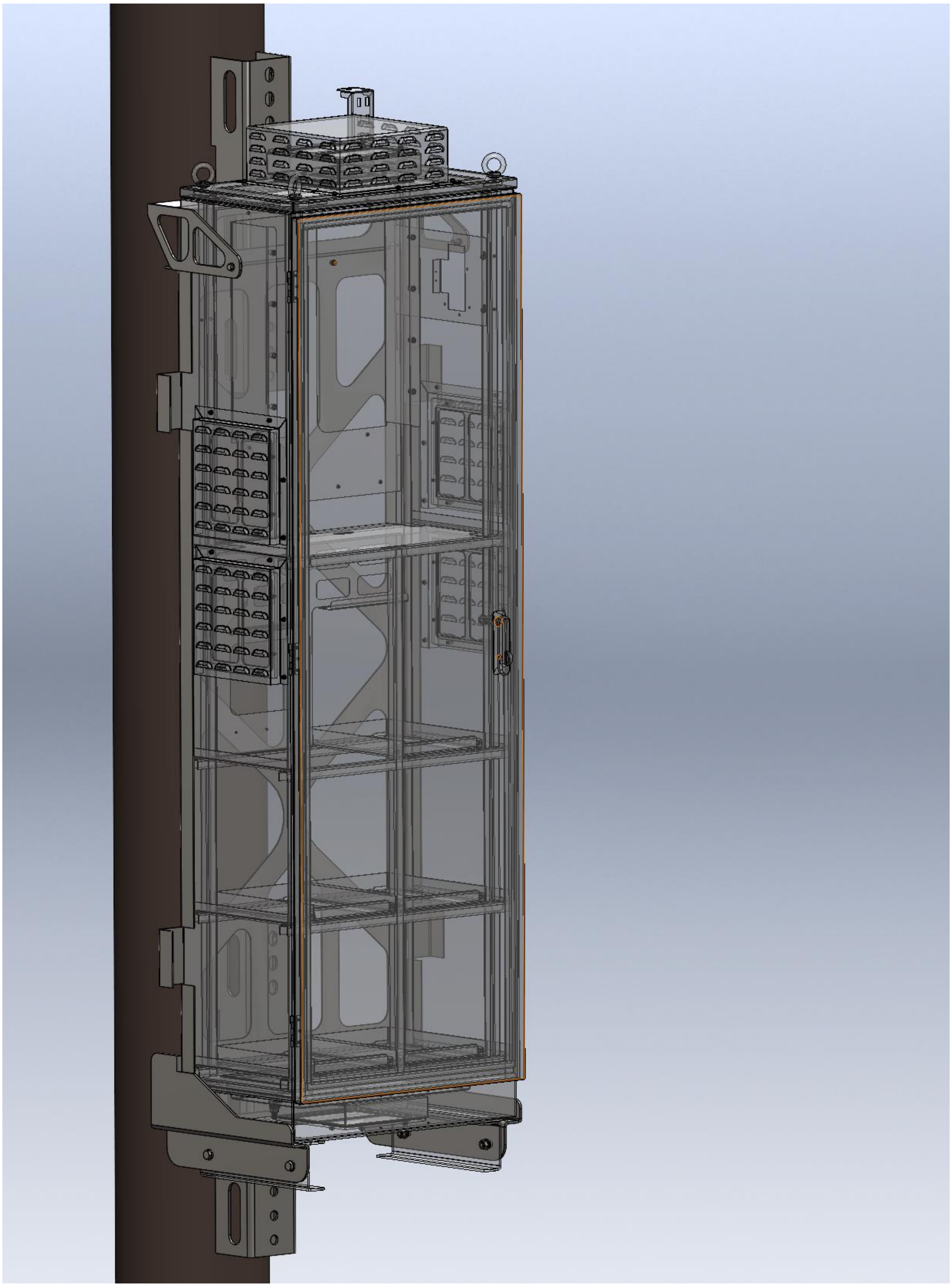

Figure 4: Pole mounting bracket with transparent main enclosure

Each phase of the EcoSTORE inverter unit is a 10kW battery inverter using the same Printed Circuit Boards and technology as the EcoVAR STATCOM being used by a number of DNSPs.

In addition the base electronics is common with our pad mount "rural" EcoSTORE.

Much of the electronic hardware and real time control software is common with the EcoVAR as shown in Fig. 5 which shows the Printed Circuit Board hierarchy. This means that much of the operation, control, mechanical design and so on has been well proven in the outdoor pole-mounted environment required.

For the EcoSTORE a DCDC converter is added to convert from the Battery voltage (~250V) to the DC Link voltage (~390V).

The enclosure is constructed from stainless steel and is powered coated a "surf mist" colour (the same colour as the EcoVAR). The inverter is essentially battery agnostic and has been tested with a number of different battery brands and chemistries, including Kokam NMC ($LiNiMnCoO_2$), Toshiba Lithium Titanate and even lead acid.

The current battery solution contains 5 series connected Kokam KBM255 1P14S 4.7kWh Lithium-ion battery modules along with a Kokam Battery Management System (BMS) (including fuses and contactors).

Two power cables (Battery Positive and Negative) and a CAT5/6 CAN Bus communications cable connect between the inverter and BMS.

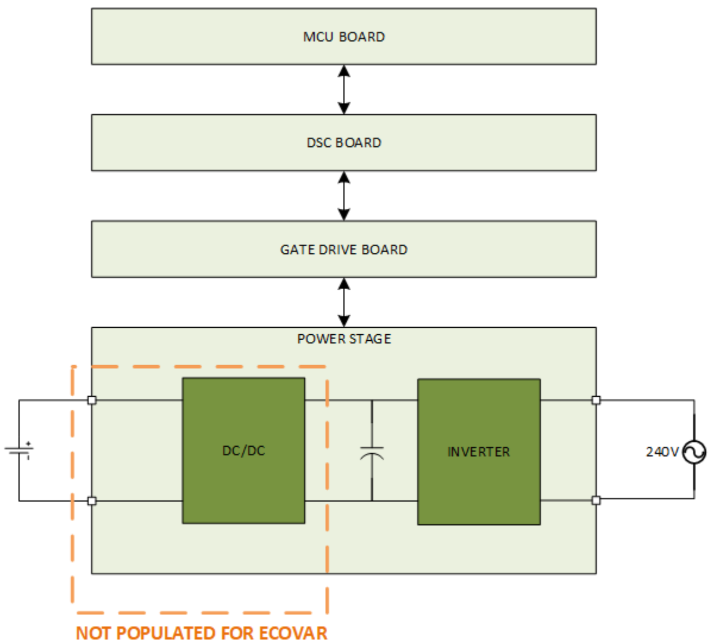

Figure 5: EcoSTORE and EcoVAR Printed Circuit Board Hierarchy

Installation sequence

The pole brackets are attached first to the pole using bolts through the wooden pole. They are mounted 120° apart (evenly) around the pole as shown in Fig. 5.

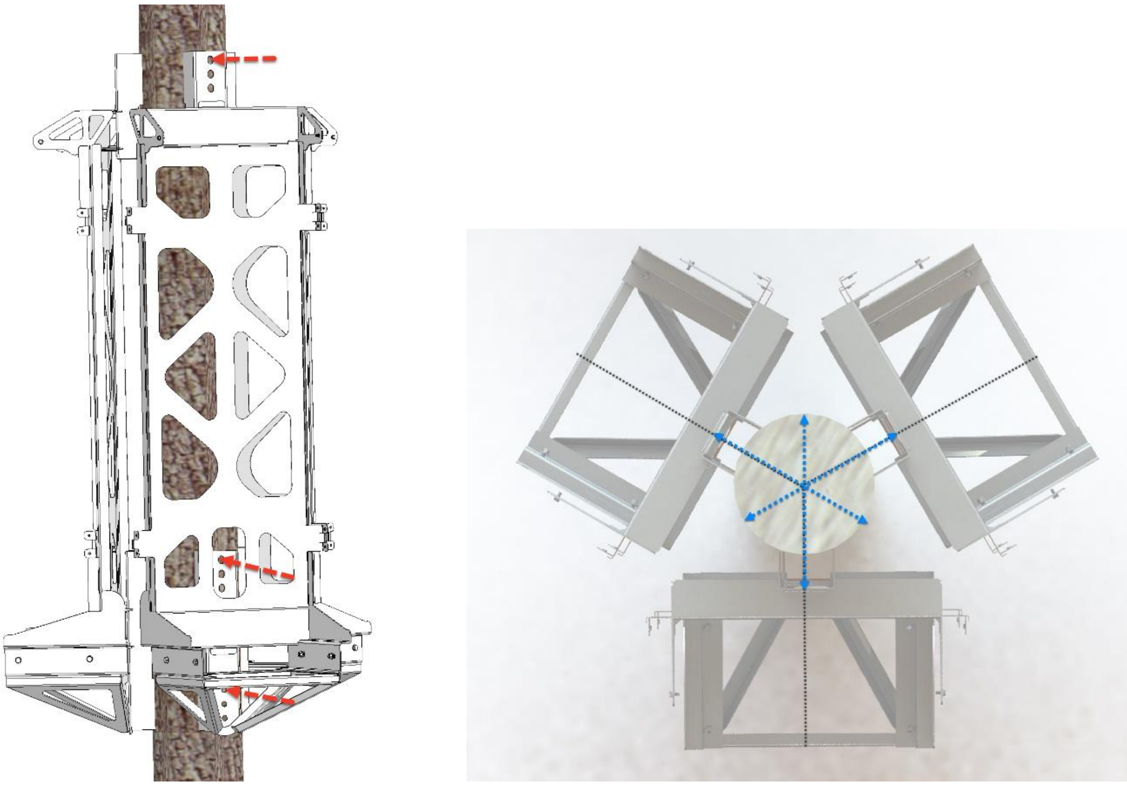

Figure 6: Installation step 1: Mount brackets onto pole

The main cabinets are then hoisted into position on the “landing” of the bracket (using the lifting eyes) by a crane and secured with four bolts on the base and two bolts on the top.

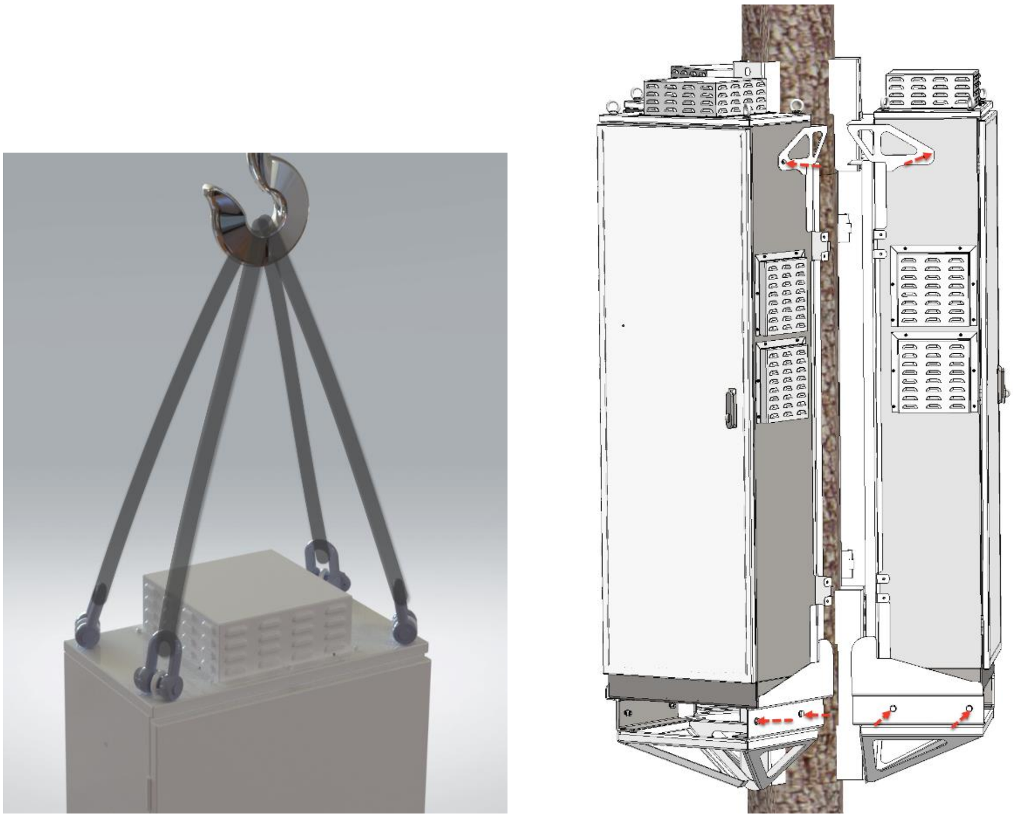

Figure 7: Installation step 2: Hoist main cabinet into position and secure with bolts

Each main cabinet (with batteries and inverter inside) weighs approximately 250kg, so is liftable with a light crane, with the overall system weighing around 850-900kg (including the brackets and sunshields). As can been seen, the mass is evenly distributed around the pole.

The sunshield is then placed over the enclosure and secured with screws. Fig. 8 shows the installation sequence.

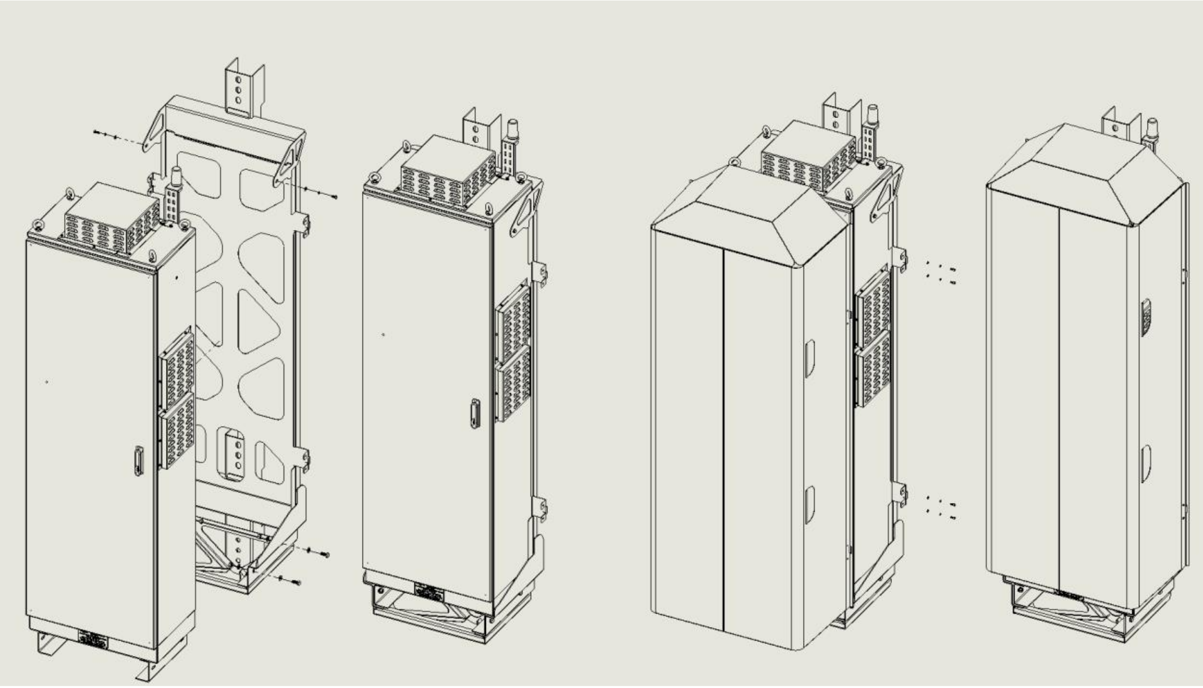

Figure 8: Installation sequence

Connection to mains

The EcoSTORE is connected in shunt (parallel) to the grid, so the connection wiring diagram can be identical to the EcoVAR.

EcoJoule recommends connection to the mains via 63A fuses and/or isolator or circuit breaker. This is to provide an easy means to isolate the unit. The units do have both passive and active anti-islanding protection, so automatically disconnect from the grid in the case of a power outage (using an internal disconnection switch). However, if there is work on the line EcoJoule recommends to isolate the unit using the circuit breaker or fuses to provide an additional level of security.

Each DNSP has its own preference as to the exact wiring configuration. Some use drop out fuses only, others use circuit breakers mounted in a small enclosure on the pole.

Electrically there is no need for an outage during installation. However the decision on this should be made considering the ability to safely mount the units with a crane without risking contacting the LV (or MV which may be located above the LV).

Servicing and removal of fans & filters

The EcoSTORE has been designed to minimise the need to open doors and access the inside of the enclosure. The only regular maintenance required is checking and cleaning of air filters. There are two fans, one on the top (for the inverter compartment) and one on the bottom (for the battery compartment) and 4 side filters.

Inspection and cleaning of the filters and potential replacement of the fans can be performed without opening the unit. The diagrams below show the removal process.

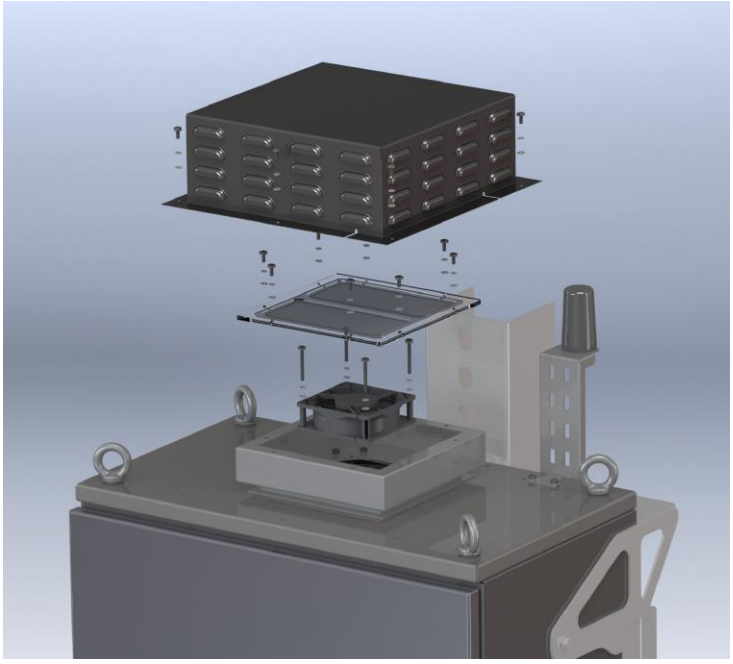

Figure 9: Top fan and filter removal

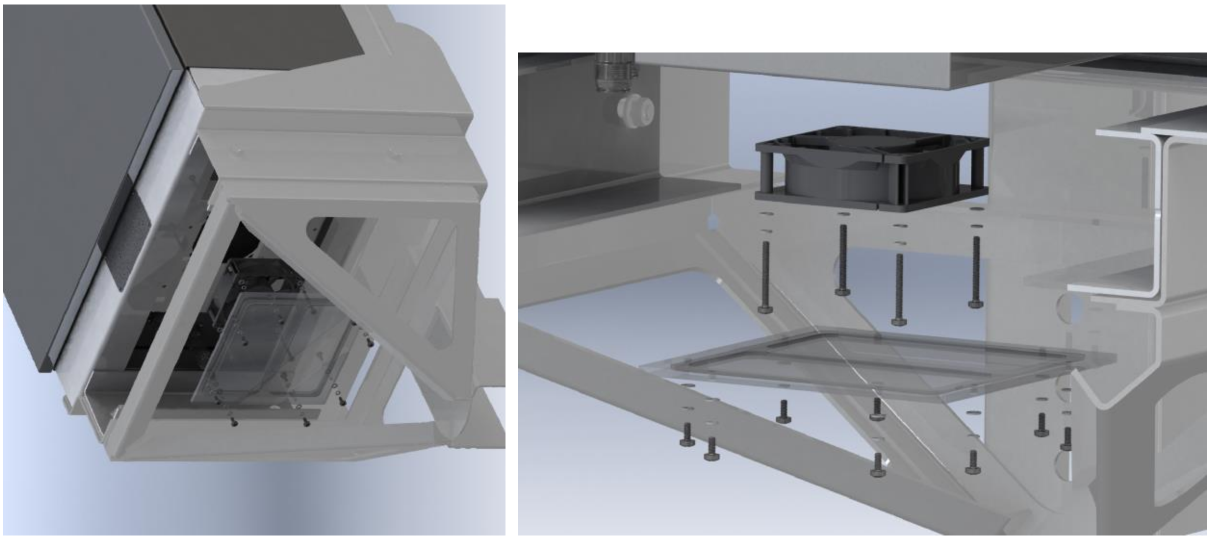

Figure 10: Bottom fan and filter removal

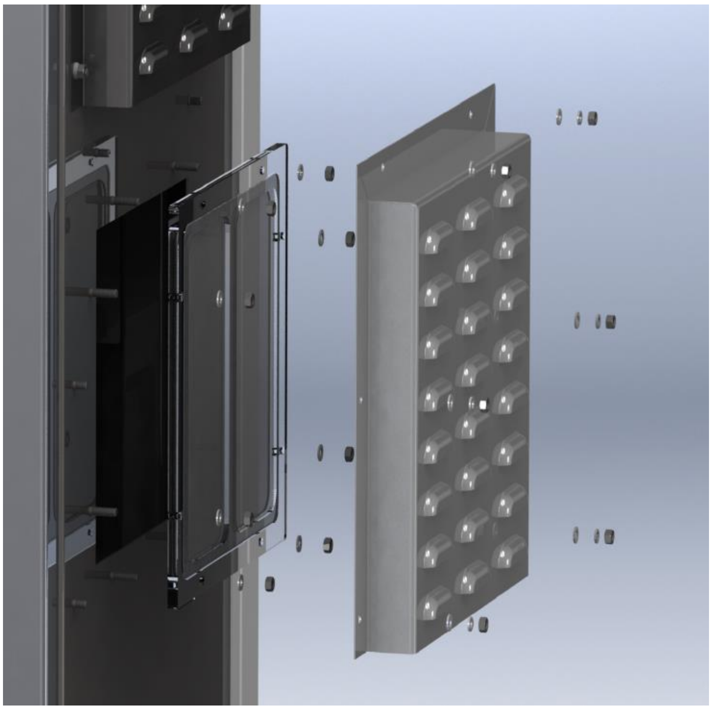

Figure 11: Side filter removal

Software

The EcoSTORE uses a similar code base to the EcoVAR with additional functionality added for the DC/DC converter control and battery and system management. Like the EcoVAR, the code can be updated Over The Air (OTA).

In addition the EcoSTORE supports the same modems & communications methodology as the EcoVAR and uses an extended version of the same EcoVIEW Engineering Access Software used for the EcoVAR.

The EcoVIEW software and its evolving fleet management variant**, cab be hosted on the utility internal network, or hosted externally on a server in Australia to avoid any potential security concerns**.

Advanced Grid Support (AGS) algorithm

Overview

EcoJoule Energy has developed an advanced grid support control algorithm specifically to address and overcome the challenges observed on Low Voltage networks.

Low voltage electrical networks with high levels of renewable generation can suffer from two main issues:

• Voltage issues. During the middle of the day solar output is generally high and load low resulting in overvoltages. Conversely in the evening solar output is low and load is high resulting in undervoltages. Voltage unbalance is another common problem experienced on low voltage 3 phase networks since it is often difficult to balance both load and solar generation across phases.

• Capacity issues: Grid infrastructure (transformers, lines) must be designed for peak loads even though these can occur for relatively infrequently. It can be expensive to upgrade infrastructure for these loads that occur infrequently.

BESS systems **if controlled correctly**, have the potential to solve both of the above issues. If controlled incorrectly they can worsen the issues.

An inherent control challenge on LV networks is that of low consumer numbers resulting in low load profile diversity and high variability from day to day as well as across phases. This load variability and uncertainty means that pre-programmed time scheduled injection and charging methodologies, although simple, are not robust and will result in incorrect control behaviour on certain days which can worsen issues.

The AGS algorithm has been specifically developed with grid control objectives and low diversity in mind in the context of Community Energy Storage where there are additional value streams for services such as FCAS, consumer solar energy storage, potentially energy arbitrage etc. It intelligently balances and optimises 5 different (and sometimes opposing) requirements:

1. The feeder voltage management, including the phase balance.
2. The feeder peak load reduction.
3. External charge/discharge signals from higher level controllers (e.g. For consumer energy storage, energy arbitrage etc).
4. Participation in FCAS markets based on local (decentralised) frequency measurements
5. The State of charge (SOC) of the batteries.

High level control objectives

The Advanced Grid Support algorithm has the following overall high level control objectives:

1. Injects and absorbs both real and reactive power in appropriate amounts and at appropriate times to optimally support the network voltage and to reduce voltage phase unbalance.
2. Injects real and reactive power during peak load periods to reduce the peak load on the feeder.
3. Manages the state of charge of the battery autonomously without affecting the grid support functionality.
4. Seamlessly integrates an external charge/discharge command from an external controller such as an ADMS or VPP system.
5. Allows participation in FCAS markets based on local (decentralised) frequency measurements.
6. Operates autonomously, not critically reliant on communications. Where communications and upstream information is available, it optimises its performance.

7. Works with multiple units, PV systems etc on the same network without any negative interactions.
8. Responds quickly to mitigate dynamic voltage effects from sudden load and/or PV output changes.
9. Supports the network effectively in the presence of low consumer numbers and high load variability.
10. Minimises conflict between these different objectives.

More details of the Advanced Grid Support (AGS) algorithm are available upon request.

Operational software and security

Ecojoule's Engineering Access and Fleet Management software can be located on a utility server on the utilities private network (or alternatively located on an external server guaranteed to be in Australia).

In addition, all software has been developed by EcoJoule (not outsourced) and is located in Australia.

These factors greatly minimises IT security risks and any potential concerns.

Continuous Development and working with our Customers

EcoJoule understands that Community Energy Storage is still in its infancy and requirements are likely to evolve over time. We understand that typically the scope of the high-level functionality of the system is not necessarily well defined at present:

- Which energy storage value streams are required (eg. community storage, Virtual Power Plant (VPP), peak load reduction, FCAS, voltage support etc).
- Which systems are to be interfaced with such as Retailer/Gentailer control systems, DNSP ADMS system, separate DERMS system, higher level wholesale market access systems eg. SwitchDin & Reposit and so on.

EcoJoule is committed to work with and support our customers to help accomplish the goals of the project as they evolve. Our Australian based R&D team will be available for the duration of the trial. While we do reserve the right to charge costs for any additional custom functionality requested during a trial we make this as economical as possible for customers and generally do not charge for features that are deemed of widespread applicability.

We consider our excellent locally available service one of our key strengths.

Draft Technical Specifications:

Specifications	Single Phase	Three Phase
Apparent Rating (per phase)	10kVA	30kVA
Reactive Power Rating (per phase)	-10kVAr to 10kVAr	-30kVAr to 30kVAr
Real Power Rating (per phase)	-10kW to 10kW	-30kW to 30kW
Ambient Temperature	-10°C to 50°C	
Operating AC Voltage Range	160 - 270 V	
Battery Nominal Voltage	204 Vdc	
Battery type	Lithium-ion NMC (LiNiMnCoO2)	
Battery cycle life (DoD 80% @ 23degC)	4,000	
Battery Communications	CAN, CAT5/6 cable between battery enclosure and Inverter enclosure	
Rated Battery Energy (Beginning of Life (BOL))	21.9kWh	65.7kWh
Cooling	Temperature controlled fans	
Power electronics Efficiency	~98% at full load	
Harmonics (THD)	<4% at full load	
External Communications	Ethernet, Modbus, Sunspec	
Modem support	Yes	
Anti-islanding	Passive and Active as per AS/NZS 4777	
On-Grid / Off-Grid	Yes (but not required in this application)	
Mechanical Protection	IP54	
Enclosure material	Powder coated stainless steel	
Approximate Weight: Battery Enclosure including batteries (per phase)	300kg	900kg