energy manager Installation and Operation Manual

Version 1.2

Model: EM4x energy manager

EM4x-01

EM4x-02

enatel energy

Warranty

Enatel Provides a one year limited warranty, details as stated under the manual section Appendix I Enatel Energy Standard Limited Warranty Policy on page 168.

Product Compliance

CE

RoHS

Release Date: 29 September 2021
Firmware compatibility: 8.0
Disclaimer: Enatel reserves the right to make changes to the information within this document without notice.

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1 ADMONISHMENTS

The admonishments are the symbols and wording used in this manual to alert readers to specific dangers and instructions. The meanings of the various admonishments are explained as follows:

Warning = risk to life or personal injury and equipment damage

Caution = risk of equipment damage.

 = risk of electrical shock potentially causing death or injury.

 = alert of risk potentially causing death or injury.

 = risk of burn injury from hot surfaces

 = an alert that must be understood and undertaken.

 = instruction of mandatory reading of product manual.

  = risk of electrostatic damage to components. Proper precautions must be taken.

 = restricted access area

 = access for children prohibited.

2 SAFETY

All installation and maintenance must be carried out by suitably qualified personnel.

For your protection, the product manual should be read and thoroughly understood before unpacking, installing and using the equipment.

The energy manager contains static sensitive components that require careful handling and proper precautions to be taken.

The equipment is intended only for use in a restricted access area. This equipment is not suitable for use in locations where children are likely to be present.

3 GLOSSARY

energy manager = an Enatel DC system controller.

EM4x = the model name of the energy manager.

NOTE: energy manager, EM4x and controller are used interchangeably within this manual.

SYNERGi = the Enatel hybrid platform incorporated into the energy manager.

I/O Board = the second I/O pcb mounted in the EM4x which provides the fundamental inputs and outputs of the energy manager. Additional I/O boards can be included in a system.

I/O Expansion Card = a legacy product of additional I/O that up to 4 can be added to any single I/O Board.

energyhub = an Enatel proprietary microCOMPACT DC system based on the EM4x controller platform.

energypak = the Enatel model name for the Enatel proprietary lithium battery pack that is integral to the energyhub.

BMS = Battery management system. The electronics built into a battery module, that controls the battery behaviour.

SoC = State of Charge. A percentage figure that designates the relative amount of energy stored in a battery in reference to its maximum capacity.

SoH = State of Health. A percentage figure that represents the current battery capacity as a percentage of its maximum optimum capacity.

DoD = Depth of Discharge. A percentage figure that indicates the amount of energy discharged from a battery during use relative to it being 'fully charged' (100% SoC). Note the energyhub is designed to never discharge completely to 0 and in many applications the recommended maximum discharge level to assist battery life is <50%.

C *Rate*: The C-rate is a measure of the rate at which a battery is being discharged. It is defined as the discharge current divided by the theoretical current draw under which the battery would deliver its nominal rated capacity in one hour. A 1C discharge rate would deliver the battery's rated capacity in 1 hour. A 2C discharge rate means it will discharge twice as fast (30 minutes). A 1C discharge rate on a 1.6 Ah battery means a discharge current of 1.6 A. A 2C rate would mean a discharge current of 3.2 A.

.xml: is a file type used to describe data (Extensible Markup Language). This file type can be opened in an Excel spreadsheet.

4 RECEIVING INSTRUCTIONS

Enatel provides all equipment to the delivering carrier securely packed and in perfect condition. Upon acceptance of the package from Enatel, the delivering carrier assumes responsibility for its safe arrival. Once the equipment is received, it is the recipient's responsibility to document any damage the carrier may have inflicted, and to file the claim promptly and accurately.

NOTE: the period to make a claim against damage by a transport carrier can be short, a matter of days, and varies by transport method, the transport contract, and local laws.

4.1 Package Inspection

Examine the shipping crate or carton for any visible damage: punctures, dents and any other signs of possible internal damage.

Describe any damage or shortage on the receiving documents and have the carrier sign their full name.

4.2 Equipment Inspection

Open the crate or carton and inspect the contents for damages. While unpacking, be careful not to discard any equipment, parts or manuals. If any damage is detected, call the delivering carrier to determine the appropriate action. They may require an inspection.

NOTE: Save all the shipping materials for the inspector to see.

After the inspection has been made, if damage has been found, contact Enatel. We will determine if the equipment should be returned to our plant for repair or if some other method would be more expeditious. If it is determined that the equipment should be returned to us, ask the delivering carrier to send the packages back at the delivering carrier's expense.

If repair is necessary, we will invoice you for the repair so that you may submit the bill to the delivering carrier with your claim forms.

It is your responsibility to file a claim with the delivering carrier. Failure to properly file a claim for shipping damages may void warranty service for any physical damages later reported for repair.

4.3 Handling

Handle the equipment with care. Do not drop. Keep away from moisture.

4.4 Identification Labels

Model number and serial number are clearly marked on all equipment. Please refer to these numbers in all correspondence with Enatel. Ideally provide a photograph of the product label for reference.

5 SCOPE

This manual covers essential information for the installing, commissioning and operation of the Enatel energy manager (EM4x). The manual covers both the EM4x-01 touchscreen and EM4x-02 keypad versions of the energy manager.

For specific applications of Enatel's DC systems that may fall outside of this scope please reference the Application Notes in the Enatel partner portal at www.enatel.net.

6 FEATURES

The EM4x microcontroller-based DC system supervisory module provides the control and monitoring functions for all of Enatel Energy's power systems. These include Enatel's energypak batteries, RM series rectifiers, CM series DC/DC converters along with solar/wind converter modules and inverters. Lead-acid batteries are managed natively from the EM4x controller. More advanced battery monitoring with individual monobloc voltage and string current measurement can be attained with Enatel's ancillary BMS boards. With an appropriate communications connection third party lithium batteries and other Modbus enabled devices can also be managed.

The EM4x monitors all power system conditions including DC voltage, rectifier current, battery current, battery temperature, distribution failure and energypak status. It has an in-built web based configurator allowing setup of system parameters, monitoring, updating and download of logs using a web browser as well as a front panel interface through which key parameters are also configurable. Visual notification of alarm conditions is given by

LEDs and a display mounted on the front of the EM4x, with remote notification being enabled by relay contacts, RS232 or TCP/IP (using SNMP).
The EM4x utilizes a USB communications port which allows for local monitoring of system operations as well as pre-commission and power down configuration of the Web UI.

The EM4x also incorporates the following features:

- Support for Enatel's energypak battery modules with optimized battery backup functions
- Support for third-party external batteries, both lead-acid and lithium based
- Support for AC-DC rectifiers (24V, 48V, 60V, 110V Outputs)
- Support for DC-DC converters (12V, 24V, 48V and 60V Outputs)
- Support for Enatel's range of solar and wind converter modules plus associated inverters
- Support for Enatel's range of ancillary devices including fan controllers, AC metering and battery monitors
- Control of up to two low voltage disconnects (magnetically-latched contactors) per I/O board*
- Network connectivity (web access)
- System voltage metering for primary system DC supply. (e.g. 48V primary DC output)
- Load, battery and rectifier current metering and alarms
- Active rectifier and converter current share
- Automatic system voltage control
- Effectively unlimited alarm thresholds as standard, for use with multiple DC outputs
- Advanced monitoring, display and logging of energypaks, and system performance data
- Advanced hybrid site control and monitoring with patented anti-stall feature for generators.
- Phase balance controls for multi-phase and single phase AC input management
- Sophisticated programmable logic control
- Grid tariff optimization – the ability to program schedules for battery assumption of load during peak grid tariff rates
- For lead-acid external batteries -
    - Battery and room temperature metering and alarms (when fitted with optional temperature sensors)
    - Optional complete or battery mid-point monitoring (when fitted with optional battery monitor cards)
    - Temperature compensation of float voltage (when fitted with optional temperature sensors)
    - Manual equalise charging to prolong the life of the batteries
    - Periodic equalise charging to prolong the life of the batteries
    - Fast charging after battery discharge
    - Battery capacity remaining indication
    - Battery testing facility
    - Battery current limit
- Six user defined General Purpose Inputs ("GPIPs") which can be software configured as either digital or analogue inputs* (up to 10 may be made available under special circumstances)
- Six relay outputs*
- I/O Expansion card capability*
- Expanded serial and CAN communications – up to 5 I/O boards can be connected to a single EM4x

*** Note:** the addition of an I/O Expansion card to the EM4x allows for analogue inputs and increases the number of digital inputs and relay outputs available. The controller allows for these new inputs/outputs to be logically combined allowing a degree of control of peripheral functions. For example, a temperature triggered room fan or humidity detection.
See Figure 9 for the EM4x architecture diagram.

7 SPECIFICATIONS

Operating supply voltage:	18V to 80V
Operating ambient temperature range:	-20°C to 70°C

Storage ambient temperature range:	-25°C to 80°C
Relative humidity range:	5% to 95%
Altitude:	less than 3500m

7.1 Protocols Supported

- IPv4
- 10/100 Base TX
- SNMP V2/V3
- Modbus
    - Modbus TCP master and server
    - Modbus RTU master and server
- USB 2.0

8 DEFINITION

The energy manager EM4x is offered in two variants.

Model Number: EM4x-01 a "large display" module with a 4¼" (108mm) LCD touch screen interface, typically fitted on a 3U DC system fold-down front panel, or pull-out drawer mounted.

Model Number: EM4x-02 a 1U "tray mount" inserted module with a 2.5" (67mm) LCD screen with a keypad interface.

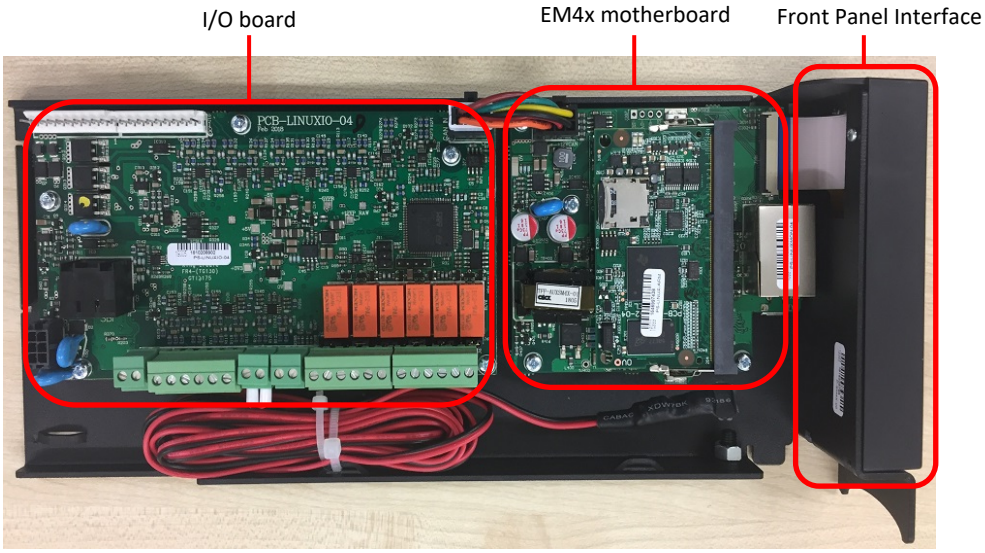
Both variants offer the same functions.

The energy manager EM4x consists of three main components:

1. A front panel with user interface
2. The EM4x motherboard
3. An I/O board

NOTE: multiple I/O boards can be daisy chained via the CAN connector, however the default definition of the energy manager is one EM4x motherboard plus one I/O board as shown in Figure 1.

Figure 1: 1U Energy Manager EM4x-02 Definition (pcb cover removed)



9 INTERFACE

9.1 Energy Manager 3U EM4x-01 Interface

Figure 2: 3U EM4x-01 Front Panel Interface

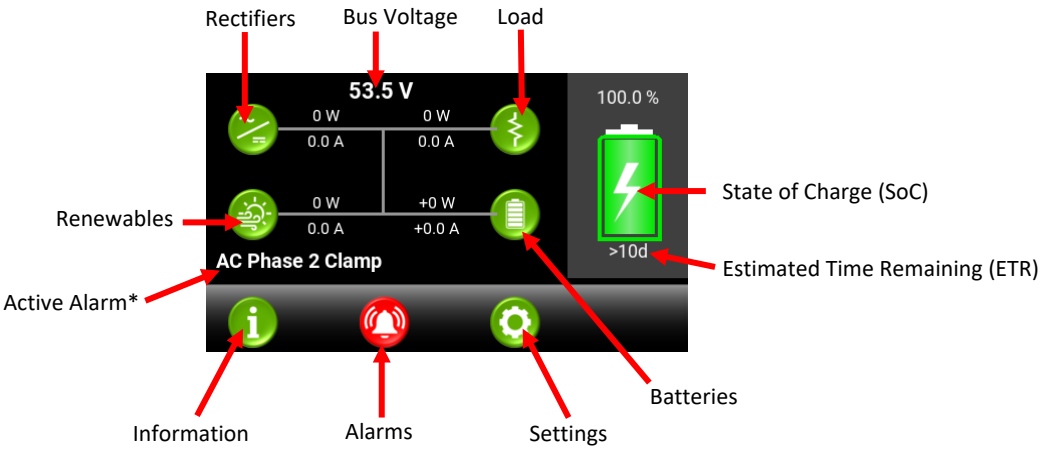
9.1.1 Alarms and Status Indicators

- Status LEDs:
  - Red LED Urgent alarm state.
  - Orange LED Non-Urgent alarm
  - Green LED DC power is connected to the unit; energy manager is functioning

  NOTE: The red and orange LED mapping can be user modified.
- The energy manager is fitted with an audible buzzer which can be configured to alert to any alarm depending on the alarm mapping.
  NOTE: To disable the buzzer when active, tap the screen.
- Micro-USB Connector: can independently power the EM4x and provides access to the Web UI

9.1.2 Energy Manager 3U Touchscreen

Figure 3: energy manager 3U Touchscreen



*NOTE: when there are multiple alarms raised the Active Alarm display cycles through the list. The complete list can be viewed by tapping Alarms.

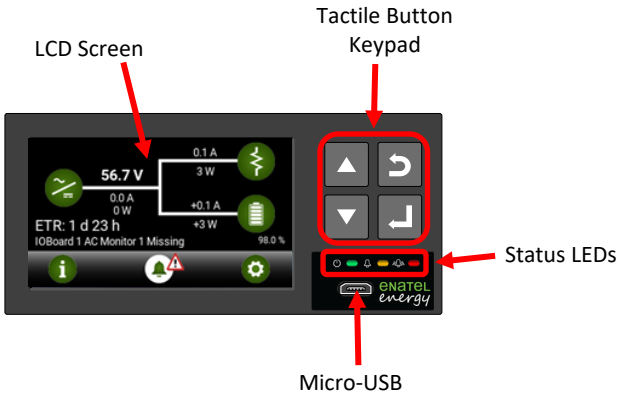
Tap the touchscreen to navigate through the menus.

See 12.3 3U Touchscreen Menu Navigation for further information.

NOTE: the EM4x-01 has the option to PIN lock function change through the front screen interface. See 11.4.5 PIN Locking the EM4x-01 for details.

9.2 1U EM4x-02 Interface

Figure 4: 1U EM4x-02 Front Panel Interface



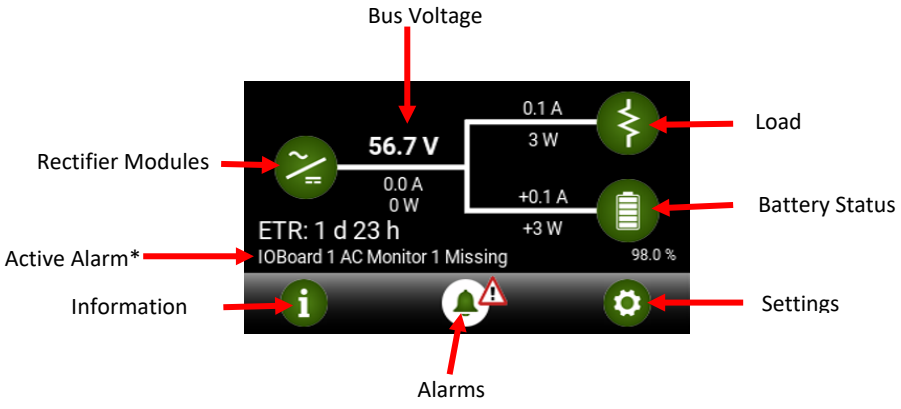
- Keypad tactile buttons to navigate through the menu. Local adjustments to operating parameters and alarm functions can be made using the menu options.
- Status LEDs:
  - Red LED Urgent alarm state.
  - Orange LED Non-Urgent alarm
  - Green LED DC power is connected to the unit; energy manager is functioning

  NOTE: The red and orange LED mapping can be user modified.
- The energy manager is fitted with an audible buzzer which can be configured to alert to any alarm depending on the alarm mapping.
  NOTE: To disable the buzzer when active, press any key.
- Micro-USB Connector: can independently power the EM4x and provides access to the Web UI

9.2.1 Energy Manager 1U Front LCD

The energy manager front LCD menus are simple and intuitive to browse. The front screen description is as follows:

Figure 5: energy manager 1U LCD Screen



*NOTE: when there are multiple alarms raised the Active Alarm display cycles through the list. The complete list can be viewed in the Alarms menu.

NOTE: ETR = Expected Time Remaining which is the estimated back-up time in days (d) and hours (h) of the batteries given their state of charge and the active load.

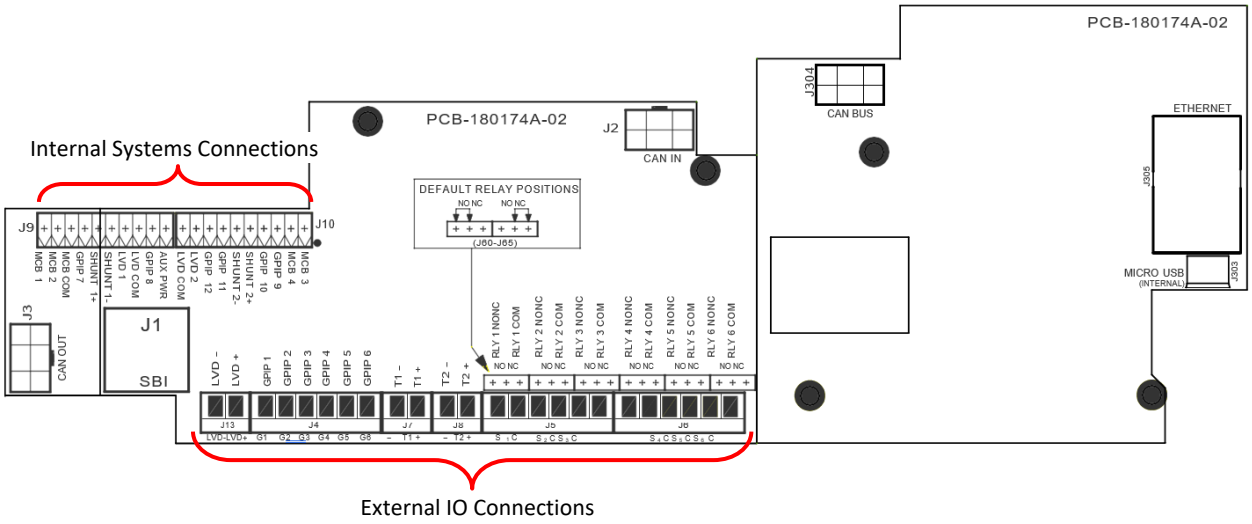
Use the keypad to navigate through the menus.

Up	
Down	
Go back	
Enter	

See 12 Using the EM4x Controller Front Panel Interface for further information.

10 CONNECTIVITY

Figure 6: EM4x Connectivity



10.1 Energy Manager Connectivity and the Web UI

The energy manager is configured via a web browser-based user interface (Web UI). There are two methods to access the Web UI:

1. Ethernet connection from the J305 ethernet connector
2. Front panel micro-USB local connection

10.1.1 Access Levels

There are 3 access levels for the energy manager Web UI:

enaguest : can only view status of system

enabasic : reduced privilege, can view settings and system status

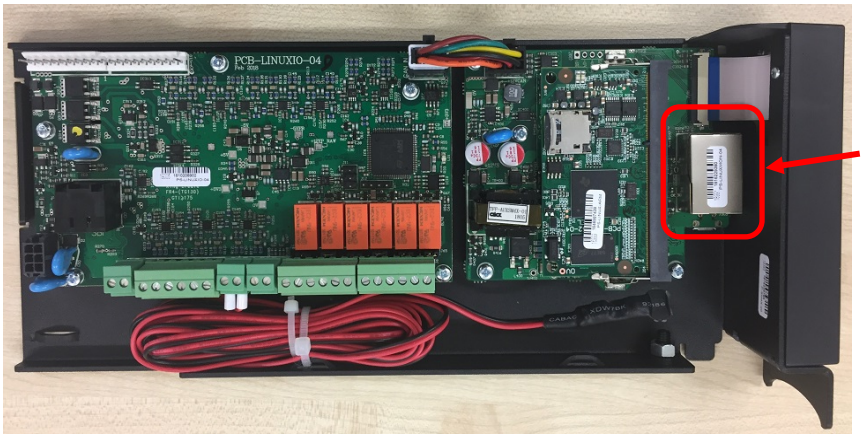
enaadvanced : this user has normal full control access of the system

The default password for all levels = **ena123**

10.1.2 Ethernet Port Connection

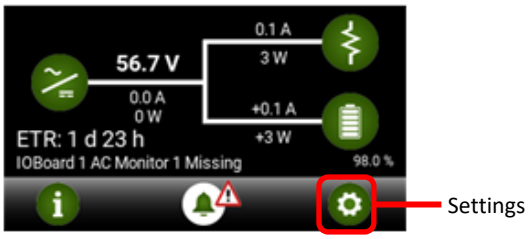
The energy manager contains static sensitive components that require careful handling and proper precautions to be taken.

Figure 7: 1U energy manager Ethernet Port (pcb cover removed)



1. Connect the communicating device to the J305 Ethernet port inside the energy manager.
2. Open an internet browser such as Edge, Chrome, Firefox or similar on the device.
3. Enter the Ethernet default IP address into the internet browser:

NOTE: the energy manager IP address can be located from the front panel LCD menu under: Settings>Networking>Ethernet.



4. The energy manager log in page appears.

5. Enter the user name and password. See 10.1.1 Access Levels.

10.1.3 USB Connection

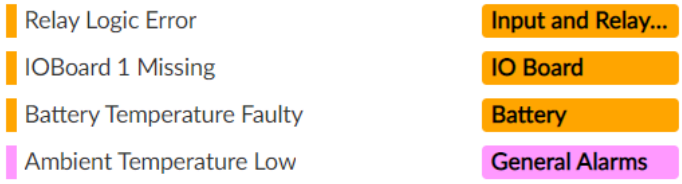
1. Connect the communicating device to the micro-USB port on the front of the energy manager. See Figure 4.
   A driver installation prompt appears.

2. Double-click the appropriate USB driver (32bit or 64 bit).
3. Follow the installation wizard instructions to install the driver.
4. Open an internet browser such as Edge, Chrome, Firefox or similar.
5. Enter the USB default IP address into the internet browser: **172.31.250.1**
6. The energy manager log in page appears.

7. Enter the username and password. See 10.1.1 Access Levels.

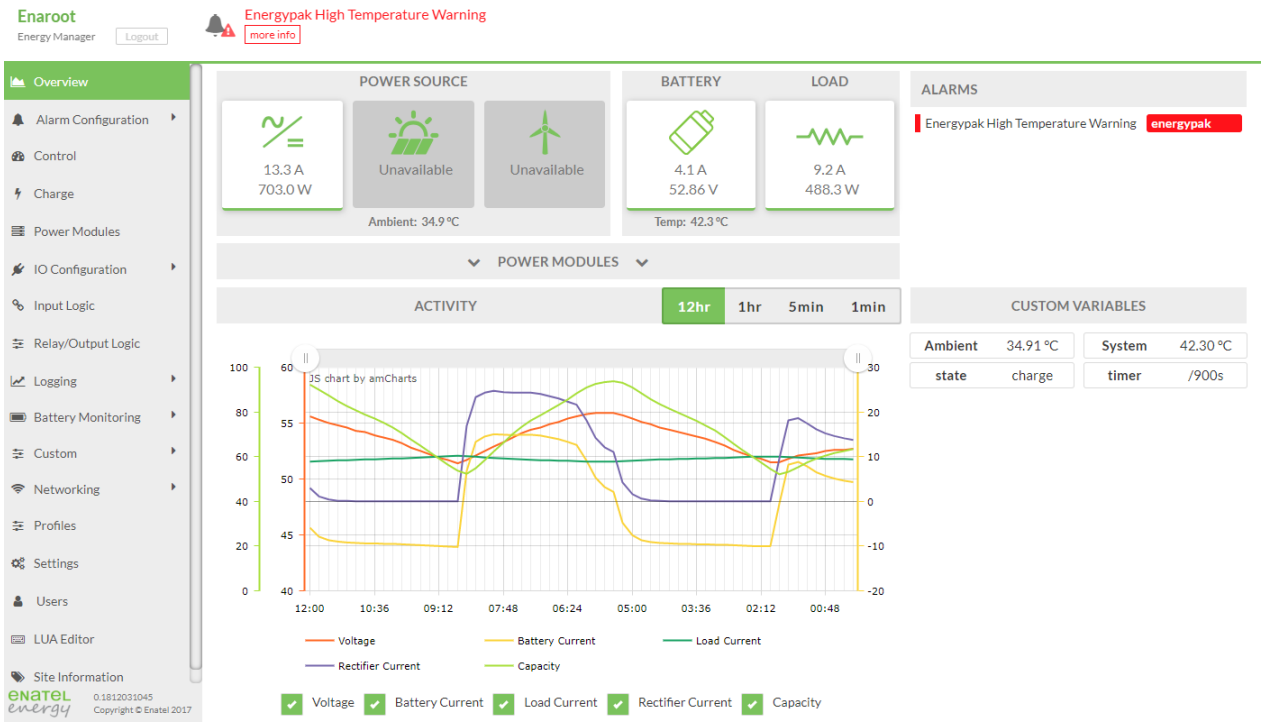
NOTE: USB connection to the energy manager is possible without AC, battery or other external power supply. The EM4x operates drawing power through the USB port. However USB supply does not power the IO Board. In this scenario there is a set of alarms that display depending on the system configuration relating to the non-operation of the IO board.

For example:



10.1.4 energy manager Web UI

Figure 8: Web UI Overview Page



The energy manager Web UI has a wide range of functions and features. Some of which are access level dependent while others are license locked. For further information please refer to the energy manager manual or your Enatel sales representative.

10.2 Terminations to the EM4x

10.2.1 Communications Bus

SBI (J1)

Explanatory Note

The EM4x can communicate over two serial busses to various peripheral devices (I/O cards, rectifier modules etc.). Please refer to the diagram in Figure 9 below.

The first, "SBI" bus is Enatel's proprietary single-wire "**S**erial **B**us **I**nterface". It is a robust, easy to deploy communications system proven to be resilient in noisy environments. The SBI comm's bus is the primary interface to Enatel's rectifier and converter modules. It was used exclusively in Enatel's SM3x range of system controllers.

The EM4x adds a CAN bus interface as well as the SBI. CAN bus makes an EM4x solution even more scalable than the SM3x controller. This gives customers/users the ability to create monitoring solutions that are virtually limitless.

NOTE: Do not confuse communications buses with DC buses. When DC buses are referenced, they are the main power buses, being usually (nominally) 48V, 24V, 12V, 60V etc. It is possible for modules on two DC power buses to communicate to the EM4x on a single communications bus.

SBI (J1)

RJ45 Connection between EM4x controller and the power system.

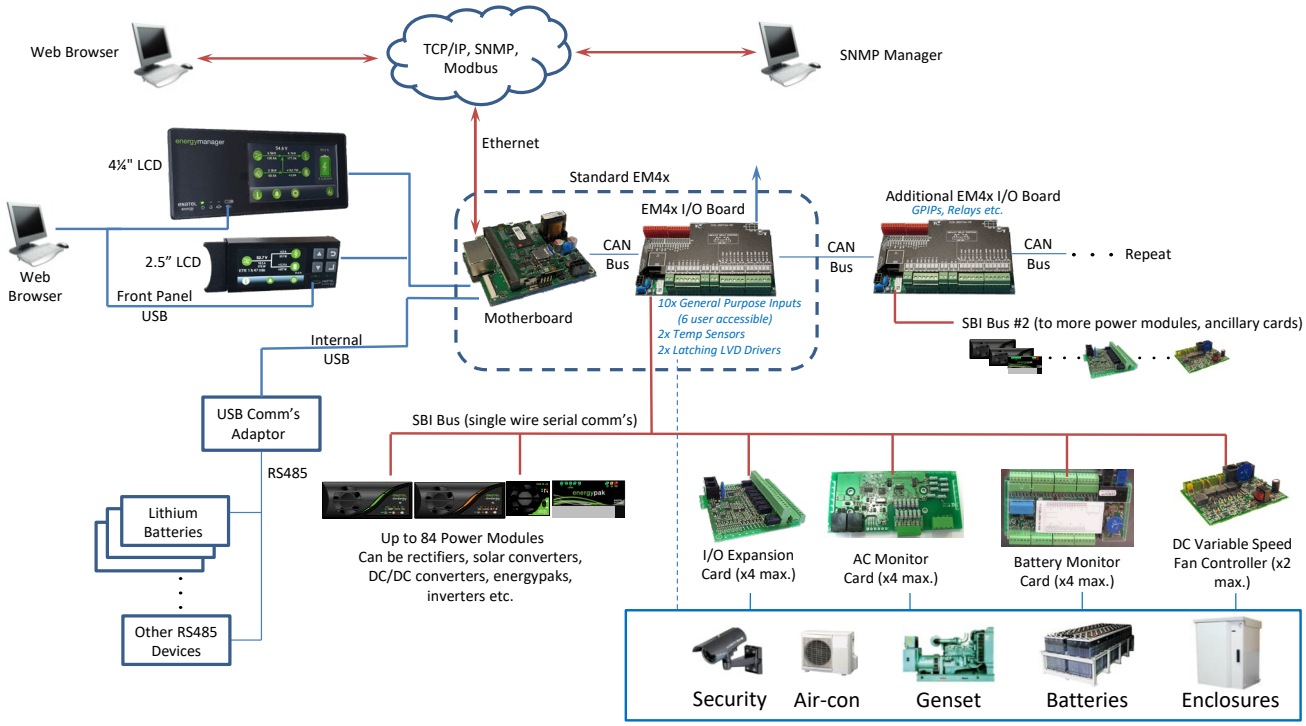
This connection provides voltage (power) supply to the EM4x as well as enabling communication between the controller and the power modules. The rectifiers/modules communicating on this bus are referred to as being on "Bus 1" (which relates to references such as "Bus 1 Volts", and Bus 1 voltage alarms). Bus 1 is used to communicate with the first 84 rectifiers (or modules) in the system.

Bus voltage can be measured through this connection by jumper setting on the power module backplane (see appropriate backplane manual for details).

CAN OUT (J3)

CAN connection between the EM4x controller and the power system and/or peripherals. Note that nominal 12V power is fed down the CAN bus to power peripheral devices.
This connection enables communication between the controller and multiple additional IO boards. Each individual IO board connects to other sets of power modules or peripheral devices.
NOTE: for implementation of CAN communication external to the DC system please consult your Enatel sales representative.

Figure 9: EM4x Communications & Peripheral Card Architecture



10.2.2 Internal Systems Connections

J9

10 way MTA connector for internal signals connecting to the power system.
This connector provides for most standard connections between the power system and the EM4x controller such as primary LVD control.

J10

10 way MTA connector for internal signals connecting to the power system.
This connection provides the connection for more advanced connections between the power system and the EM4x controller, such as secondary current shunt inputs & an extra LVD control.

10.2.3 External I/O Connection

GPIP 1-6 (J4)

6 way Minicobicon connector for external general purpose input signals to the EM4x providing six customer dedicated inputs.

TS1 (J7)

2 way Minicobicon connector for signal from the primary temperature sensor to the EM4x (usually configured as the Battery Temperature Sensor).

TS2 (J8)

2 way Minicobicon connector for signal from the secondary temperature sensor to the EM4x (if fitted, this is usually configured as the "Room" or "Ambient" Temperature Sensor).

Relay 1-3 (J5)

6 way Minicobicon connector for external volts free relay signals from the EM4x providing 3 of the 6 customer dedicated outputs.

Relay 4-6 (J6)

6 way Minicobicon connector for external volts free relay signals from the EM4x providing 3 of the 6 customer dedicated outputs.

10.2.4 Supply Voltage

The EM4x Controllers may be used in systems with nominal voltages 12V (secondary voltage only), 24V, 48V or 60V. A controller can operate with input supply from 18V to 75V. It is not necessary to make physical adjustments to a controller when used in different voltage systems. It will, however, be necessary to alter the configuration parameters to suit the system voltage by loading a suitable configuration file.

Note that while the EM4x supply voltage is from 18V to 80V, all of the internal electronics is referenced to the negative supply. That is, all of the current and voltage sensor input operational amplifiers are referenced to the –ve rail, which in a normal -48V telecommunications system (which is +ve earth), is actually the System live bus.

10.2.5 energy manager Communications

A controller communicates to rectifiers, converters, and auxiliary system modules using serial communications over RJ45 patch cables (this is the SBI – see 10.2.1 Communications Bus above). It communicates to additional EM4x IO Cards by CAN bus. The controller has two separate communication connections: a Serial Bus (SBI) connector (BUS1) which is connector J1 (RJ45 connector) and a CAN Bus Out which is connector J3. In smaller system all serial communications are generally done using the SBI only. However, in larger systems the capacity of the serial bus may be exceeded and additional IO boards require daisy chaining with the EM4x.

The capacity of the SBI bus on each EM4x I/O board is as follows:

- 84 combined HE Rectifier Modules, and DC-DC Converters
- 4 AC Metering Modules (ACM)
- 4 Battery Condition Monitors (BCM)
- 4 IO Expansion cards
- 2 DC Fan controllers

SBI Bus RJ45 Connector Pin Out

The pin allocation on the SBI Bus RJ45 is as follows:

Pin 1 V- Power

Pin 2 V+ Power

Pin 3 Rectifier Serial Bus

Pin 4 Not Assigned

Pin 5 Voltage Sense - (See 10.2.6 Voltage Sense)

Pin 6 Voltage Sense + (See 10.2.6 Voltage Sense)

Pin 7 V+ Power

Pin 8 V- Power

NOTE: When an EM4x is used outside a rack it must be powered through V+ and V- Power (Pins 1 and 2 or Pins 7 and 8) to the Primary Serial Bus connector (J101). The connected cable should be divided from the RJ45 connector to separate wires.

NOTE: Voltage sense requires 4K7 resistors fitted in series in both + and – lead, to protect the monitor, cable and maintain calibration.

NOTE: either a T568A or T568B ethernet cable can be used for the SBI bus. DO NOT use a cross-over ethernet cable.

10.2.6 Voltage Sense

The Serial Bus connector allows for sense voltage (VS1) to come directly from the rectifier and shelves via the RJ45 connection. Sensing directly from the shelf via the Serial Bus Connector requires jumpers to be fitted on the shelf backplane, no other external hardware is required (See the Rectifier Shelf Manual).

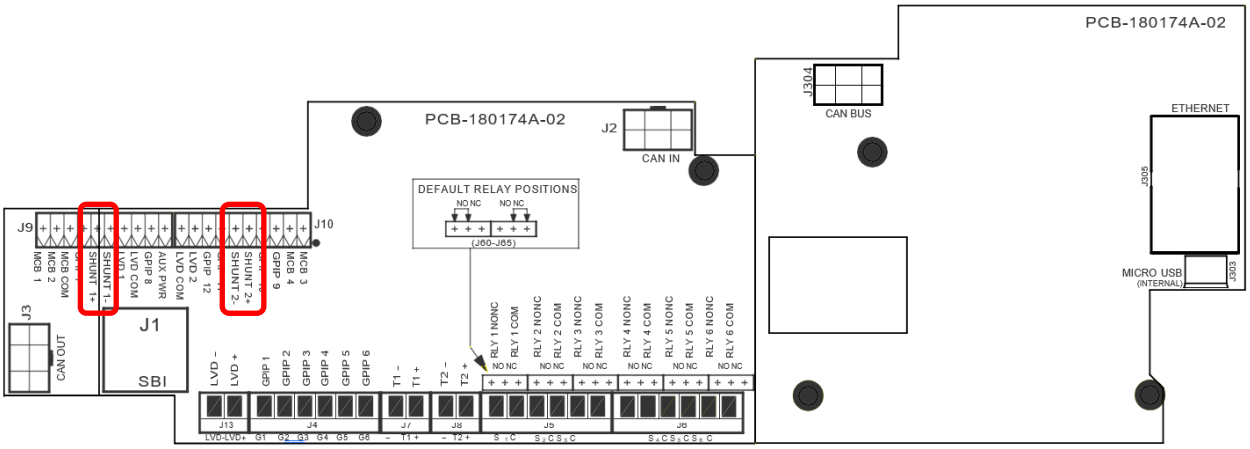
Note that in larger systems it may be desirable to sense the System Bus Voltage at the point where the battery is connected to the rectifier/load bus. This will keep the voltage on the battery more constant (during battery float charge) as the load varies. In this case the voltage sense wires will need to be "broken out" of the RJ45 control loom. The specific system schematic for that application will show this.

10.2.7 Current Measurements

The EM4x controller has two current inputs (SHNT 1 and SHNT 2), each configured to take a bipolar input within the range ±55mV which is adjustable in the Web UI. See IO Configuration>IO Boards>Shunt Controls.

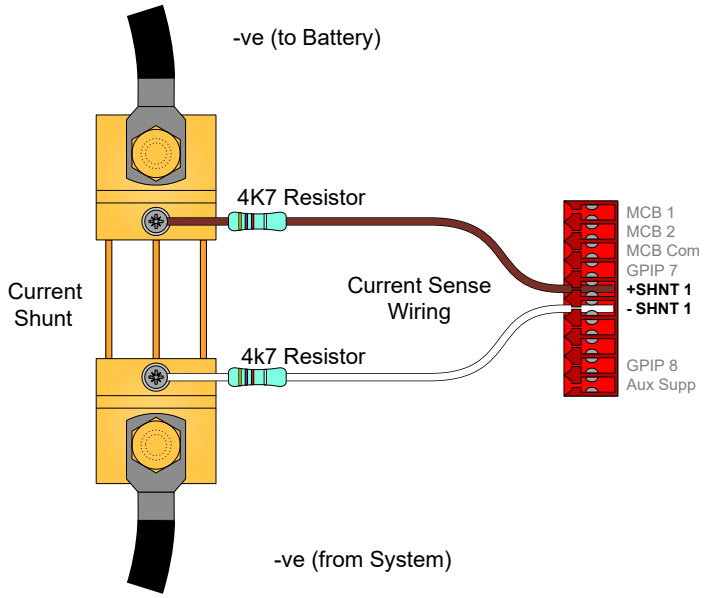
These input connections are available on the Internal Systems Connectors, J9 and J10.

Figure 10: EM4x Shunt Input Connectors



The current sensors must be placed in the negative of the DC system. When the current sensors are wired to a controller, a 4k7 resistor should be placed in series with each sense wire at source. The main reason for this is to protect the sense wire, however, it also provides the required input resistance to a controller to maintain the calibration. Current shunts are available from Enatel which already have these resistors fitted.

Figure 11: Connection of a shunt to the controller



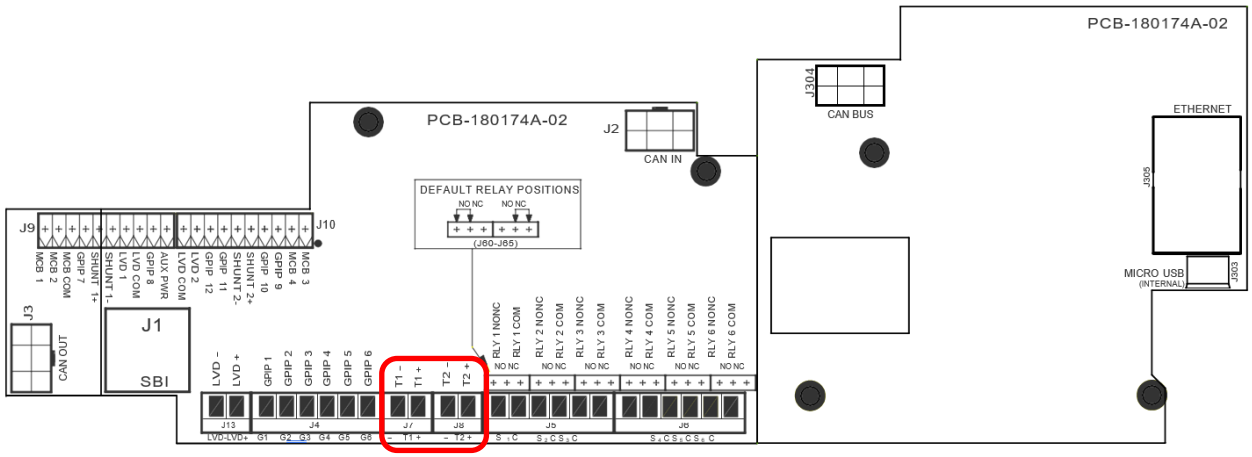
10.2.8 Temperature Sensor (Optional)

WLA-TEMPEM4X-03 Calibrated Temperature sensor cable assembly (length 3 metre)

WLA-TEMPEM4X-07 Calibrated Temperature sensor cable assembly (length 7 metre)

When connecting the temperature sensor to the controller, the trace wire should be connected to the -ve terminal and the non-trace wire to terminal TS1 (or TS2) on connector J100 (or J110).

Figure 12: EM4x Temperature Sense Inputs



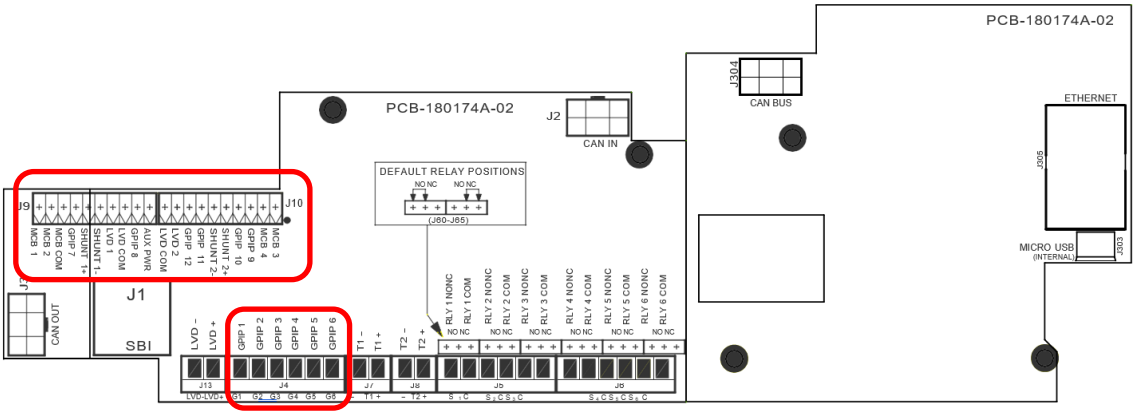
The temperature sensors can be configured to measure any temperature, however TS1 is normally designated as Battery Temperature. It should be placed in a position that represents the ambient battery temperature and is required for temperature compensation of float voltage.

TS2 is normally designated as Ambient (or room) Temperature.

10.2.9 General Purpose Inputs

General Purpose Inputs (GPIPs) may be configured as either digital or analogue inputs. There is a total of 12 GPIPs on the EM4x I/O card (the number available for customer usage depends on specific system configuration). Connections are to be made to the corresponding terminal on connector J4 (1.5mm^2 plug-in Combicon connectors). Configuring the inputs as analogue or digital is done from the Input Logic of the Web UI.

Figure 13: EM4x General Purpose Inputs



When used as digital inputs, the GPIPs are normally activated by connecting the system positive (usually system common) to the input. With a simple configuration modification in the Web UI Input Logic page the GPIPs can be activated by connecting to negative.

These inputs may be assigned to contribute to alarm states within a controller. This state mapping is defined in the Web UI configuration file.

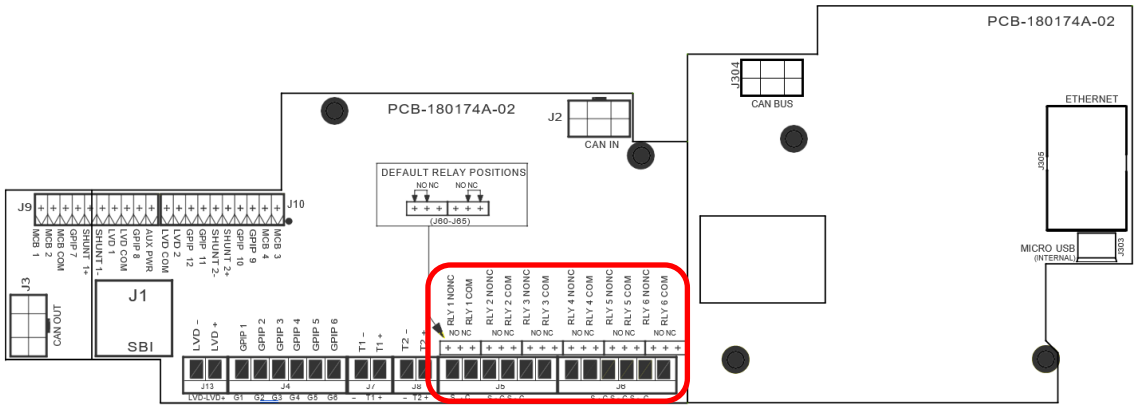
When used as an analogue input, the range is from 0V to 70V, where 0V is referenced to the system negative.

10.2.10 Relays 1 to 6

Each EM4x I/O card has 6 relay outputs for remote indication of alarms or control (if more relay outputs are required, further IO boards can be fitted). The function of each relay is defined in the configuration file.

Connections to the relays are available on connectors J5 (relay 1-3) and J6 (relay 4-6) of the controller with one pair of voltage free contacts for each relay. Each relay output has a common (C) connection and switched (S) connection.

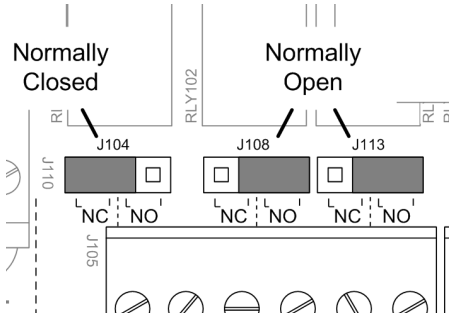
Figure 14: EM4x User Relay Outputs



The output state of each relay is dependent on the selection of the jumper corresponding to each relay. For Normally Closed contacts the jumper must be in the NC position, for Normally Open contacts the jumper must be in the NO position.

NOTE: the relays must be either NC or NO.

Figure 15: EM4x Relay State Jumpers



Relay 1 is permanently configured as Monitor OK, and as such is in a Normally Energised state.

Relay 2 has a default setting as an Urgent Alarm, and as such is in a Normally Energised state.

Relay 3 has a default setting as a Non-urgent Alarm, and as such is in a Normally Energised state.

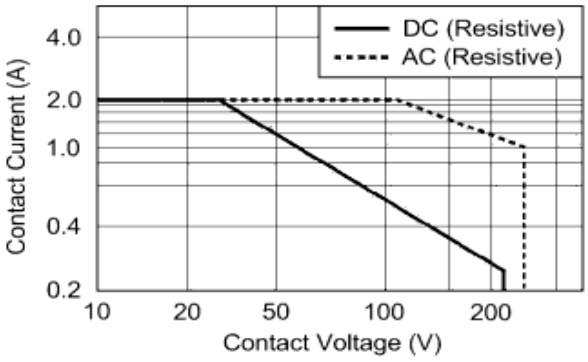
Relays 4-6 are spare and can be set to indicate any number of fault conditions as set in the controller configuration.

The default configuration relays can be modified and programmed as either normally energised or normally de-energised. The energised state requirements are dependent on the alarm/s mapped to the relay. Normally energised relays change state in the event of a system controller failure (i.e. low float alarm will activate if DC is removed), whereas normally de-energised relays do not change state.

NOTE: All labelling refers to the contact state when the relay is not energised.

To check the actual state of the alarm contacts, simply measure the relay output terminals with a multi-meter (check for continuity).

Figure 16: Relay Contact Ratings



NOTE: The relays fitted are not suitable for use with inductive type loads. A suitably rated interface relay should be used for inductive load applications.

10.2.11 Low Voltage Disconnect (LVD) Connections

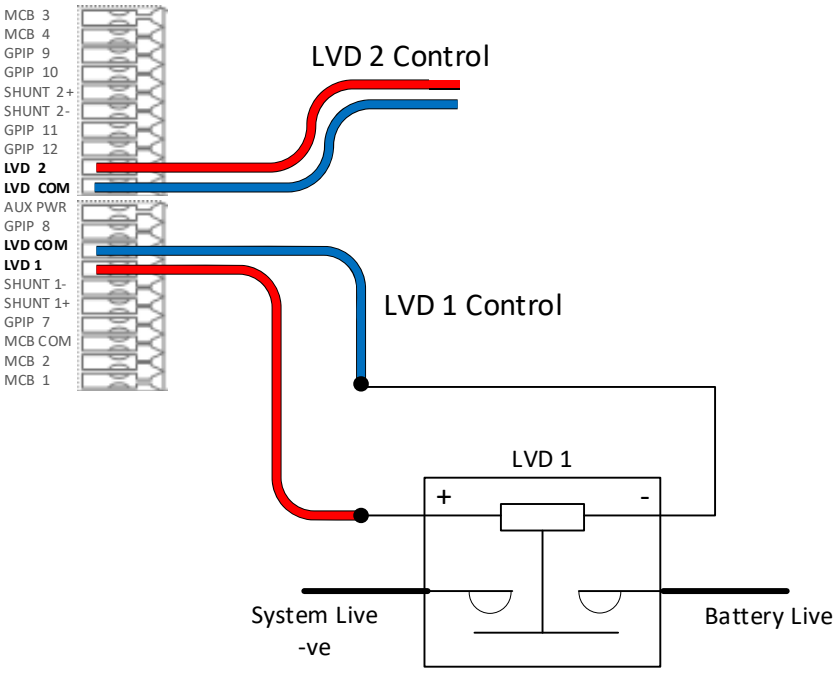
The Low Voltage Disconnect (LVD) function in the controller can be used for load disconnect or battery disconnect – the function dictated by the system wiring.

Each EM4x I/O board controls up to 2 ordinary coil type or magnetically latched type contactors. The method of connection is different for each type of contactor. Enatel's recommendation is to only use latching style contactors.

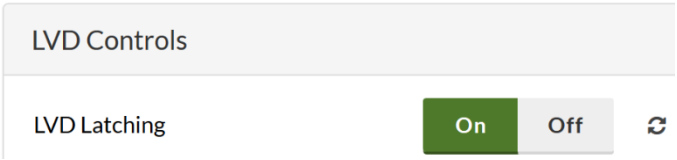
The controllers have a dedicated FET drive circuit for powering contactors. This drive circuit has a rating of 3A per LVD output. This requires a 48V power source typically connected to the bus.

The following figures give examples of how the different types of LVD are to be connected to a controller. (For simplicity only one LVD is shown in each diagram, but the same principles apply to subsequent LVDs connected.)

Figure 17: Magnetically Latched LVD Connections

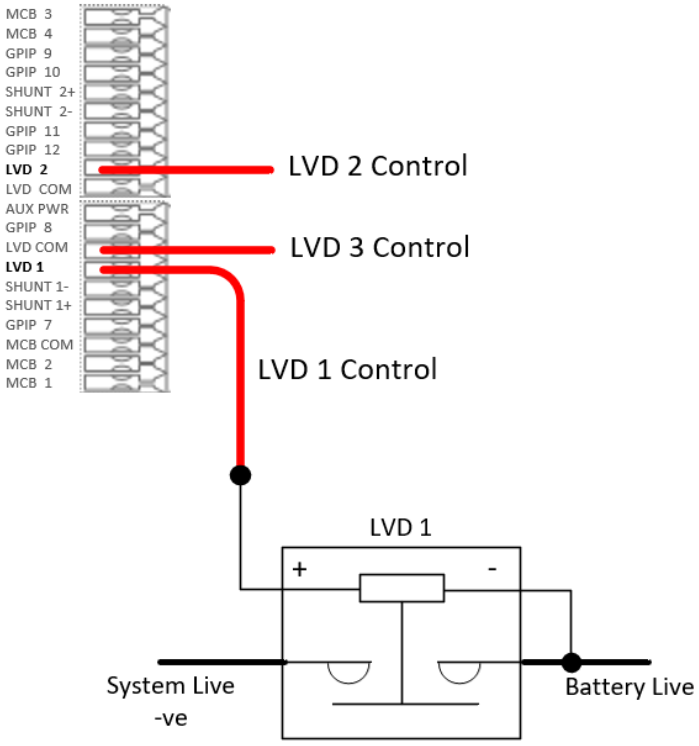


CAUTION When using magnetically latched contactors (as is usual practice), at IO Configuration>IO Boards>LVD Controls make sure that LVD Latching is ALWAYS ON:

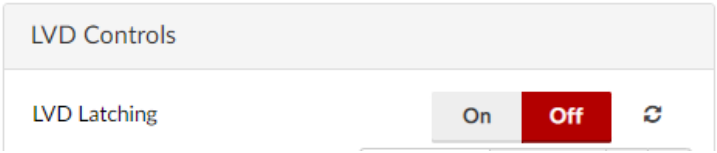


Failure to do this may lead to the LVD contactor coil overheating and burning out.

Figure 18: Normally Open/Normally Closed LVD Connections



CAUTION When using non-magnetically latched LVDs at IO Configuration>IO Boards>LVD Controls make sure that LVD Latching is OFF.



10.3 Cable Management

The EM4x 1U tray model allows cables to exit through either the front or rear of the controller, or a combination of the two. Cable relief slots are provided on the controller metalwork for either method of termination and should be used to secure cables.

10.3.1 Front Termination

Connections are made to the terminals required according to requirements of the system.

The cables should be loomed together to allow easier management of the loom. Route the cable along the front and out the left-hand side of the controller metalwork. The fold allows for full insertion of the controller yet allowing some space for cable exit.

10.3.2 Rear Termination

For the EM4x 1U connections are made to the terminals according to requirements of the system.

The cables should be loomed together to allow easier management of the loom. Route the cable through the rear of the controller and out the rear of the system. Cable lengths should allow for access when the controller is pulled forward for removal and maintenance.

10.4 Manual Reset

To reset the controller manually the power supply through the J1 SBI Port can be disconnected and reconnected.

10.5 Inclusion of Additional EM4x I/O Boards

10.5.1 General

The I/O Board provides additional input and outputs to the controller. One board is mounted inside the controller enclosure. Additional I/O boards may also be included separately elsewhere in the DC system as required to expand functionality.

NOTE: There are two types of I/O boards/cards. The ones referred to in this section are EM4x I/O Boards. The other type is the legacy I/O expansion cards from the previous SM3x range of controllers. These are referred to as I/O Expansion cards. Up to 4 I/O Expansion cards can be connected to each EM4x I/O Board. In the Web UI you will see reference to these two types of pcbs. It is important to understand which ones are being referred to as their functionality and form factor are different.

10.5.2 Additional EM4x I/O Board Connection

The EM4x I/O board CAN IN connects to CAN OUT of the controller I/O board. Downstream I/O boards are the same, each additional board CAN IN connects to the CAN OUT of the last board connected.

The limit to the total number of I/O boards that can be included in a system is five (5).

It is recommended that for customer installed, complex, lengthy wiring, multiple IO board inclusion into a system an Enatel sales representative is consulted.

The EM4x I/O board is powered from the 12V auxiliary power provided on the CAN bus connection.

11 SITE INSTALLATION AND INFORMATION SETUP

NOTE: see 10.1 Energy Manager Connectivity and the Web UI for access to the Web UI.

11.1 Comment on the Web UI and Commissioning

During commissioning specific attention should be given to the following Web UI functions:

- If batteries are installed check the correct battery type is selected for the system. See 13.8.1 Battery Type.
- Complete the general settings. See 11.4 General Settings.
- Complete the network settings. Refer to the Settings>Network Settings page of the Web UI.
- Download and store a back-up configuration file that includes the site and network settings. See 14.3 Configuration File.
- Complete the site information. See 11.5 Site Information.
- Download and store a copy of the site information.
- Complete the Web UI security settings: to establish a new set of usernames and passwords as required plus modifying the user level functionality at need. See 11.6 Users.
- Enter a new PIN code for the EM4x-01 touchscreen if required. See 11.4.5 PIN Locking the EM4x-01.
- Erase previous periodic and battery logs as required to remove spurious system test records or otherwise. See 13.7 Logging.

11.2 Web UI Primer

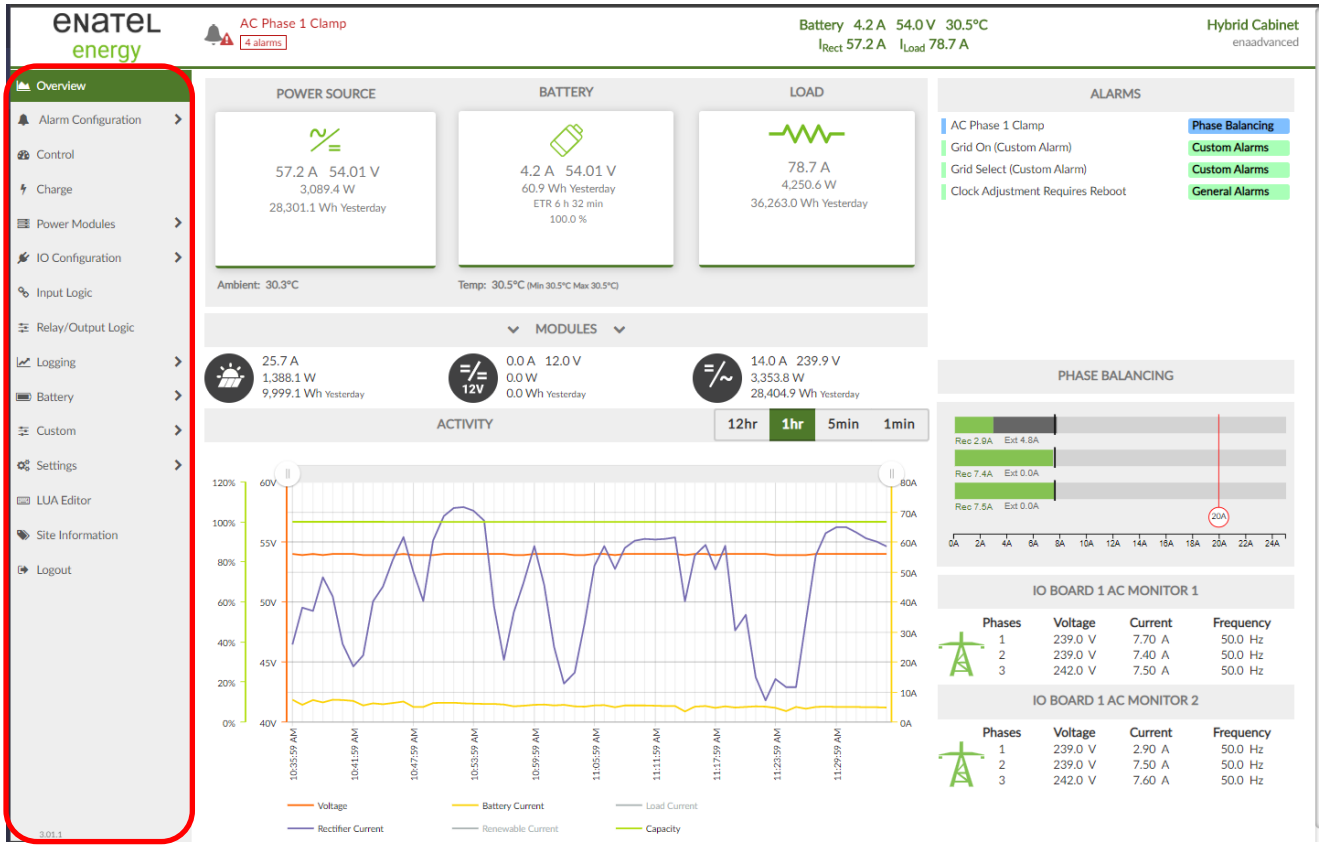
The Web UI content and features are dependent on the type of system, software feature unlocks, battery types and configuration. Please note images, menus and materials in this manual are not necessarily what each user may see when opening the Web UI.

The EM4x Web UI opens on the **Overview** page. The **Overview** page shows critical system information in real time, custom configurations and has an expandable section for further information on the power modules and associated peripherals.

11.2.1 Navigation Pane

On the left side of the screen is a navigation pane page hierarchy that provides access to the features listed.

NOTE: the available features can vary depending on the specific system type and the license locked features enabled.



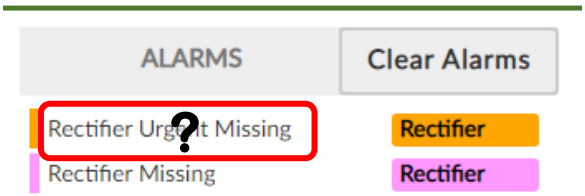
11.2.2 Header

The universal header section displays:

1. An alarm notification list.
   NOTE: this header alarm list is different from the **Alarms** section of the Overview page. Alarms in the **Alarms** section provide a help file when selected. See 11.2.3 Alarms.
2. A system status summary.
3. The site identifier. See 11.5 Site Information.
4. The user logged in. See 11.6 Users.
   NOTE: when no unique user name has been created this displays as the access level logged in as.

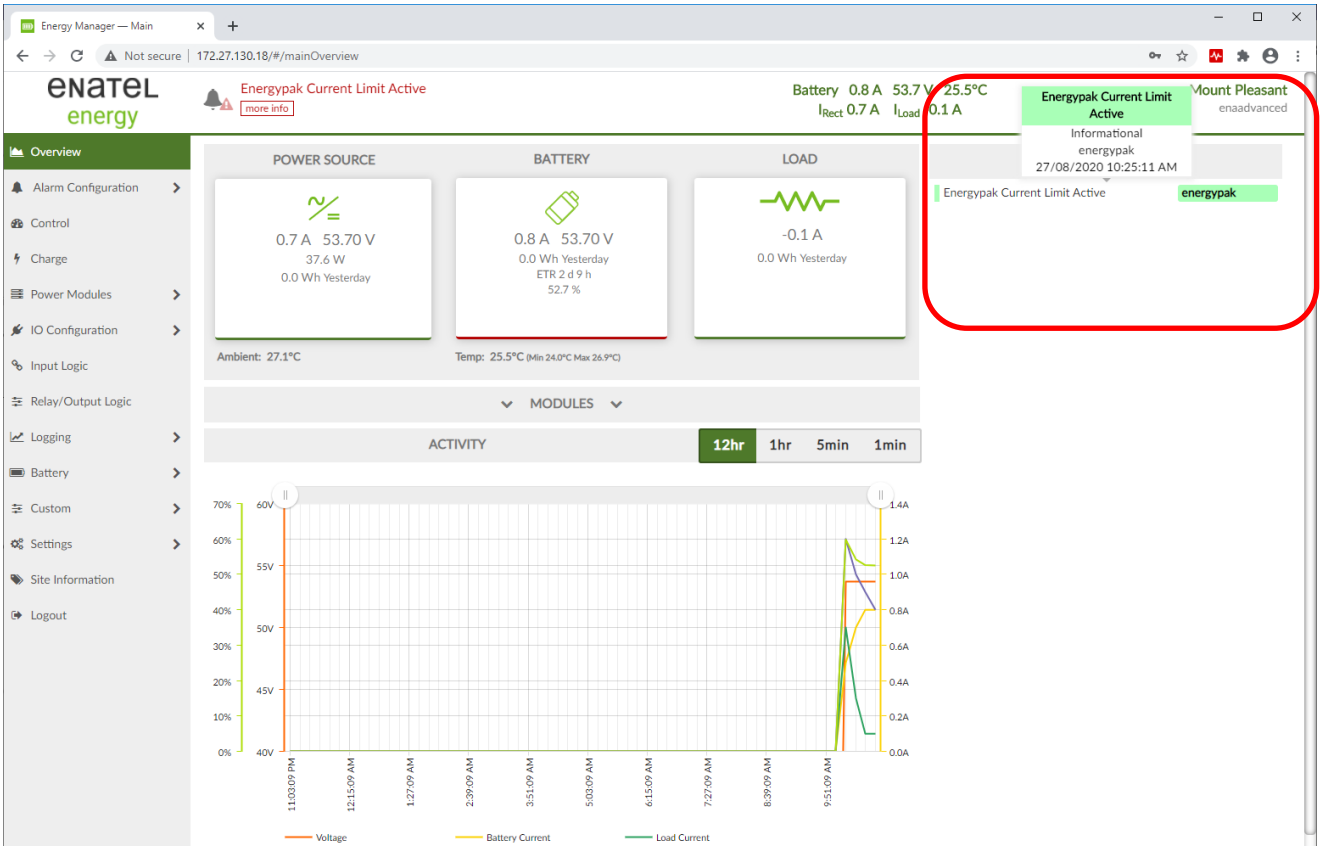
11.2.3 Alarms

Note the **Alarms** section of the Overview page that displays the current active alarms. Custom alarms also display here. Further information on the alarms can be obtained by placing the cursor over them. Clicking on the alarm brings up a pop-up menu with the alarm description and recommended action as appropriate.



Alarms also display on the header which is seen on every page.

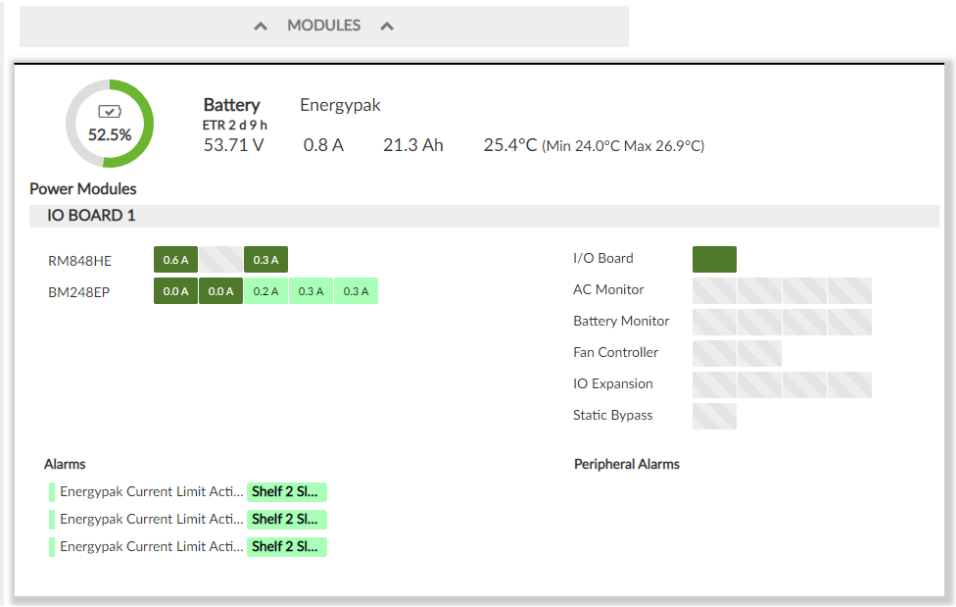
NOTE: see16.3 Alarm Configuration to understand the colour coding of the alarms. A pale green alarm could be termed a flag rather than an alarm for instance, indicating normal operation and informative only.



See 16.4 Energy Manager Alarm List, Description and Action for a complete list of alarms (except custom alarms), their definition and any recommended actions.

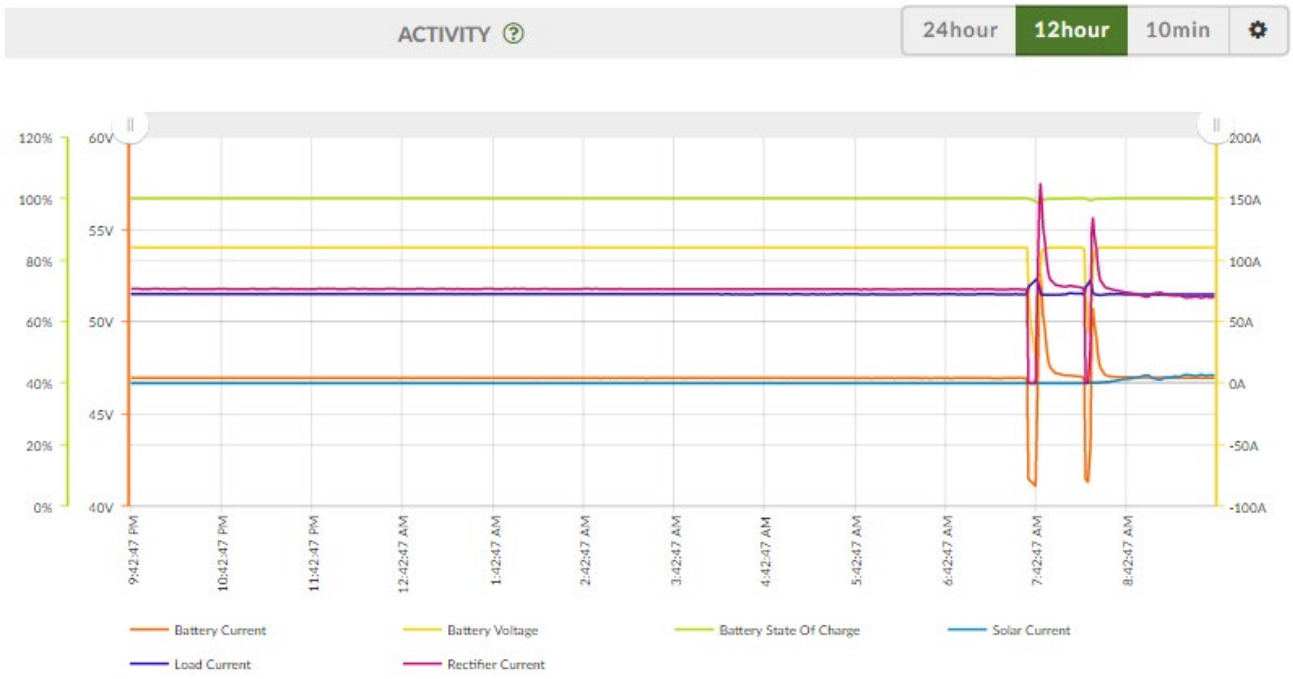
11.2.4 Modules Expanding Section

Click on the **MODULES** grey bar to expand the section which provides information on the power modules in the system and status.

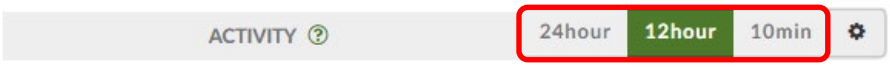


Click on the individual modules for further information. See 13.6 Power Modules.

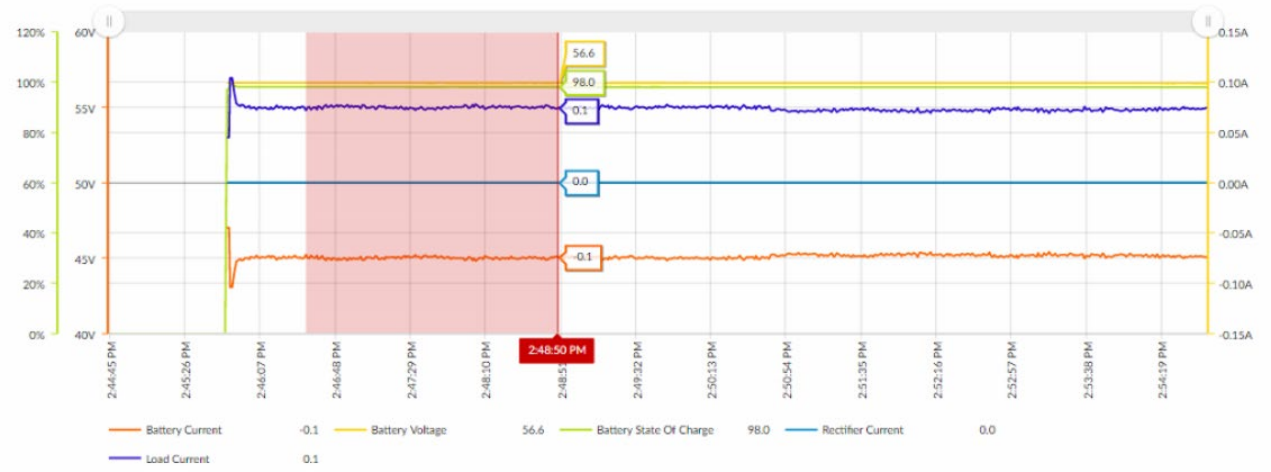
11.2.5 Activity Graph



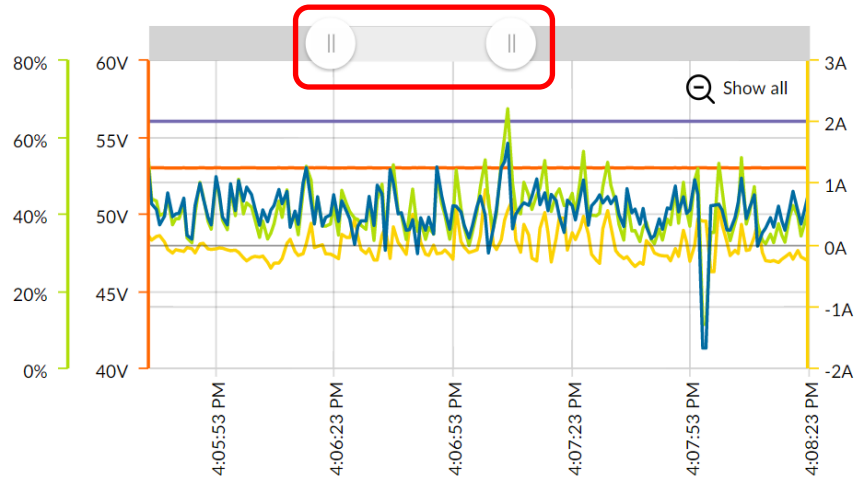
NOTE: if the activity graph displays no information (particularly when first commissioning a system) change the time scale on the Activity bar.



A section of the graph can be zoomed in on by click, hold and dragging the cursor over the required graph section.

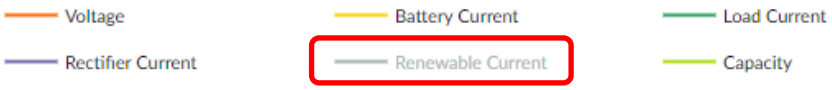


The time scale can be manually adjusted by dragging the icons at the end of the graph inwards.

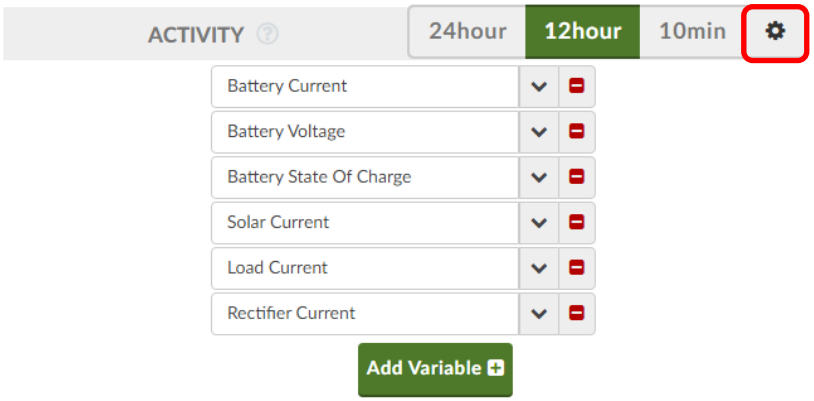


The information displayed in the activity graph can be managed by clicking on the parameter options, to toggle each display line on and off.

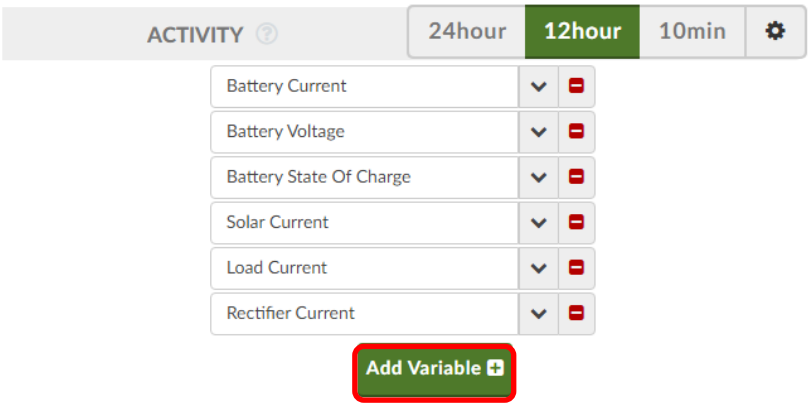
For example, the **Renewable Current** is toggled off and greyed out in the following screenshot.



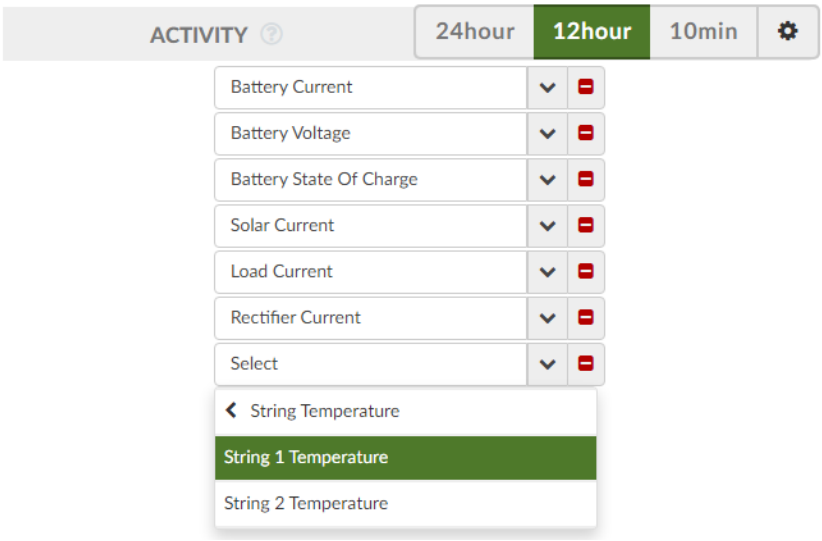
Click the gear icon  to add a variable to the graph.



Click the **Add Variable** button.

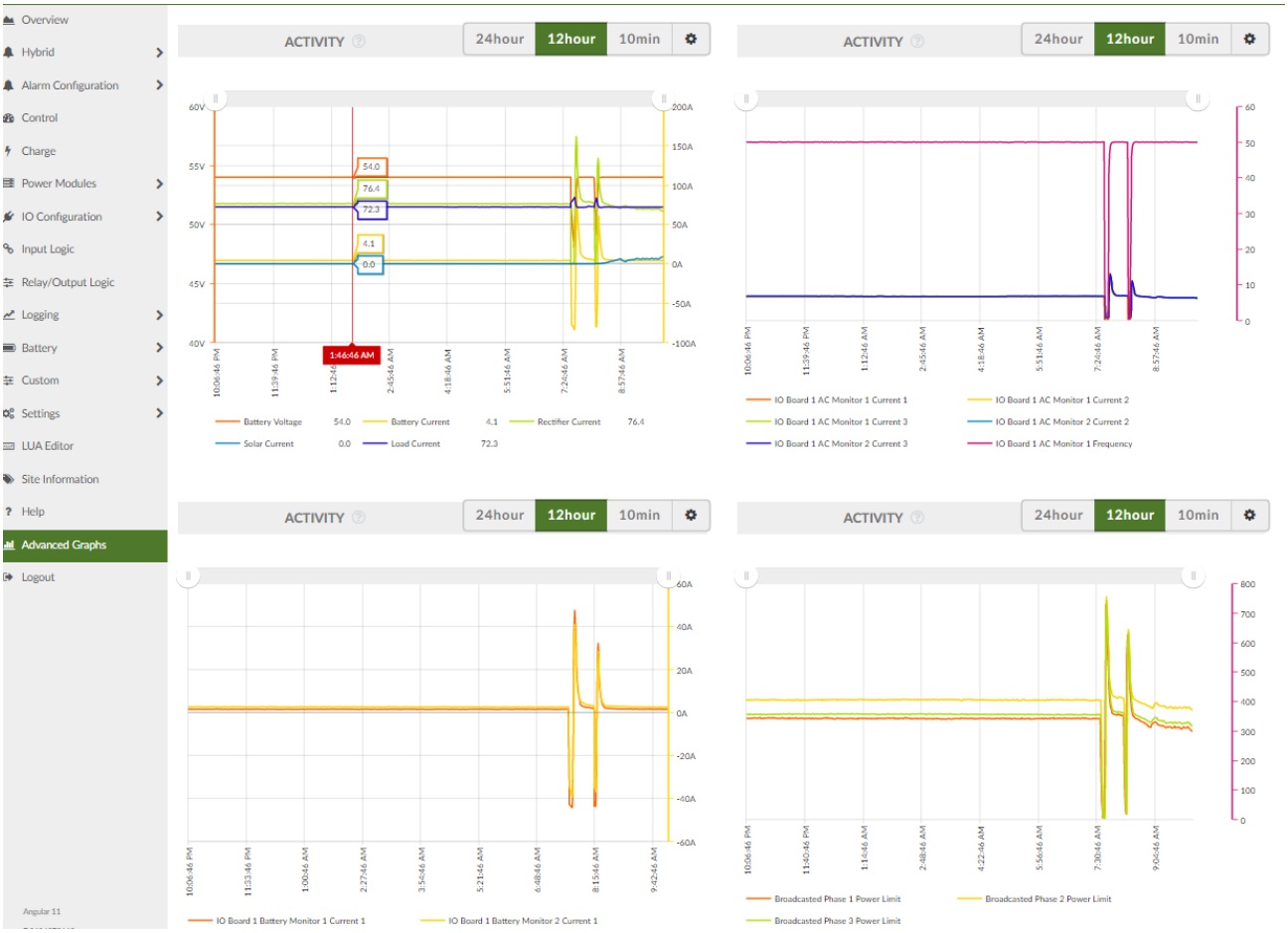


Select the required variable from the dropdown menu.



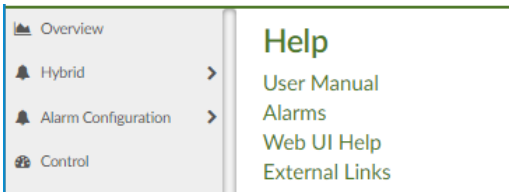
11.2.6 Advanced Graphs

The Advanced Graphs page provides four activity graphs which can be customised to allow concurrent observation of multiple variables as required. See 11.2.5 Activity Graph.

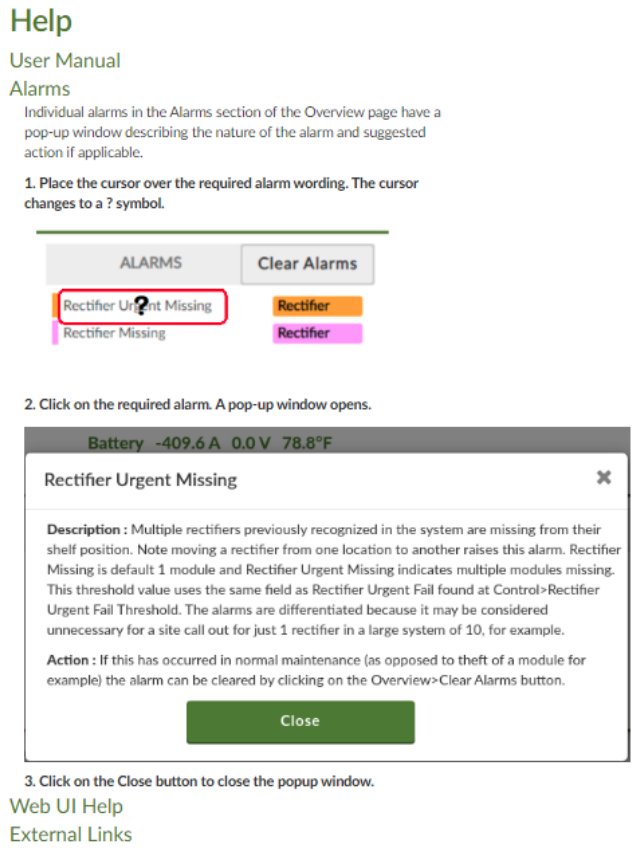


11.3 Help

The Help page provides explanation of the Web UI inbuilt help functions along with resources to assist the user.



Click on each heading to expand the section.



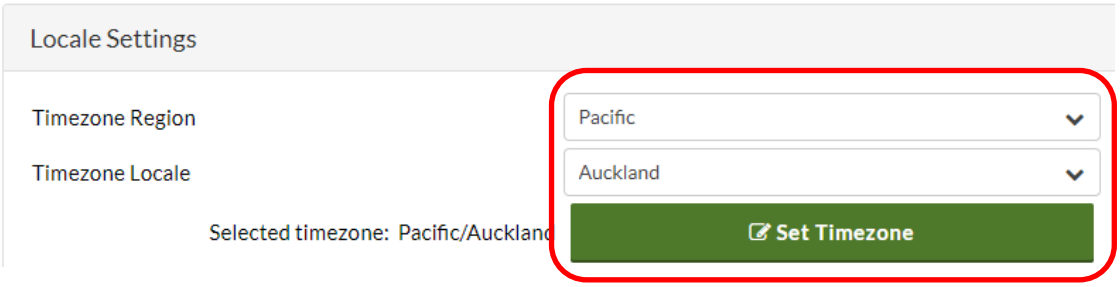
11.4 General Settings

Fundamental parameters for the power system are defined on the Settings>General Settings page of the Web UI.

NOTE: see 14.3 Configuration File and 14.6 Firmware for information on the **Upgrade Firmware** and **Backup/Restore Configuration** functions of the Setting page.

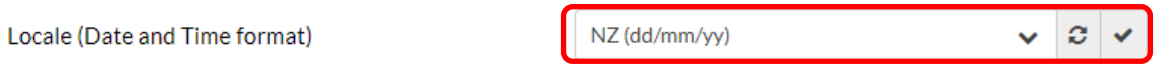
11.4.1 Locale Settings

Select the **Timezone Region** and **Timezone Locale** from the dropdown menu then click on the **Set Timezone** button to set the applicable time zone. Access level required: *enabasic*.



Important: temperature scale, whether degrees Celsius or Fahrenheit, is set by the **Timezone Locale** drop-down menu selection (which can be also managed on the EM4x screen interface at Settings/Time/Network Time setting.

Set **Locale (Date and Time format)** to select between dd/mm/yy and mm/dd/yy calendar displays.

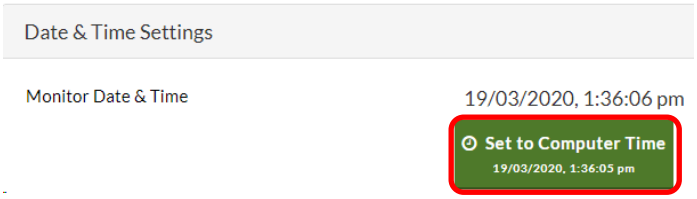


11.4.2 Date and Time Settings

Access level required: *enabasic*

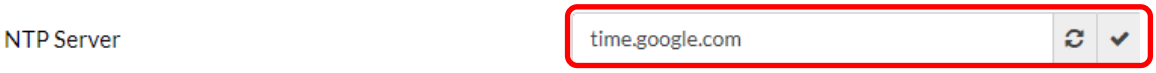
The energy manager date and time can be synchronized to a connected computer by clicking on the **Set to Computer Time** button.

NOTE: this over-writes the Locale Settings for timezone region. Do not use this function unless in the correct timezone for deployment.



To allow the energy manager to access an external server clock toggle NTP Enable **On**.

To set the required NTP server, enter the location in the NTP Server field.



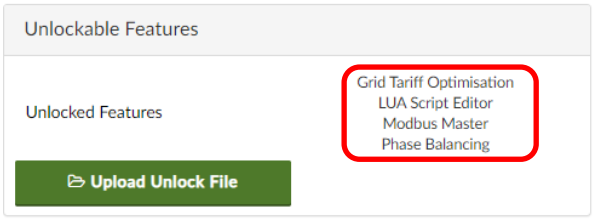
NOTE: daylight saving is supported via NTP server synchronization.

11.4.3 Unlockable Features

The energy manager has a variety of features that are license locked. These features are, either included in the Web UI at the factory when supplied to a customer or able to be enabled via a dedicated unlock file.

NOTE: if a license locked feature has not been enabled it does not display in the Web UI.

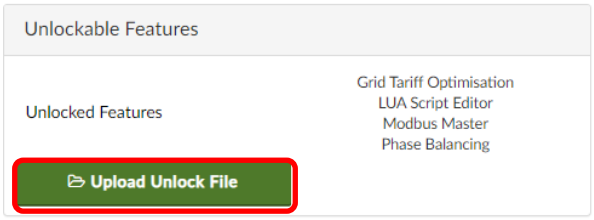
Those features already enabled are displayed in the Unlockable Features section.



NOTE: to confirm what license locked features may be suitable for your applications please discuss with your Enatel representative.

To access a licensed feature an unlock file must be first obtained from Enatel.

1. Click on the **Upload Unlock File** button. Access level required: *enaadvanced*.



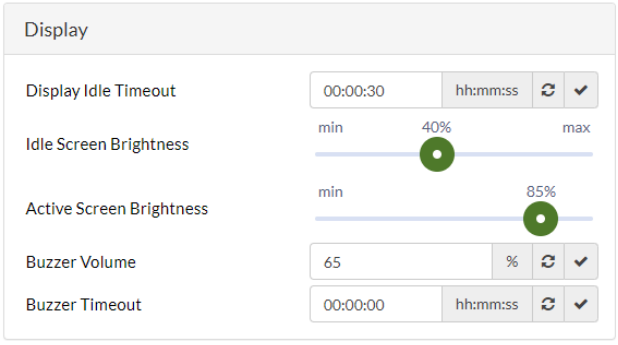
2. Drag and drop or navigate to the unlock file to upload into the EM4x and complete the process.

11.4.4 Display

This section modifies the energy manager LCD screen and alarm buzzer. Access level required: *enaadvanced*.

Options are self-explanatory. Changes can be viewed in real time.

NOTE: if a buzzer alarm is raised pressing any keypad button on the energy manager front panel interface turns the buzzer off.



Note that setting the Buzzer Timeout to 00:00:00 means the buzzer will run constantly until a front panel button is pressed.

Calibrate Display

The touch display of the EM4x-01 controller can be recalibrated at need.

Click on the **Calibrate touch display** button then follow the on-screen instructions on the EM4x LCD.

NOTE: this button only displays on the EM4x-01 Web UI

11.4.5 PIN Locking the EM4x-01

The EM4x-01 has the option to PIN lock setting change through the touchscreen interface.

Access level required: *enaadvanced*.

1. Toggle the PIN code enabled **On** to engage this feature.

2. Click the eye icon to display the PIN code.

3. To change the PIN code, enter the new password then click the tick icon to save the change.

The PIN code can be from 4 to 8 numbers long. It cannot start with a 0. That is, the PIN code must be at least 1000.

NOTE: the default PIN code = 1234

NOTE: a factory reset reverts the PIN code to the default 1234.

The PIN code time out duration begins from the last action on the touch screen.

4. To change the time out period, enter the new time then click the tick icon.

11.4.6 Restart Monitor

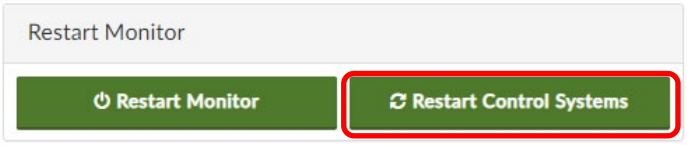
To force an energy manager reboot click on the **Restart Monitor** button. Access level required: *enaadvanced*.

NOTE: a restart over-rides any active process.

NOTE: the system continues to supply the load during this process.

11.4.7 Restart Control Systems

To restart the control loop (effectively a soft restart) click on the **Restart Control Systems** button.

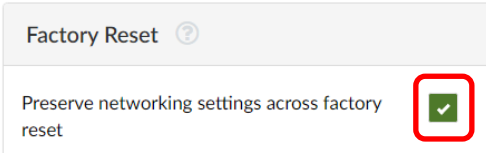


This function is primarily used during troubleshooting to assist with problem identification.

11.4.8 Factory Reset

CAUTION **A factory reset over-writes all site specific settings and customized input logic.**

IMPORTANT: make sure the **Preserve networking settings across factory reset** check box is enabled if doing a factory set remotely. If this is not enabled the network settings are lost and the energy manager could go off-line.

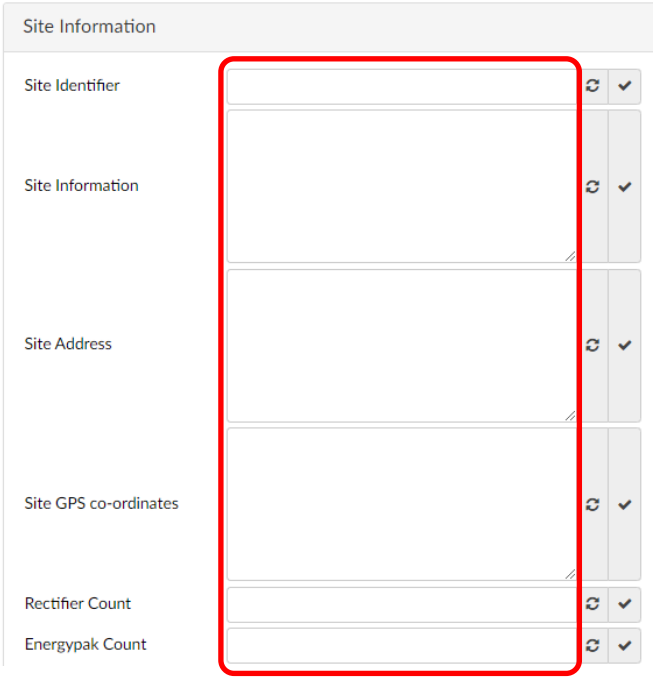


Click on the **Factory Reset** button for a complete factory default settings reset of the system. Access level required: *enaadvanced*.

NOTE: the system continues to supply the load during this process.

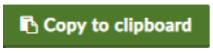
11.5 Site Information

The Site Information Web UI page Site Information section provides for the recording of individual site details. The non-greyed-out fields should be completed during site commissioning as appropriate.



The site details can be downloaded as an xml file for record keeping.

Or copied onto a clipboard for pasting into any text reading program such as Word or Note.



NOTE: It is recommended a backup file record of each site is kept as there may be critical site information required when the site is down and the Web UI unavailable remotely.

Access level required to save the *.xml site information file is *enaguest*.

NOTE: for license unlocking the **CPU Board Serial Number** is found here in the EM4x Monitor Information section.

11.5.1 Create Diagnostic File

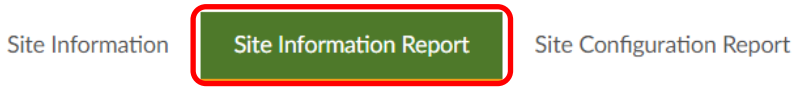
This is a factory use only feature that creates a *.tgz file for diagnostic assistance.

11.5.2 Site Reports Print to pdf

There are 2 reports that can be printed to a pdf file for record keeping on the Site Information page.

- **Site Information Report**: which provides a summary of the site name, information, monitor and devices.
- **Site Configuration Report:** which provides all configuration settings of the EM4x.

1. Click on the required tab.



2. Click on the – and + icons besides the file heading to manage what is displayed and printed in the report.

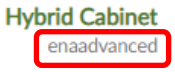
3. Click on the Download PDF report button to download the required pdf file.

11.6 Users

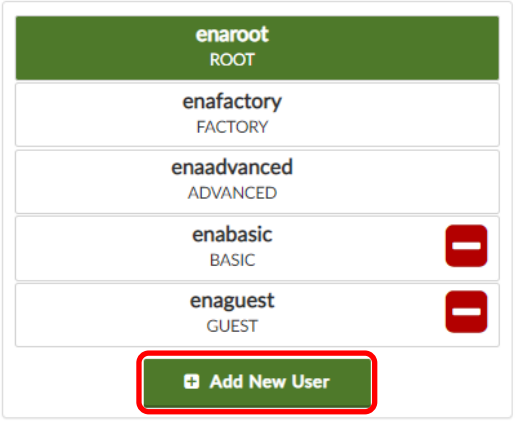
On the Settings>Users page new users and the user permissions can be set along with changing or adding new passwords.

NOTE: those fields the current access level does not have permission to modify are greyed-out.

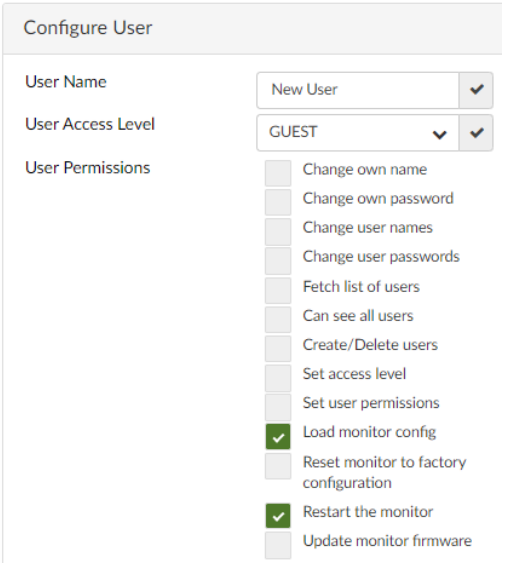
NOTE: the current logged-in user level is indicated on the top right corner of the Web UI header.



Click on the **Add New User** button to open the New User menu.



In the Configure User section modify the new, or existing user. Enable each feature to provide permission access to the new user as required.

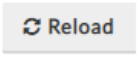


Enter a new password.

NOTE: the default password for all customer available levels is: **ena123**

To delete a user click on the icon.

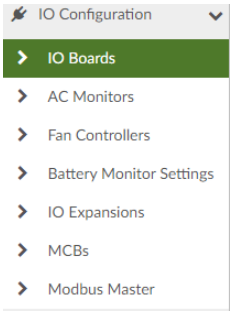
Click on the **Reload** button to remove a user before entering a new password.



11.7 IO Configuration

DC system IO boards, ancillary cards, and breakers are typically preconfigured and provided with a system. To expand system functionality ancillary cards and new breakers can be incorporated. Additional devices can also be incorporated via Modbus communication. This is all managed through the IO Configuration menu of the Web UI.

NOTE: the options available in the IO Configuration drop down menu in the Web UI navigation side pane are system type dependent. Not all options shown in this manual section may be available to a system.



The layout and structure of the IO Configuration menus follow the connectivity limitations of the IO boards.

- Up to 5 IO boards can be included in each DC system via CAN Bus daisy-chain.
- Each IO board can connect to:
    - 4 AC monitors
    - 2 fan controller boards

- 4 battery monitor cards
- 4 IO expansion cards.

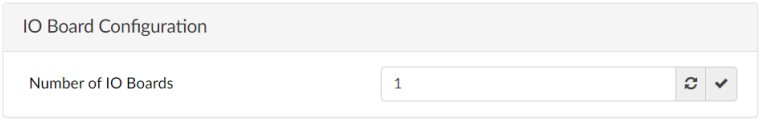
MCBs are treated separately.

Up to 2 Modbus communication busses can be included in the system. These can be Modbus RTU or TCP, where the system can act as either a master or server.

11.7.1 IO Boards

NOTE: unlike AC Monitors, Fan Controllers, IO Expansion cards and Battery Monitors, IO Boards are not auto-detected and auto-populated in the Web UI. IO Boards must be configured and enabled manually.

To expand functionality if additional IO boards are required the **Number of IO Boards** must be set first at IO Configuration>IO Boards>IO Board Configuration.



If multiple IO boards are included in the system these are displayed in each submenu as tabs. Click on the required IO tab to configure the functionality of each IO board under each submenu.

See 10.5 Inclusion of Additional EM4x I/O Boards for details on the hardware connection of additional IO boards.

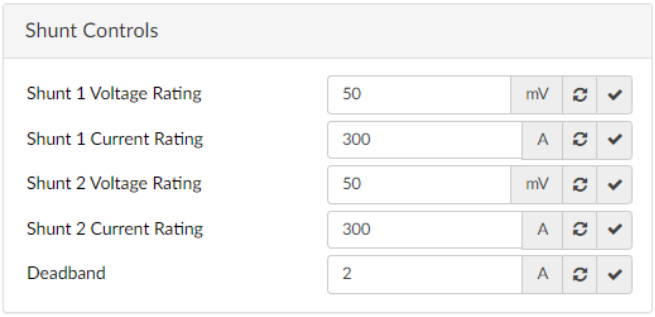
LVD Controls

See 13.3 Low Voltage Disconnect (LVD) for details on LVD Controls.

Shunt Controls

In this section shunts in the system have their parameters entered. In the example below there are two 300A/50mV shunts.

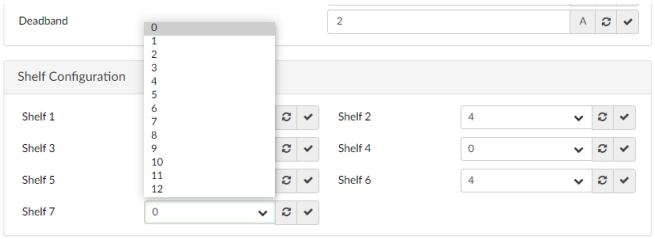
The **Deadband** is the threshold below which the EM4x assumes the current to be zero.



See 10.2.7 Current Measurements for the shunt 1 and 2 connector locations on the IO board. 2 shunts can be connected to each IO board.

Shelf Configuration

Enter the number of modules for each system shelf from the drop down menu. An incorrect number entered here raises a module missing alarm.

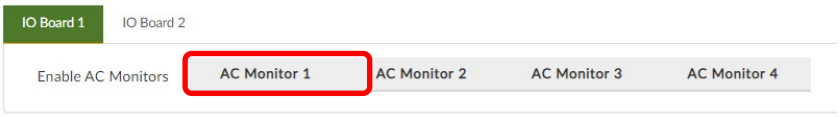


11.7.2 AC Monitors

See also 13.2.1 AC Monitoring via AC Monitor Card.

AC Monitor cards auto-populate under each IO Board tab if present in the system.

Click on the AC Monitor tab to enable or disable each AC monitor. A green highlighted tab indicates the AC Monitor is enabled.

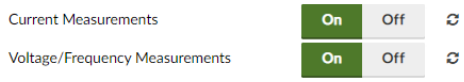


NOTE: enabling or disabling the AC monitors does not require clicking on the **Save** button.

When adding AC monitors:

1. Select the number of phases **1** or **3**

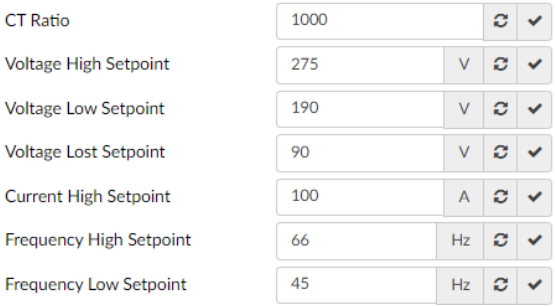
2. Enable **Current Measurements** and **Voltage/Frequency Measurements**.



3. Select the correct **CT Ratio** for the appropriate number of turns.

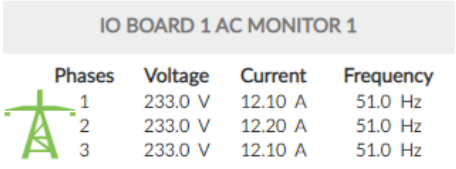
NOTE: the inputs have a range 0-100mA so the CT must be chosen to ensure the input current to the module is within this range, e.g. for a maximum peak current of 100A then a CT to measure this should have a minimum 1000:1 turns ratio.

4. Enter the required alarm Setpoints.



5. To have the data from the AC Monitor show in the Overview page toggle **Show in Overview** to **On**.

Which appears on the Overview page as:

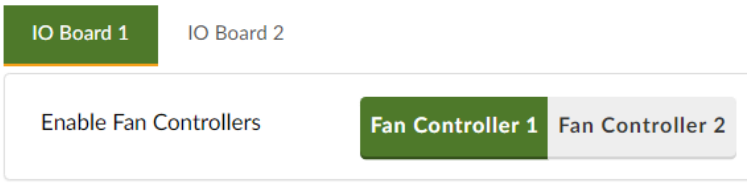


11.7.3 Fan Controllers

Fan Controller cards auto-populate under each IO Board tab if present in the system. A maximum of 2 fan boards can be included on each IO Board (comms bus).

Click on the **Fan Controller** tab to enable or disable each fan controller under each IO Board tab. A green highlighted tab indicates the Fan Controller is enabled

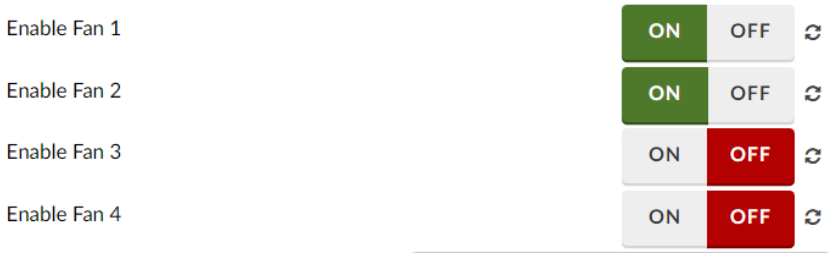
NOTE: enabling or disabling a fan controller does not require use of the **Save** button.



Click on the **Clear Alarms** button to remove alarms that have been raised as displayed on the page. Typical usage might be during setup when an alarm is spuriously triggered.

Fan Speed displays the current speed of the fans as a percentage of their maximum speed.

Up to 4 fans can be controlled by the fan control board. Toggle the required fan **ON** to enable it.



Maximum Fan Voltage must be set to the voltage rating of the fans being used.

Important: if the voltage is set incorrectly it could damage the fan.

Minimum Fan On Time is the minimum duration in seconds that the fans run for when turned on regardless of any command to turn off.

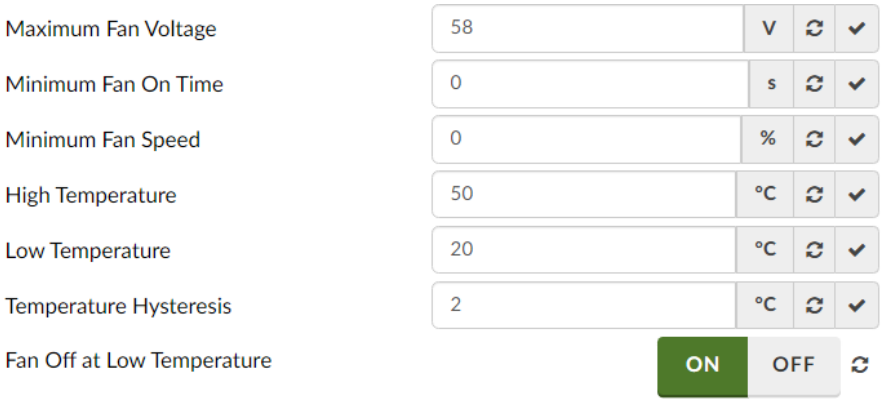
Minimum Fan Speed is set as a percentage of the maximum fan speed such that the fan does not stall under normal conditions.

High Temperature is the temperature at which the fans run at maximum speed.

Low Temperature is the temperature at which the fans run at minimum speed.

Temperature Hysteresis is the difference in temperature between the fans switching off and on.

Fan OFF at Low Temperature when toggled **ON** the fans turn off at low temperature. When **OFF** the fans run at minimum fan speed at low temperature.



11.7.4 Battery Monitors

Battery Monitor cards auto-populate under each IO Board tab if present in the system.

Click on the **Battery Monitor** tab to enable or disable each battery monitor. A green highlighted tab indicates the Battery Monitor is enabled

NOTE: enabling or disabling a battery monitor does not require use of the **Save** button.

Shunts for the battery monitor cards have their parameters entered in the respective fields. Enatel battery monitor cards are typically supplied with 330A/50mV shunts.

NOTE: the **Current Deadband** can be defaulted at 1% of the Shunt Current Rating however please consult your Enatel representative at need to assist with this figure.

11.7.5 IO Expansions

IO Expansion cards auto-populate under each IO Board tab if present in the system.

Click on the **IO Expansion** tab to enable or disable each IO expansion. A green highlighted tab indicates the IO Expansion card is enabled

NOTE: enabling or disabling an IO expansion does not require use of the **Save** button.

With an IO expansion card included in the system additional custom relays, temperature sensors, LVDs, and GPIPs can then be connected. See 10.2 Terminations to the EM4x and 15 Creating Custom Features.

11.7.6 Battery MCBs

A maximum of 4 battery MCBs can be configured with each IO board.

Automatic MCB Inputs when toggled **Off** uses Input Logic dedicated configuration for the battery MCB settings rather than the default EM4x firmware battery MCB input settings. This is an advanced setting typically only used in factory configuration.

Digital MCB Inputs when toggled **On** allow for the use of GPIPs to be connected across the auxiliary contact of a breaker

Current Rating of each MCB is obtained from the breaker data sheet.

Power Rating of each MCB is obtained from the breaker data sheet detailed as Power Loss.

Voltage Threshold is typically 0.15V.

12 Using the EM4x Controller Front Panel Interface

12.1 Introduction

The EM4x 1U and EM4x 3U monitors have an LCD display on their front panel that allows system parameters to be observed or modified. The display menu is navigated using the keys or touch control.

The display shows the default screen when operating normally and no key has been pressed for about 60 seconds.

NOTE: due to ongoing feature inclusions all LCD screenshots are liable to change.

12.1.1 Default Screen

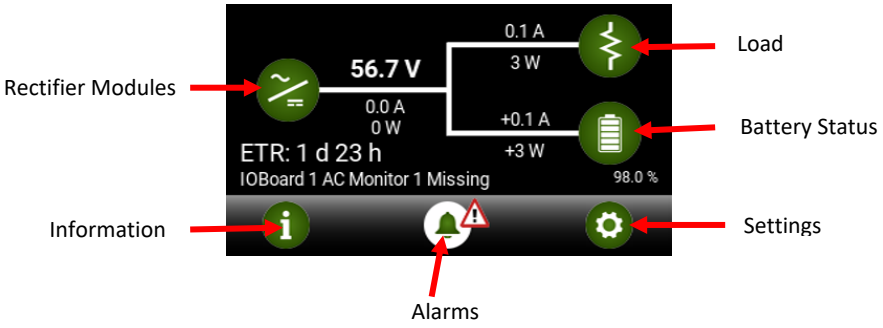
When the controller front panel interface is in an idle state, it shows the default screen and the backlight is at minimum.

When any key is pressed (1U) or the screen touched (3U), the backlight increases to maximum. The user interface is now active.

12.2 1U Keypad Menu Navigation

The front screen icons are navigated using the keypad on the front panel. See 9.2 1U EM4x-02 Interface.

Figure 19: 1U LCD Main Menu Active Elements



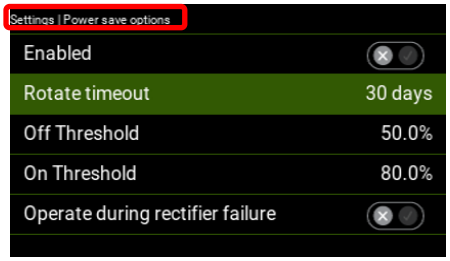
Press the ▼ ▲ keys to move around the front screen icons, up and down a menu or back and forth between options.

Press the ↵ key to select an item. To modify a selected item press the ↵ key to toggle an option on or off or to confirm and option.

Press the ↩ key to return to the previous screen.

A » symbol at the end of a menu line indicates there is a sub menu below this item.

When entering a menu, the title of the menu is displayed on the top line.

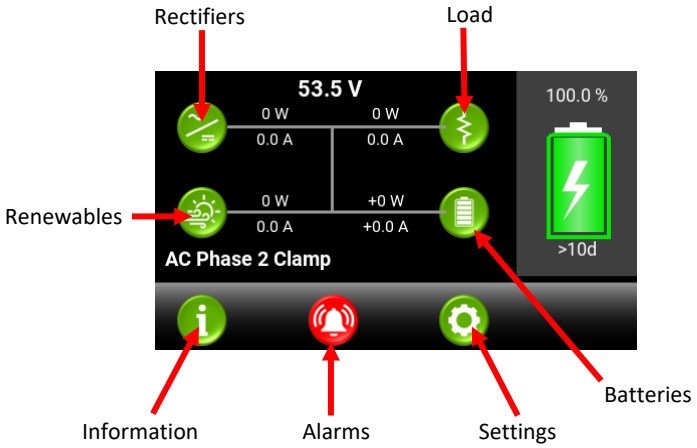


NOTE: ETR = Expected Time Remaining which is the estimated back-up time of the batteries in days (d) and hours (h) given their state of charge and the active load. See 13.8.6 Estimated Time Remaining (ETR) .

12.3 3U Touchscreen Menu Navigation

The touchscreen menu is navigated by tapping the active elements. See 9.1 Energy Manager 3U EM4x-01 Interface.

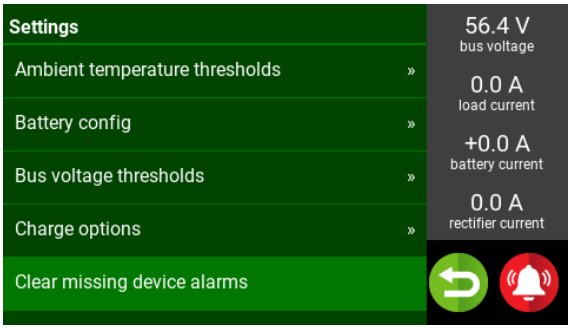
Figure 20: 3U Touchscreen Main Menu Active Elements



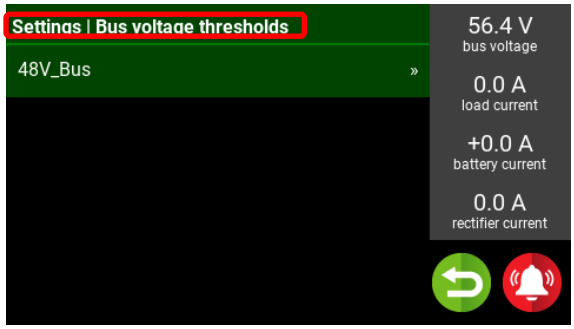
Tap the required icon as shown in Figure 20 to access the submenus.

Slide to scroll through the menu options.

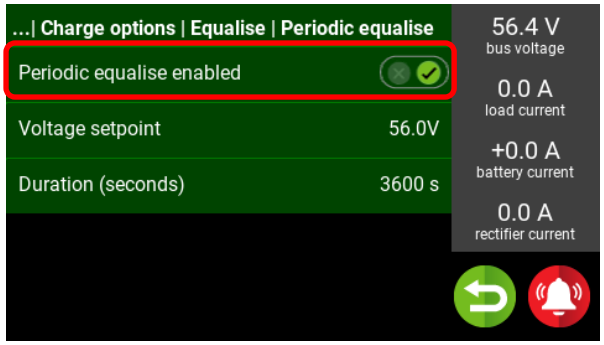
Tap an item line displaying the » icon to access further sub-menus.



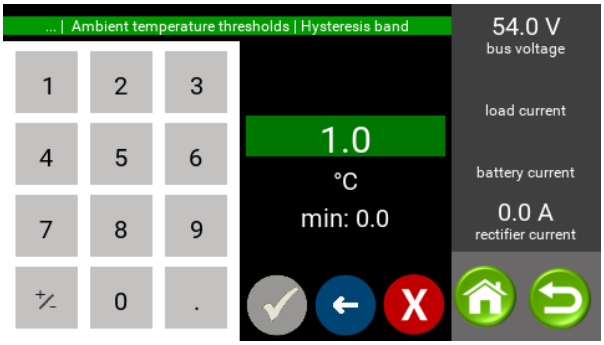
When entering a sub-menu, note the title of the sub-menu is displayed on the top line.



Tap the line item to toggle state changes as required.



Tap a line item with a numeric value. A number pad appears.



Tap the required field to be modified.

Tap the icon to delete individual items in the field.

Tap the icon to clear the field.

Tap the required numerals on the number pad.

Tap the icon to confirm the entered information.

Tap the icon to return to the previous screen.

Tap the icon to return to the front screen.

NOTE: the EM4x-01 has the option to PIN lock function change through the front screen interface. See 11.4.5 PIN Locking the EM4x-01 for details.

When attempting to change a setting through the touchscreen with PIN code enabled, a request to enter the PIN code appears.

Enter the PIN code to proceed with a required change.

NOTE: the default PIN code is 1234.

12.4 1U and 3U Front Screen Interface

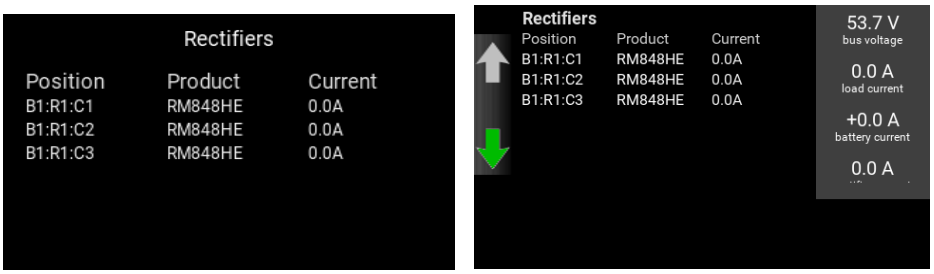
12.4.1 Rectifier Modules

Selecting the Rectifier icon displays a list of rectifiers in the system with the shelf locations where:

B = bus number = a bus number assigned to each I/O board which matches the IO board number.

R = row number = which is the same as the shelf number which in enatel systems starts at the top 1U of the system (not the first row of battery modules for example).

C = column number = columns relative to the row arrangement. That is, where a row might have an energy manager installed C1 would be the first rectifier in the row after the energy manager reading left to right.



Selecting an individual rectifier displays the serial number, the firmware number, the active current and any alarms raised.

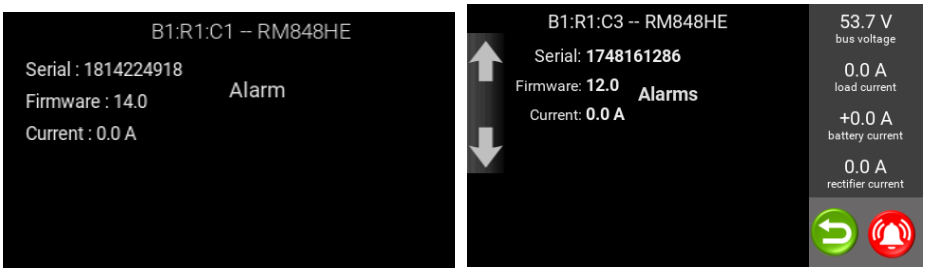
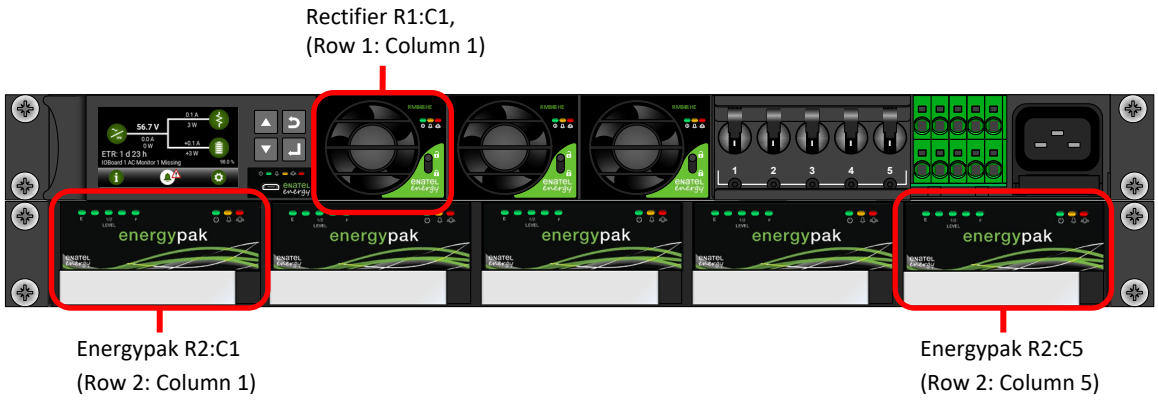
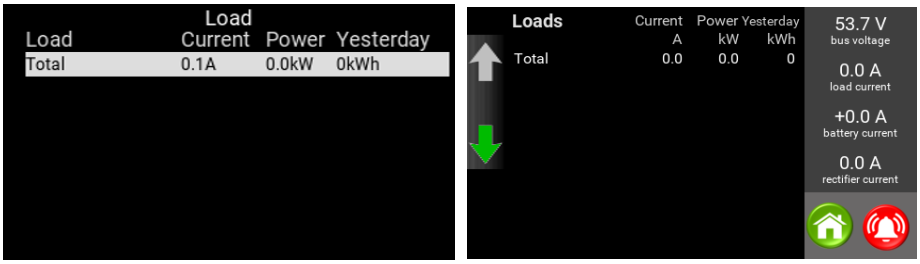


Figure 21: System Row and Column Numbering Example



12.4.2 Load

Selecting the Load icon  displays the active current, power and power consumed the previous 24 hours.



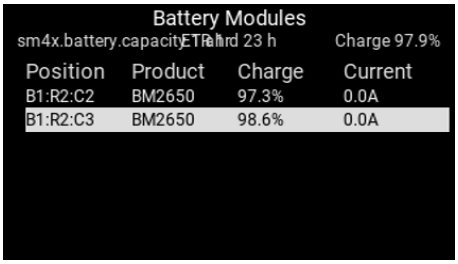
12.4.3 Battery Status

Selecting the Battery Status  icon varies according to the battery type configured. It displays:

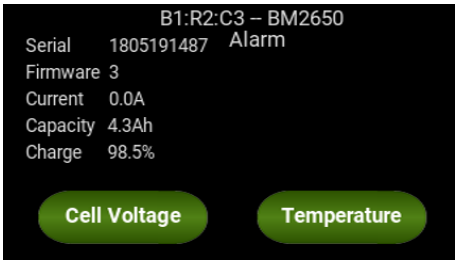
- the total estimated back up battery time remaining for the system (the ETR)
- the average charge percentage of the energypaks or battery strings,
- and either Battery Modules by location with their model name (Product), state of charge (Charge) and active current where -

B = bus number = where in systems with multiple I/O boards the bus number is assigned to each I/O board in the daisy chain.
R = row number = which is the same as the shelf number which in enatel systems starts at the top 1U of the system. The default arrangement of the energyhub has the first shelf of energypaks as R2 for example.
C = column number = columns relative to the row arrangement.

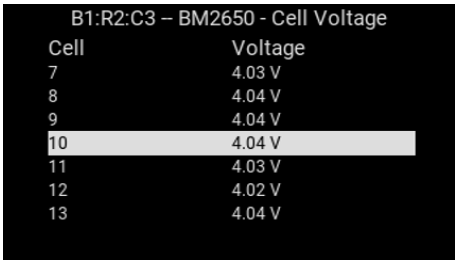
- Or the battery strings



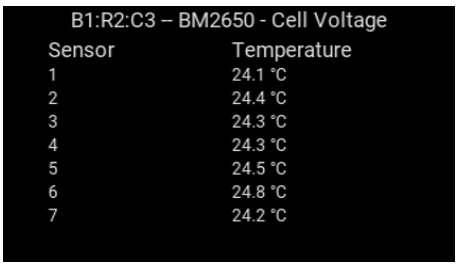
Selecting a specific battery module brings up the module details.



Select **Cell Voltage** to display the voltage of each cell in the battery module.



Select **Temperature** in the Battery Module screen to bring up the temperature of each cell in the module.



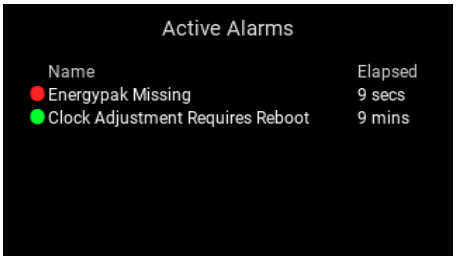
12.4.4 Settings

The various Settings  are described with reference to their related functionality in the appropriate sections of this manual.

12.4.5 Alarms

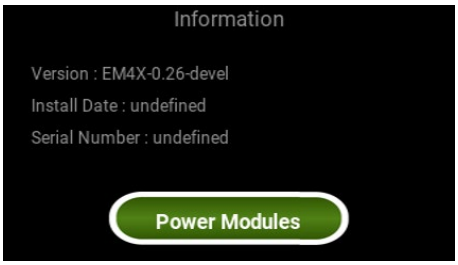
The Alarms  menu contains alarm states that are currently active. It is a dynamic list and updates whenever an alarm state activates or deactivates.

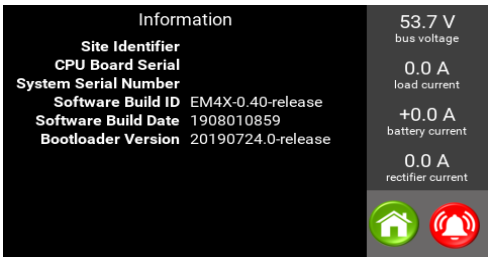
NOTE: If no active alarms are raised, the list is empty.



12.4.6 Information

Selecting the Information icon displays the EM4x key product details.





Press the key to select **Power Modules** which displays all rectifiers and batteries in the system.

B = bus number = where in systems with multiple I/O boards the bus number is assigned to each I/O board in the daisy chain.

R = row number = which is the same as the shelf number. In Enatel systems this starts at the top 1U of the system. The default arrangement of the energyhub has the first shelf of energypaks as R2 for example. Where a row might have an energy manager installed C1 would be the first rectifier in the row after the energy manager reading left to right.

C = column number = columns relative to the row arrangement.

Selecting a module displays details of the individual module.

13 ENERGY MANAGER PROCESSES, FUNCTIONS AND REPORTING

NOTE: see 10.1 Energy Manager Connectivity and the Web UI for access to the Web UI.

13.1 Introduction

The energy manager gathers information from the DC system and runs processes that control the function of the system. These processes are described in this section.

Sections of the Web UI report information gathered by the energy manager and explanation of these page sections is also provided in this part of the manual.

NOTE: not all features are present in each system type. Also several features are license locked which are noted as appropriate.

NOTE: when a function is active the Web UI section header changes colour to pale green.

13.2 AC Monitoring

The EM4x has two principal modes of monitoring AC input voltage & other AC parameters.

13.2.1 AC Monitoring via AC Monitor Card

A separate AC Monitor card (Enatel Part Number ASM-AC3P) can be fitted to the system to monitor the AC input to the system if desired. AC Monitor cards are essential for the function of the Phase Balancing and Hybrid (SYNERGi) features.

The ASM-AC3P has the option of monitoring 3-phase AC voltage (phase to neutral) & frequency, plus, with the addition of current transformers, it can also monitor AC input current. The AC Monitor connects to the DC system serial communications bus for communications with the EM4x. Up to four AC Monitor cards can be connected to any one EM4x for monitoring. Additional IO boards, each with up to four AC Monitor cards connected, can be daisy chained as required up to a maximum of 5 IO boards.

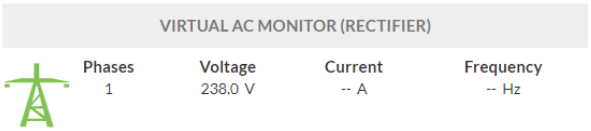
For details of the fitment and operation of this card, consult the ASM-AC3P AC Monitor manual.

13.2.2 AC Monitoring via the RM848HE Rectifiers

The RM848HE and legacy RM648/848 rectifier modules have the capability of communicating their AC input voltage directly to the EM4x (the RM2048HE & RM3048HE rectifiers do not have this feature). Note that this is a voltage only measurement (not frequency or current). Also note that the AC Input Voltage is only displayed when the DC output current is >0.5A per rectifier. This is due to the methodology of the voltage detection.

The capability of the RM648/848 rectifiers to monitor AC voltage is only on rectifiers with firmware version "SWEN-RM848-09" or above.

When connected, the EM4x automatically detects the voltage reading from one of the rectifiers. The first rectifier to respond with an AC voltage is the displayed voltage. This means that it is possible to have only one rectifier in the system that has the AC monitoring capability, and an AC voltage measurement still displays. It does not matter which position the rectifier is in. This is displayed in the Web UI termed as a Virtual AC Monitor. An example of a controller measuring a single phase input is shown from the Web UI **Overview** page:



The AC voltage can also be viewed on the EM4x front panel.

See also Virtual AC Monitor.

13.3 Low Voltage Disconnect (LVD)

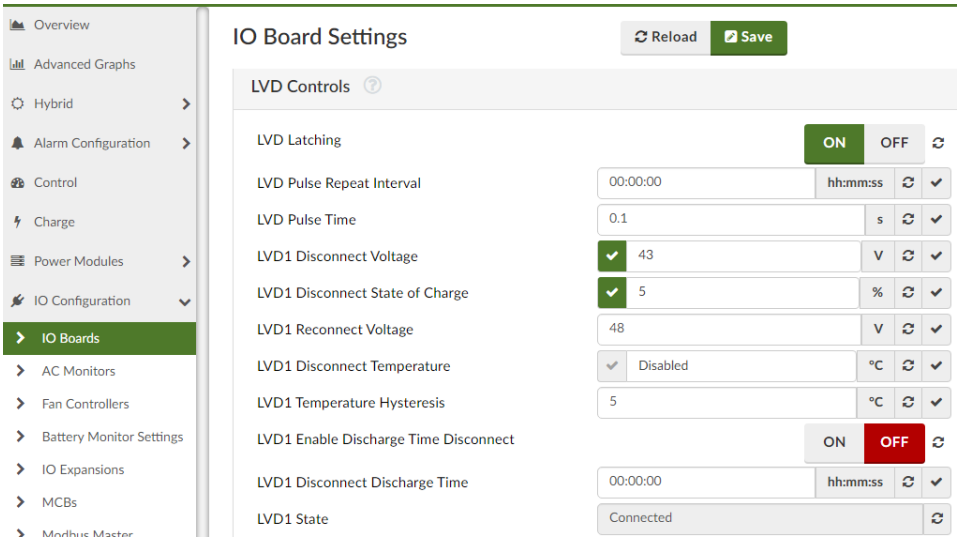
The DC system is designed to have batteries connected to maintain DC supply when the AC supply has failed. The batteries have a finite capacity and are designed to support the DC system for only a predetermined period of time. When the battery discharges below certain levels, permanent damage can occur to the battery. The LVD

function is designed to detect the end of battery discharge and disconnect the battery from the system to prevent damage. The battery reconnects again when the system recovers (e.g. AC power restored).

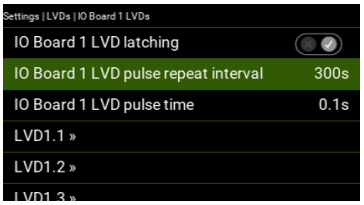
The LVD process provides a range of options to select how the battery disconnects. The LVD method selection is usually battery type dependent. Lead-acid battery LVD is typically set by voltage, when the voltage drops below the set threshold, the LVD contactor is opened, disconnecting the battery from the system. DC power will be lost to the load equipment at this moment, but the battery is preserved to recharge when the AC supply is restored. his voltage mode is the default mode of LVD operation. For lithium-phosphate batteries disconnect using State of Charge (SoC) may be preferred as more accurately calculated than voltaged. Disconnect options by temperature limit or time are also offered.

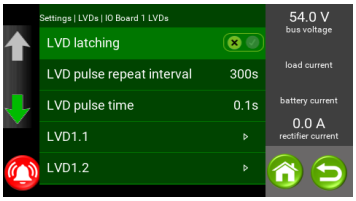
Low voltage disconnect settings are accessed:

- Using the Web UI at IO Configuration>IO Boards>LVD Controls



- Using the front panel at Settings>LVDs>IO Board 1 LVDs





The EM4x can control up to 2 magnetically latched contactors. It can control up to 3 Normally Open or Normally Closed LVD contactors. Magnetically latched contactors require no energy to keep them closed or open, only a pulse to make them change state, whereas N.O. or N.C. contactors require permanent energy to keep them in one state or the other.

Due to the stability and security of operation of magnetically latched contactors, Enatel uses them in preference to Normally Open or Normally Closed contactors.

Note that in most Enatel systems the EM4x is kept powered even after the battery LVD may have opened.

Note that when multiple disconnect options are enable the first circumstance encountered triggers a disconnect.

See 10.2.11 Low Voltage Disconnect (LVD) for the LVD connections to the EM4x.

LVD Latching: toggle LVD functionality **ON**.

LVD Pulse Repeat Interval and **LVD Pulse Time** are settings which in usual operation require no modification from the default 5 minutes and 0.1 seconds respectively.

LVD1 Disconnect Voltage: the default LVD setting to disconnect by voltage. The default setting for lead-acid battery systems is 43V.

LVD1 Disconnect State of Charge: the percentage of full charge that the batteries disconnect at. This varies considerably by battery type and directly impacts battery health. Consult your battery vendor for information on the appropriate settings.

The user must be aware of the consequences of discharge level on the battery health. Enatel accepts no responsibility for incorrect use of this function.

LVD1 Reconnect Voltage: the voltage the battery reconnects to the bus. The default setting for lead-acid battery systems is 48V. Note it is the DC bus that must reach this voltage level for reconnection, not the battery voltage.

LVD1 Disconnect Temperature: the temperature the battery disconnects at when the battery temperature is greater than the value set.

LVD1 Temperature Hysteresis: allows differentiation of the battery reconnect temperature relative to the disconnect temperature. The hysteresis sets a reconnect temperature lower than the Disconnect Temperature. For example, if the hysteresis is 5° and the disconnect temperature is 45° the battery reconnects at 40°. This provides a buffer to allow the battery internal temperature to drop to safe levels or prevent incorrect restarts.

LVD Disconnect Discharge Time: when enabled this sets a period of time the battery discharges for.

For LVD 2 and 3 these settings are made to either align with LVD1 or be significantly different to clarify what are the active parameters.

13.4 Control

13.4.1 Rectifiers

Access level required: *enaadvanced*.

In typical usage the parameters in the Control>Rectifier section are not recommended to be changed.

Rectifier Phases

Sets the phase number as 1 or 3.

Rectifier Voltage Regulation Enabled

The purpose of this feature is to improve the accuracy of the float voltage to the batteries. The default setting is ON.

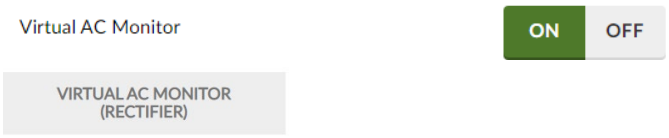
The long term float voltage, when the battery is fully charged and drawing almost no current, is one of the most important parameters affecting the battery life. Voltage is sensed at the DC system bus. With this enabled, as the system load increases (& the rectifier output voltage droops due to circuit resistance), the EM4x ensures that the voltage at this point is maintained. In systems without this active voltage control, typical regulation will be up to -0.5V from zero to full load. With this enabled, regulation can be reduced to better than 0.1V and is often better than 20 or 30mV.

Rectifier Current Share Enabled

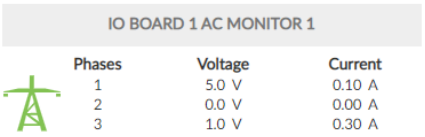
This feature provides for the EM4x to more accurately current share than to rely on the default current share in-built in the rectifiers as this is critical to the long-term health of a DC system. The default is ON.

Virtual AC Monitor

The Virtual AC Monitor when ON is where the AC parameters are measured from the rectifier. This displays on the Overview page as Virtual AC Monitor (Rectifier) and only provides a voltage reading.



The **Virtual AC Monitor** toggled **OFF** is used when a dedicated AC Monitor card is installed. The relevant information from the AC Monitor card then displays on the Overview page.



See 13.2 AC Monitoring for more details.

Enable Voltage Sense Fail alarm

This is **ON** by default, to warn if the rectifiers are measuring a different input voltage than the IO Board. It is only turned off in specific system dependent use cases or fault finding.

Float Voltage

Float voltage is a system critical parameter that defines the voltage that the load is supplied at, and the voltage the batteries are charged to. This setting is battery type specific.

NOTE: for energypak's lowering the float voltage below 56.7V limits the energypaks' capacity. That is, battery back up time is reduced if the float voltage is lowered.

Minimum and Maximum Rectifier Voltage

These values are either default or set by the site limitations of load equipment and the allowed voltage range.

Minimum and Maximum Rectifier Module Power and Current

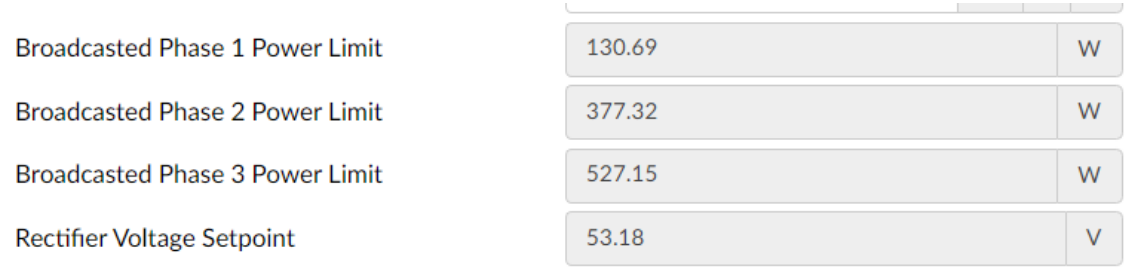
These settings are default and available to be modified typically only for factory purposes.

Rectifier Urgent Fail Threshold

This figure sets the limit for change in alarm from Rectifier Fail or Rectifier Missing to Rectifier Urgent Fail and Missing. The option is provided for systems with a large number of modules and available redundancy such that a customer may wish to differentiate the alarms and not require call out for a specific number of failures.

Broadcasted Phase 1,2,3 Power Limit & Rectifier Voltage Setpoint

These are parameters that are displayed when phase balancing is enabled. They are primarily included for troubleshooting purposes.

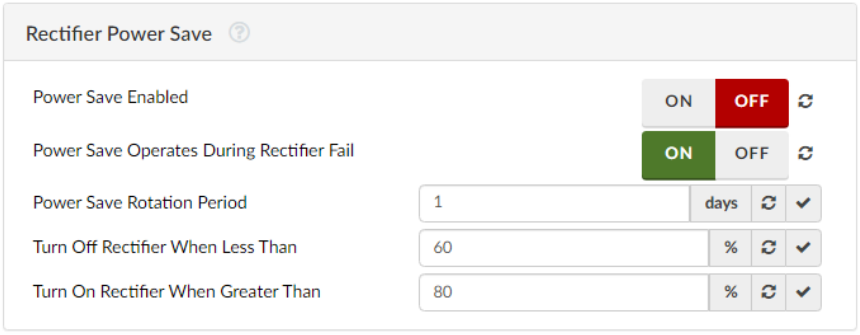


13.4.2 Rectifier Power Save

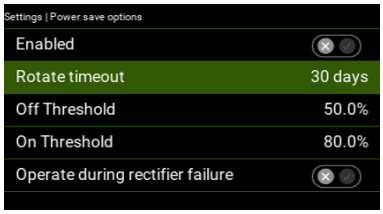
The controller is capable of controlling a DC system in a mode that reduces power consumption as rectifiers are more efficient at higher output currents. It does this by shutting down (into a "cold standby" state) enough rectifiers to make the remaining rectifiers operate at the higher efficiency load.

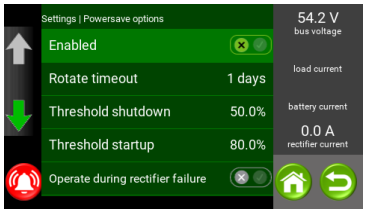
The Power Saving Mode is accessed:

- Using the Web UI at Control>Rectifier Power Save



- Using the front panel at Settings>Power save options





The Power Saving Mode works by progressively shutting down rectifiers that are not required to meet the load demands of the system. The mode becomes active when enabled and none of the cancellation conditions (see below) are active. When active it waits 60 seconds then will turn one rectifier module off if the load current is below the "Turn Off" percentage (e.g. 50%). If the load is still lower than the "Turn Off" percentage for the remaining rectifiers, it will wait 60 seconds then shut down a further rectifier. This process will continue until the load current is greater than the "Turn Off" percentage for remaining rectifiers. To maintain n+1 redundancy, there will always be a minimum of two rectifiers that remain active regardless of how small the load is. This is because those rectifiers that are shut down in their "cold standby" state, take some seconds to ramp back up to full power.

If the load current increases so that it is above the **Turn Off Rectifier When Less Than** percentage, one rectifier will turn on again. If the load is still greater than the **Turn On Rectifier When Greater Than** percentage of the rectifiers on, a further rectifier will turn on after 60 seconds. This process will continue until the load current is less that the "Turn On" percentage.

Power Saving Mode will immediately cancel if any one of the following occurs:

- a rectifier fails
- a mains fail occurs
- any rectifier goes into current limit
- a Battery Test occurs

Power mode will become active again when all these events have been cleared.

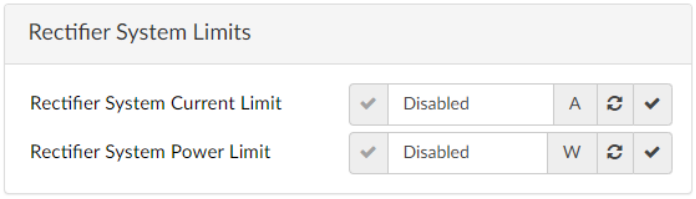
After the defined Auto Rotate Period the rectifier module that has been shutdown the longest will turn on and the next rectifier module in sequence will be shut down in its place. This rotation can ensure that all rectifiers get even usage.

This mode can only be used in concert with rectifiers having serial numbers beginning 0819xxxxxx (i.e., manufactured after 2008) or greater. If used with earlier rectifiers, these rectifiers will not respond to power saving commands.

13.4.3 Rectifier System Current and Power Limit

CAUTION **Use this function with care. If these values are set too low it may be possible after a battery discharge to end up in a state where there is insufficient current to power the load AND charge the battery. If this occurs, the battery will continue to discharge, eventually causing the site to go off air. Enatel cannot be held responsible for miss-application of this function and these parameters.**

Access from the Web UI, Control>Rectifier System Limits:

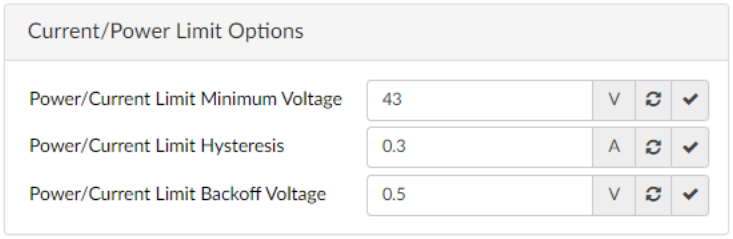


In specific system scenarios it is desirable to limit the rectifier output to a setting lower than their maximum. This may be used when the AC grid feed is constrained and is a way of limiting input current. The current and the power is the total system output current or power (not the current or power per module).

This function is **not** the same as the Rectifier Current & Power Limits that are set in the rectifier module EPROM in the Control>Rectifier section.

13.4.4 Current/Power Limit Options

This section is used for legacy non-HE Enatel rectifiers.



This is not the same as setting the **Rectifier Current Limit**. See Minimum and Maximum Rectifier Voltage.

Power/Current Limit Minimum Voltage

Current & power limiting operate by lowering bus voltage. Set this value to a level that is higher than the LVD trip threshold to guarantee that abnormal operation of the current limit does not cause complete system failure.

Power/Current Limit Hysteresis

As the bus voltage decreases to achieve the target Current Limit this hysteresis is applied to prevent "hunting" around this set point.

For example, if a battery size is 100Ahrs, and the Battery Current Limit is set to 25%, then the target current is 25A – 1A hysteresis, making it 24A.

This setting is usually only relevant in larger systems with larger batteries where a small increase in voltage results in a large increase in battery current.

The default setting is 1A, however, in larger systems (with batteries of say, >1000Ahrs) this can increase to 5 or 10A, or about 1% of the total battery Ahrs.

Power/Current Limit Backoff Voltage

This is the voltage step that the EM4x will reduce the bus voltage by as soon as one of the Current/Power Limits is exceeded. This should immediately cause the over-current situation to cease.

The EM4x will then increment the voltage in smaller steps so that the current/power threshold can be carefully controlled.

This setting is useful during Hybrid control set-up where it may be desired to reduce generator load by smaller amounts rather than a large step change. This can help prevent generator over-run/over-speed.

13.4.5 DC Converters

Converter Voltage Regulation Enabled

The purpose of this feature is to improve the accuracy of the float voltage to the batteries. The default setting is ON.

The long term float voltage, when the battery is fully charged and drawing almost no current, is one of the most important parameters affecting the battery life. Voltage is sensed at the DC system bus. With this enabled, as the system load increases, the EM4x ensures that the voltage at this point is maintained. In systems without this active voltage control, typical regulation will be up to -0.5V from zero to full load. With this enabled, regulation can be reduced to better than 0.1V, and is often better than 20 or 30mV.

Converter Current Share Enabled

This feature provides for the EM4x to more accurately current share than to rely on the default current share in-built in the converters as this is critical to the long-term health of a DC system. The default is ON.

Converter Voltage Setpoint

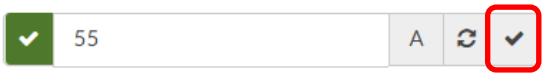
Enter the required voltage to set the voltage output of the converters.

Converter Current Limit

1. Click the left side icon to enable converter current limit.

2. Enter the required figure.

3. Click the right side icon to save the changes.



DC Converter Urgent Fail Threshold

This figure sets the limit for change in alarm from Converter Fail or Converter Missing to Converter Urgent Fail and Missing. The option is provided for systems with a large number of modules and available redundancy such that a customer may wish to differentiate the alarms and not require call out for a specific number of failures.

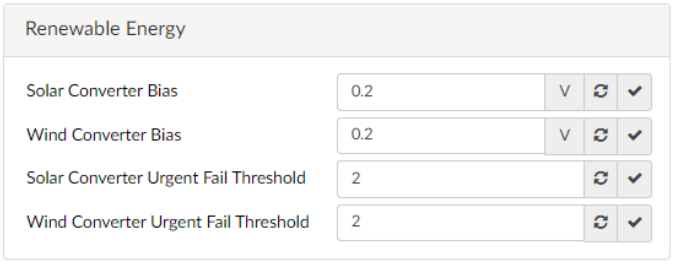
13.4.6 Renewable Energy

When solar and/or wind modules are present in the system the Renewable Energy section displays.

The Converter Bias is set to force the load to be supplied from the renewable modules as a priority over the rectifiers.

NOTE: the default value for the bias is .2V.

The Urgent Fail Threshold is the number of modules that must fail before the Urgent Fail alarm is raised. This is done to allow a priority of warning or critical alarms settings if there is n+1 redundancy on the modules.



13.5 Charge

In the Charge>Charge Settings page details of the charge options are provided. The information displayed on this page is battery type specific.

If a charge function is prevented from initiating the cause displays in the **Inhibit Reason** field.

13.5.1 Lead-Acid Fast Charge

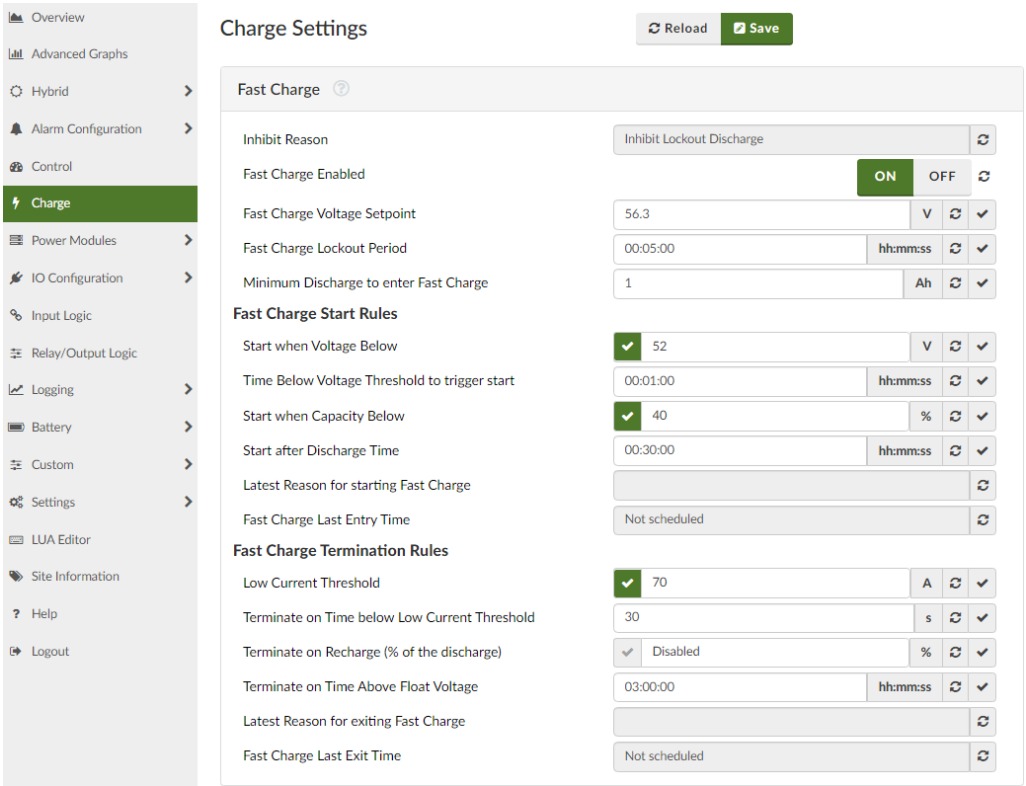
The controller has an optional Fast Charge feature for lead-acid batteries. This feature aims to reinstate the batteries to the fully charged state as quickly as possible after a discharge, without damaging the batteries.

When Fast Charge is enabled the controller measures any battery discharge, recording the amp-hours of that discharge. When the recharge begins it raises the charge voltage to a higher level until the total discharged amp hours has been returned to the batteries plus a percentage.

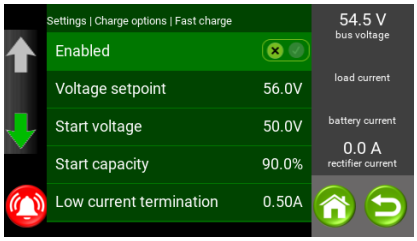
Fast Charge, once activated, will remain active until the Recharge capacity has been returned to the battery or the Fast Charge time limit expires.

Access Fast Charge:

- Using the Web UI at Charge the Fast Charge section



Using the front panel at Settings>Charge options>Fast Charge



Fast Charge Voltage Setpoint is the target bus voltage that the EM4x tells the rectifiers to aim for during the Charge session. Set this value to that recommended by the battery manufacturer (usually between 2.3V/cell to 2.4V/cell (55.2 and 57.6 for 48V systems) at 25°C). Note that this voltage is temperature compensated.

Fast Charge Lockout Period is, when enabled, the period of time after completing fast charge set up before a fast charge may occur, as might be required during commissioning for example.

Minimum Discharge to enter Fast Charge is a value set to protect against effective false triggers.

Start when Voltage Below is where if during a discharge the bus voltage drops below this level then Fast Charge will be enabled during recharge. This is subject to some other general conditions for fast charge being allowed to start. The bus voltage must remain below the voltage setpoint for a full 30 seconds before this initiates a fast charge start.

Time Below Voltage Threshold to trigger start is a time limit to ensure correct triggering of the Start when Voltage Below parameter.

Start when Capacity Below is the battery capacity that if the battery gets below during a discharge, the EM4x will initiate the Fast Charge when AC power is restored. For example when set at 90%, if you have a 400Ahr battery, and you have a discharge event that takes out 36Ahrs (i.e., say 9A for 4 hours), then when AC is restored the Fast Charge will not be activated. However, if the discharge is a 40.4Ahrs (i.e., say 10.1A for 4 hours), then when AC is restored the Fast Charge routine will be activated. This is subject to other general conditions for fast charge being allowed to start.

Start after Discharge Time is where if a discharge lasts longer than the stated time, then Fast Charge will be enabled during recharge. This is subject to other general conditions for fast charge being allowed to start.

Low Current Threshold and Terminate on Time below Low Current Threshold is when during recharge, the battery voltage is within 0.5V of the target Fast Charge voltage (taking into account temperature compensation), and the Battery Current drops below this value for more than 10 minutes, the Fast Charge will cease, and the system will revert to Float Voltage. Note the figures stated are Enatel default and are customisable.

Terminate on Recharge (% of the discharge) is where if the Recharge amount is reached before the Fast Charge Time Limit elapses, then the Fast Charge routine will cease.
NOTE: the Recharge amount is the percentage of the Ahrs taken out of the system during the last discharge. The percentage entered here is not percentage of the battery capacity. For example, if this setting is 110%, and if 50Ahrs is taken out of the battery, Fast Charge will continue until 55Ahrs is put back in (unless the Time Limit is reached first).

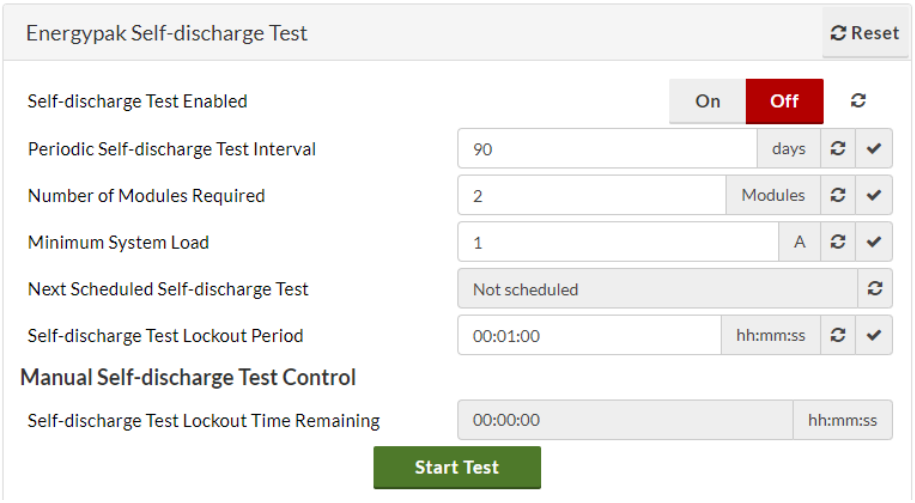
Terminate on Time Above Float Voltage provides a maximum duration for fast charge to be provided once recharge to float voltage is achieved.

13.5.2 Energypak Self-Discharge Test

CAUTION **Do not undertake battery testing with no load on the energyhub.**

The energypak Self-Discharge Test discharges each energypak in the system one at a time until it cycles through all the energypaks in the system. This is done **without** affecting the system bus voltage as each energypak uses its internal buck/boost circuit to perform the test. The EM4x then repeats this cycling process at set intervals, or if manually activated stops after one cycle of testing all the energypaks in the system.

This is designed differently from the Battery Test so that in typical usage the energypak Self-Discharge Test is able to undertaken during normal operation without compromising backup requirements.



Note **Number of Modules Required** which sets the minimum number of energypaks that are needed to populate the energyhub before the test is allowed to proceed. This can be configured to allow necessary backup or redundancy depending on the load during testing.

The **Minimum System Load** can be configured to ensure an energypak test discharges within an expected time frame, or while the system is behaving in an expected manner, for example.

A lockout period ensures that a test is not undertaken for a specific duration. For example, during an initial post commissioning period when energypaks shipped at 30% SoC are brought up to full charge.

Click on the **Start Test** button to initiate either a periodic or one time manual test depending on the settings made.

If another prioritized system process is active a test may not start. An in-process test may be over-ridden by a prioritized event.

NOTE: this test is to check the State of Health (SoH) of the energypaks. To test the capability of the energypaks to supply the load, use the Battery Test. See 13.5.3 Battery Test.

13.5.3 Battery Test

The Battery Test process is intended to test if the batteries can supply the load.

Lead acid, lithium, energypaks and other battery types can be tested using the battery test. With regards energypaks this tests all system energypaks simultaneously, to be discharged on-line using the system load. Which has inherent dangers compared to testing each energypak individually using the energypak self-discharge test. See 13.5.2 Energypak Self-Discharge Test. A battery test may compromise backup capability.

CAUTION Setting up Battery Test requires the user to be familiar with the type of battery they are using, its discharge characteristics, and the system load. The battery test time must be considered carefully. The voltage range of the test must be considered carefully. If the AC power should fail during the test or the subsequent recharge cycle, there should be enough capacity remaining in the battery to ensure security of the DC supply. If the voltage range is outside the battery normal operation the batteries could be damaged.

Enatel cannot be held responsible for a user's lack of knowledge or miss-application of this feature.

CAUTION **Do not undertake battery testing with no load on the energyhub.**

When a battery test begins, the rectifier modules are turned down to a voltage just below the specified termination voltage. (This ensures that if the battery does not perform, the rectifiers automatically re-assume the load.) The battery test continues for either the **Battery Test Duration** specified or the **Battery Test Minimum Voltage** is reached, whichever comes first. If the test ends due to the time expiring then the test is a pass. If the test ends due to the termination voltage being reached, this is a fail and a **Battery Test Fail** alarm is generated.

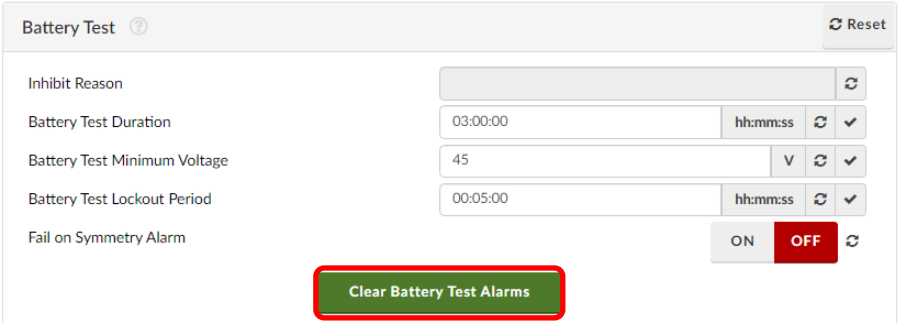
The battery test time must be considered carefully. If the AC power should fail during the test or the subsequent recharge cycle, there should be enough capacity remaining in the battery to ensure security of the DC supply.

Battery tests may be activated manually or set to run periodically. The manual test is performed using all the periodic test criteria.

Battery Test Lockout Period may be set to ensure that battery tests are not attempted too soon after a previous discharge event, whether that event was a simulated or a real discharge. This ensures the battery is fully recovered before further tests are allowed.

Some active system processes can prevent a test occurring. A battery test may be over-ridden by a prioritized event.

The failure of a battery test produces a **Battery Test Fail** alarm. This alarm will remain active until the next test or until reset via the **Clear Battery Test Alarms** button.



Fail on Symmetry Alarm: if this is enabled and the **String Asymmetry Setpoint** is exceeded the battery test will cease, and the **Battery Test Fail** alarm is raised. See the Battery Settings>Battery String Configuration section for the **String Asymmetry Setpoint**.

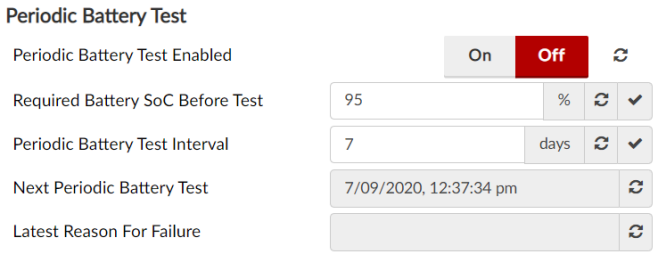
Periodic Battery Test

Periodic Battery Test Enabled toggled **ON** performs a battery test every **Periodic Battery Test Interval**.

The **Required Battery SoC Before Test** is set to prevent the battery test starting after a discharge event when the batteries may be at a charge too low to provide required back up

Next Periodic Battery Test states the duration till the next test is scheduled to run.

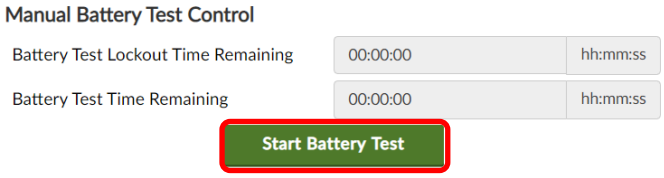
Latest Reason for Failure displays a record of why the previous test was cancelled.



NOTE: Periodic battery test must be enabled for DC systems configured with the phase balancing licence unlock features. Should a periodic battery test fail, phase balancing is inhibited.

Manual Battery Test Control

Click on the **Start Battery Test** button to manually start a battery test.



Battery Test Lockout Time Remaining indicates if a **Battery Test Lockout Period** is active and the duration before a battery test may be performed.

Battery Test Time Remaining is the duration a currently running battery test requires to complete the test.

13.5.4 Lead-Acid Equalise

Lead-Acid Periodic Equalise

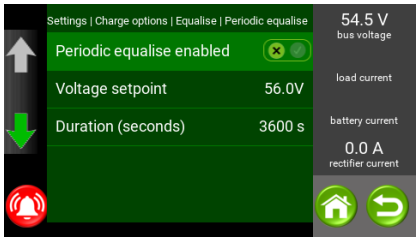
The Periodic Equalise function allows lead-acid batteries to be charged on-line at an elevated voltage for a set period of time. This charge function will repeat automatically at the specified interval. The initial interval begins from when the Periodic Equalise function is enabled or the interval changed.

A periodic equalise will not occur if a battery test or manual equalise is active. It will cancel that instance and try again after the next interval.

Access Periodic Equalise:

- Using the Web UI at Charge>Equalise.

- Using the front panel at Setting>Charge options>Equalise>Periodic equalise



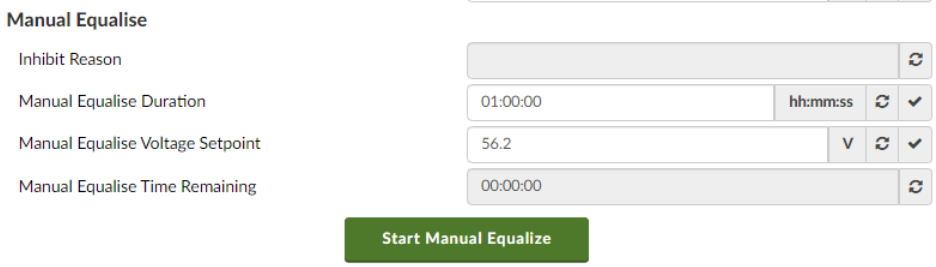
Lead-Acid Manual Equalise

The Manual Equalise function allows lead-acid batteries to be charged on-line at an elevated voltage for a set period of time. This function must be manually enabled each time this charging is to occur. It is disabled when the charge cycle is complete.

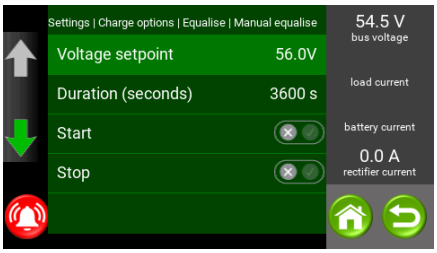
A manual equalise cannot be instigated if a battery test or periodic equalise is currently active.

Access Manual Equalise:

- Using the Web UI at Charge the Equalise section



- Using the front panel at Settings>Charge options>Equalise>Manual equalise



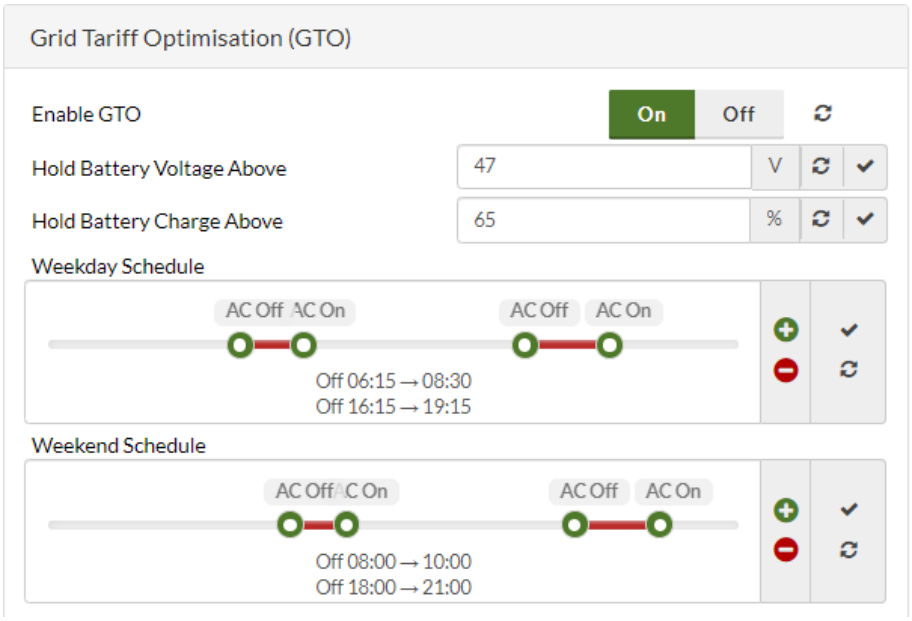
13.5.5 Grid Tariff Optimisation (GTO)

NOTE: Grid Tariff Optimisation is a license locked feature. See 11.4.3 Unlockable Features.

Grid Tariff Optimisation is a function that can be used with the EM4x controlled DC systems incorporating any battery type. The GTO feature enables the user to select certain periods during the day where the DC system can be "turned down" to zero power draw from the AC grid. During this period the site is powered from the batteries for the specified period or until the battery reaches a pre-determined voltage/discharge level. Multiple periods per day can be selected, and the user can set 2 different period settings, typically used to differentiate weekday and weekends separately.

The safety parameters to cease battery discharge during GTO are based on SoC (**Hold Charge Above**) or voltage (**Hold Battery Voltage Above**).

The following is an example of the setup page (on the EM4x Control page):



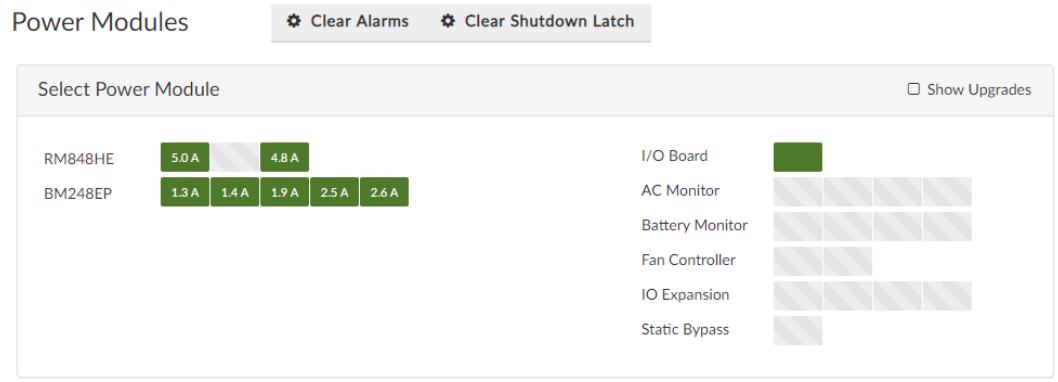
Adding or subtracting GTO periods is done by clicking on the "**+**" or "**-**" symbols. The length of time for each period is adjusted by sliding the OFF and ON icons. The increments are in 15 minute intervals.

NOTE: GTO has low priority compared to other system user controlled functionality. An energypak self-test overrides a GTO.

Which days are selected as the **Weekend** are managed with the **Weekday Classification** table. Enable the check boxes to specify which days are managed under the **Weekend Schedule** period selector.

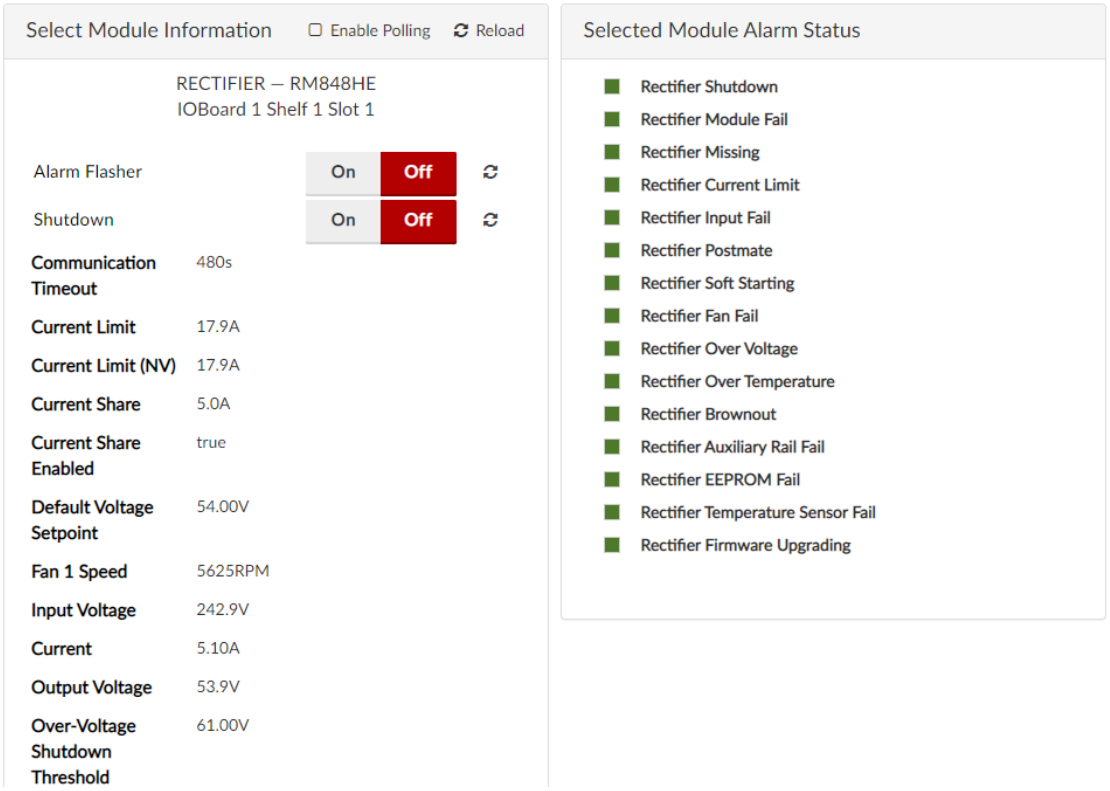
13.6 Power Modules

The Power Modules>Power Modules page displays the power modules present in the system along with ancillary boards and cards.



Click on a module to bring up details on each module and associated alarms.

NOTE: the module is displayed in its respective shelf location.



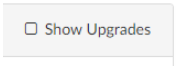
Toggle the **Alarm Flasher** to have the orange LED blink on the selected module. This feature is to assist positive identification of a module at site.

Toggle **Shutdown** to turn off the module where clicking the **On** button shuts the module down. The module remains shutdown until toggled **Off**.

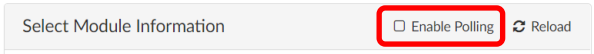
Click on the **Clear Alarms** button to clear module alarms raised. This is usually used during maintenance and commissioning where moving or replacing modules raises a Rectifier Missing or Rectifier Missing Urgent alarm or similar.

Click on the **Clear Shutdown Latch** to manually clear a shutdown latch of a module.
Comment: while latching for over temperature or over voltage where the module is shut down (i.e. locked out from attempting to restart) can be enabled for each module, in modern DC systems this is seldom used.

For use of the **Show Upgrades** check box see 14.6.3 Upgrading Non-Controller Firmware.



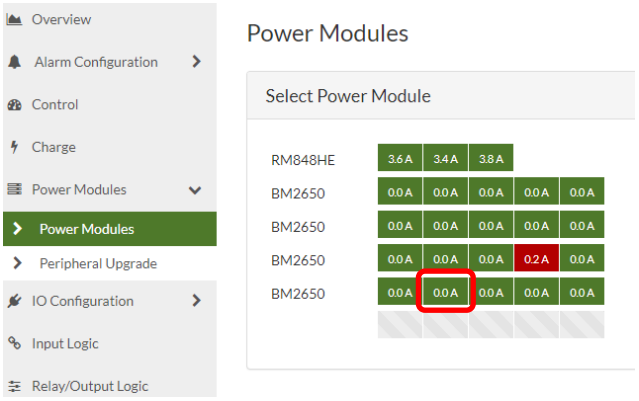
Click on the **Enable Polling** check box in the **Select Module Information** section bar to have the information of the selected module automatically refresh on the page.



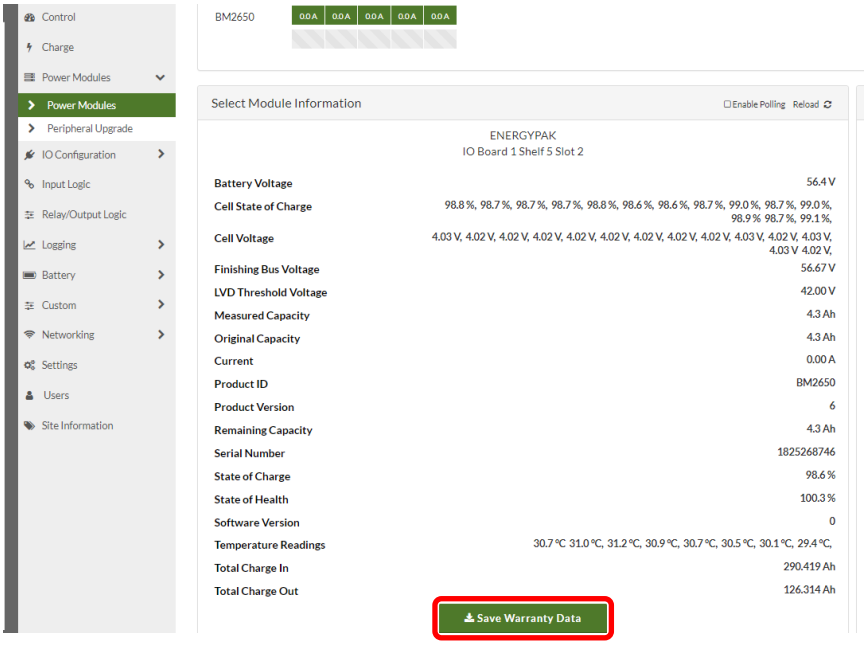
13.6.1 Energypak Warranty Data

When used in conjunction with the Enatel energypak, the EM4x has two options to download the warranty data of the energypaks.

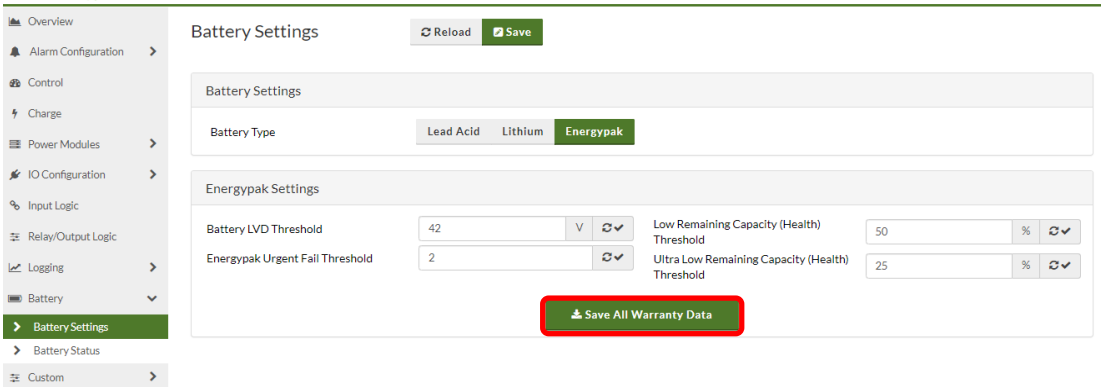
1. Individual energypak warranty data can be downloaded by:
    a. Navigate to the Power Modules>Power Modules>Select Power Module page.
    b. Click on a specific energypak.



    c. Click on the **Save Warranty Data** button.



2. Warranty data of all the energypaks compiled together can be downloaded on the Battery>Battery Settings page by clicking on the **Save All Warranty Data** button.



NOTE: file size can be large and considerable time required to download.

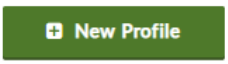
13.6.2 Profiles

All Enatel power modules are shipped configured with a parameter profile, either default factory settings, or configured for a specific DC system. These setting provide hard limits that the controller cannot override and are the limits the system works to if the controller fails or comms are lost.

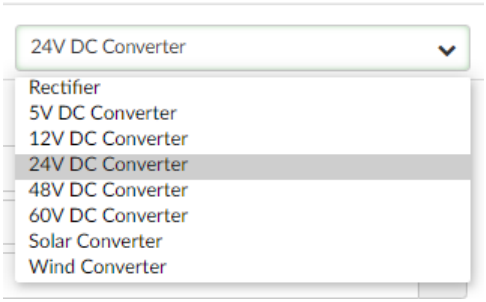
These settings may need to be changed after installation, perhaps new equipment has been added to the site load with different voltage limitations, perhaps new breakers are installed and the modules' output limits need to be adjusted to suit.

Some or all of the power modules profiles can be modified at Power Modules>Profiles.

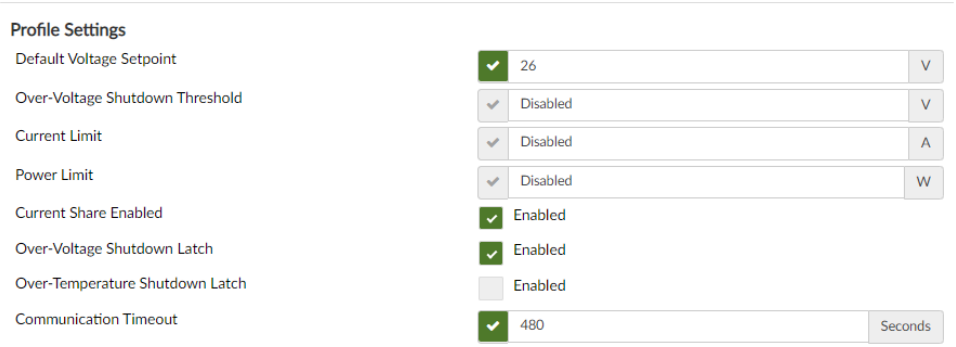
1. Click on the **New Profile** button.



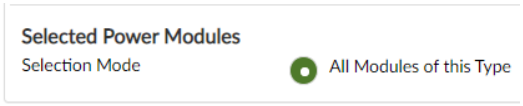
2. Select the **Profile Type** from the drop down menu.



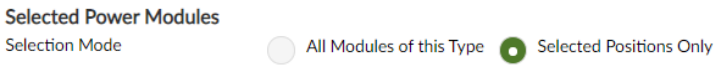
3. Click on the check boxes to enable features or adjust settings.



4. Click on the **All Modules of this Type** radio button to modify all of the power modules of this type in the system to match the new settings.



5. Click on the **Selected Positions Only** radio button to choose which modules in the system array to have the new profile loaded into.



6. Click on the required **IO Board**.

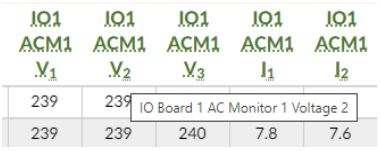
7. Click on the module required and modify the **Profile Settings**.
8. Click on the **Save** button to write the new settings to memory.

13.7 Logging

The EM4x controller records and displays detailed system parameters. These are accessed via the Web UI under Logging.

1. **Periodic Logging:** records a wide suite of system functionality parameters. Both default system and custom variables can be logged. Note that file size can be large and varies in proportion to the polling rate set at Logging>Periodic Logging>Show Settings>**Logging Interval** in the Web UI. Also note that events are overlaid into this log, so that if there is say a 5 minute periodic log, you may see a number of logs between the 5 minute markers which would have been triggered by events "rising" or "falling".

NOTE: mouse-over column headings for full descriptions of each item.



3. **Battery Logging:** records battery specific related information such as logs of individual energypak performance.
4. **Energy Logging:** records information regards the time stamped status of battery charge and discharge, the load and rectifier usage all in Wh to assist clarity of overview. Records of custom metering configured in the Web UI under Custom>Custom Metering also appear here.
5. **Power Module Log:** records information regards individual power modules such as rectifiers and DC converters from the bus. Note it is not recommended to have this poll continually, it is intended to be a time limited analysis tool, only. The default state of this log is **Off**. To activate this log, click on the **Show Settings** button and toggle Power Module Logging **On**.
6. **Hybrid Event Log:** records the date stamped events and status change of hybrid equipment.
7. **Hybrid Cycle Log:** records detailed information of each hybrid cycle.
8. **Real Time Metering:** records and displays a list of system performance indicators shown in a time scale format. The system metrics displayed are generated automatically. Click on the **Previous** tab to show the equivalent values for the period of time immediately preceding the time blocks displayed on the **Current** page.

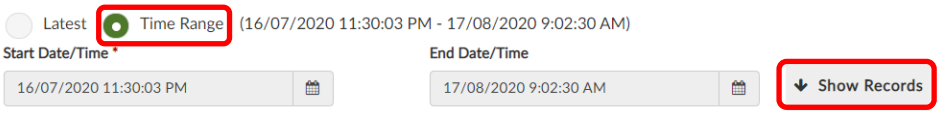
Metering	5 Minutes	Hour	Day	Month
Inverters	91.01 Wh	351.71 Wh	14,432.72 Wh	82,122.27 Wh
Battery Charge	10.08 Wh	40.95 Wh	1,911.16 Wh	56,918.01 Wh
Battery Discharge	0.00 Wh	0.00 Wh	0.00 Wh	43,593.61 Wh
12V DC Converters	0.32 Wh	1.21 Wh	48.90 Wh	242.58 Wh
48V DC Converters	0.00 Wh	0.00 Wh	0.00 Wh	0.00 Wh
Solar Converters	62.18 Wh	284.08 Wh	1,213.37 Wh	23,491.53 Wh
Wind Converters	0.00 Wh	0.00 Wh	0.00 Wh	0.00 Wh
Generator 1	0.00 Wh	0.00 Wh	0.00 Wh	44,931.12 Wh
Generator 2	0.00 Wh	0.00 Wh	0.00 Wh	2,726.08 Wh
Grid	71.31 Wh	235.91 Wh	20,387.47 Wh	52,545.39 Wh
Load	123.52 Wh	479.07 Wh	19,688.61 Wh	110,488.45 Wh
Rectifier	71.42 Wh	235.94 Wh	20,387.18 Wh	100,322.46 Wh
Custom Metering	**5 Minutes**	**Hour**	**Day**	**Month**
Battery Power	10.08 Wh	40.95 Wh	1,911.16 Wh	13,324.39 Wh
Rectifier Power	71.42 Wh	235.94 Wh	20,387.18 Wh	100,322.46 Wh
Solar Power	62.18 Wh	284.08 Wh	1,213.37 Wh	23,491.53 Wh

All pages except Real Time Metering follow the same functionality as outlined in this Hybrid Event Log example.

13.7.1 Hybrid Event Log

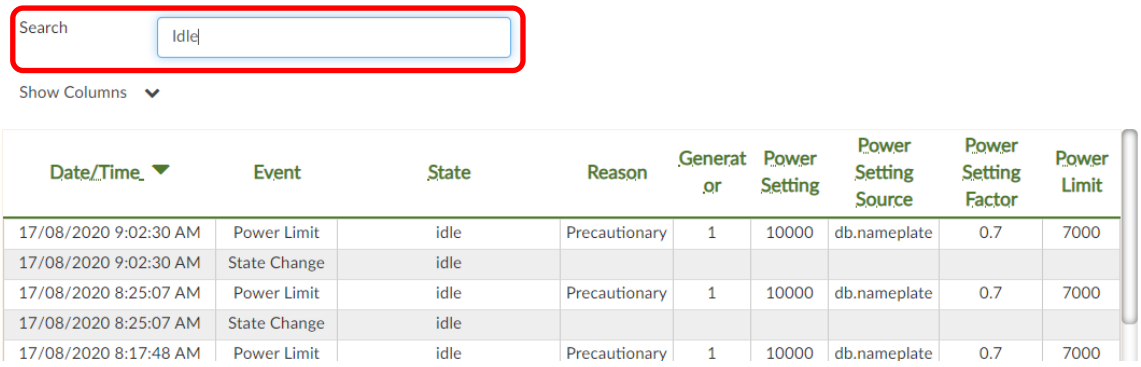
The Hybrid Event Log lists date stamped events and status changes of the hybrid equipment. The Hybrid>Hybrid Event Log page has various features to assist filtering the logs displayed along with download options to obtain the information in an .xml or csv file. Both file types can be opened in Excel.

Click on the **Time Range** radio button to select the required time range. Click on the **Show Records** button to display the selected range.

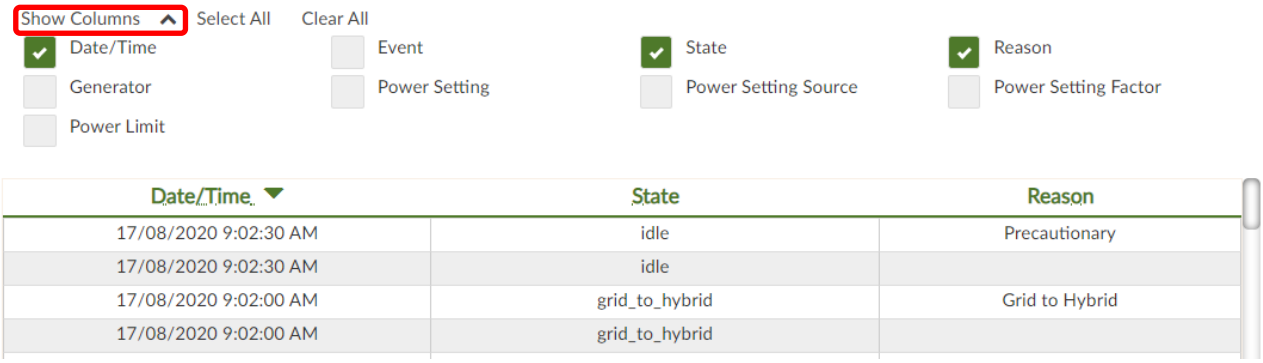


Enter the number of records required in the **Number of Records** field. Click on the **Show Records** button to display the required number.

Enter a parameter into the Search bar to quickly filter results.

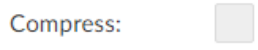


Click on **Show Columns** to display all the log column headers. Enable or disable each check box to limit the columns displayed as required.



Choose between XML or CSV format for the log download file.

Click on **Compress** to compress the log file to be downloaded.

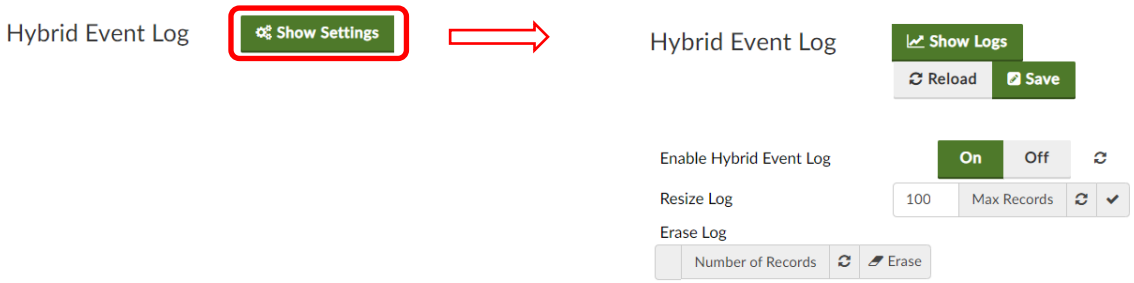


Click on **Download selected** to download only those logs selected or Click on **Download all** to download all logs in memory. Note that large log files can take considerable time to download.

NOTE: both *.xml and *csv files can be opened in Excel.

Click on **Show Settings** to access **Log Settings** and other controls, to toggle logs on and off, to define how many logs are kept in memory, and to clear logs from memory.

NOTE: logs are typically erased during commissioning to ensure that any prior records are not in memory.



Click on **Show Logs** to return to the log display page.

13.8 Battery Settings

13.8.1 Battery Type

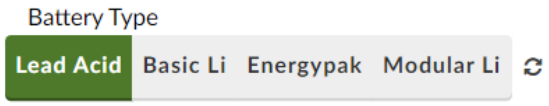
Many of the energy manager functions depend on the type of batteries associated with the DC system to be monitored.

The energy manager must be configured for use with the correct battery type when batteries are included in the system.

For typical applications the configuration file provided with the energy manager is set to the use case default batteries.

NOTE: the energy manager is not able to manage multiple battery types in the default factory configuration. Should a mix of battery technologies be required for a DC system please consult your Enatel sales representative.

See Battery>Battery Settings in the Web UI:



Lead Acid are the traditional lead acid batteries used in the telecom industry.

Basic Li are Lithium chemistry based batteries whose BMS cannot be communicated with via Modbus RTU.

Modular Li are a limited group of batteries whose BMS can be communicated with via Modbus RTU. Contact your Enatel representative for the full list of batteries with this functionality.

For further details regards the Enatel **Energypak** battery functionality refer to the energyhub installation manual.

13.8.2 MCB Current Limit Scaling

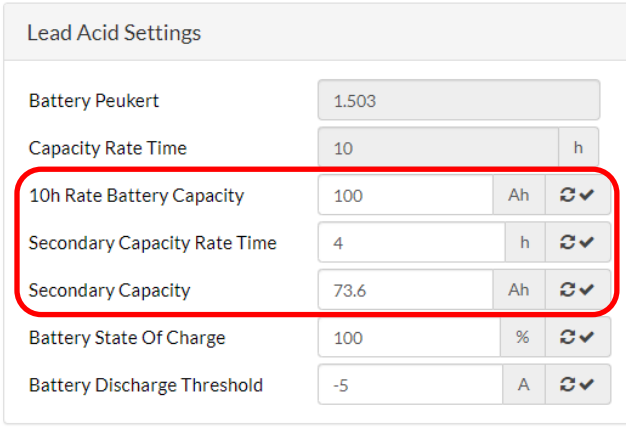
The main circuit breaker current limit scaling feature is enabled in systems that rely on voltage drop across a battery circuit breaker to detect if the battery circuit breaker is open or closed. This feature is disabled in systems where the breaker status is detected by auxiliary contacts on the circuit breaker for example.

13.8.3 Lead-Acid Battery Capacity Settings

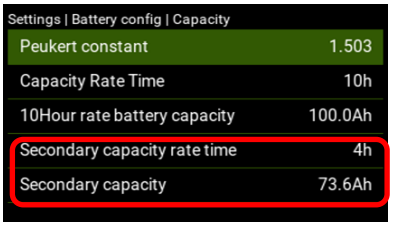
To calculate the battery capacity and discharge time remaining lead acid batteries require information entered under Battery>Battery Settings. The **10h Rate Battery Capacity**, the **Secondary Capacity Rate Time** and the **Secondary Capacity**. Refer to the battery specification sheet for this data. Note that the Ah values entered in this section are for the total battery capacity of the system (i.e. all strings added together).

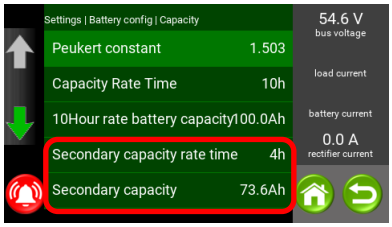
Access capacity settings:

- Using the Web UI at Battery>Battery Settings



- Using the front panel at Settings>Battery Config>Capacity





Battery State Of Charge can be used at the time of installation (or for testing purposes) in case the installed battery is not initially fully charged. Enter the value that the battery SoC is estimated. The value corrects itself once the battery has been on charge for some time or gone through charge/discharge cycles.

Battery Recharge Efficiency is a setting to assist capacity exit conditions during battery cycling. It is how good the battery is at storing energy e.g. 97% is being converted into stored charge - 3% of inefficiency of charging so the battery is over charged by 3% to account for the losses.

Battery Discharge Threshold is a buffer to prevent false triggering of discharge notification.

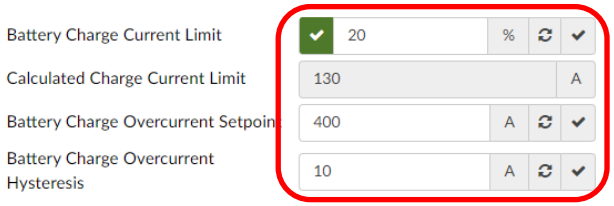
13.8.4 Battery Current Limit

It is important to prevent batteries being charged faster than the recommendations of the manufacturer. Lead-acid batteries charging too fast can cause excessive gassing in the battery and can also damage the battery.

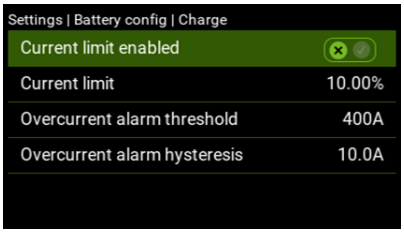
The controller allows for the maximum battery charge current to be limited to a percentage of the battery capacity. The rectifiers, if this function is enabled, reduce their output voltage so that the load current is supplied as normal, but the battery current is limited.

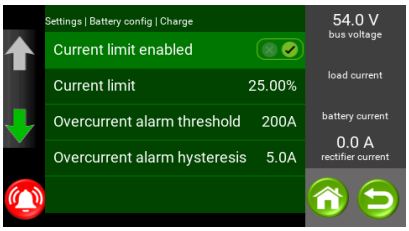
Access the Battery Current Limit settings:

- Using the Web UI at Battery>Battery Settings in the Lead Acid Settings section



- Using the front panel at Settings>Battery Config>Charge

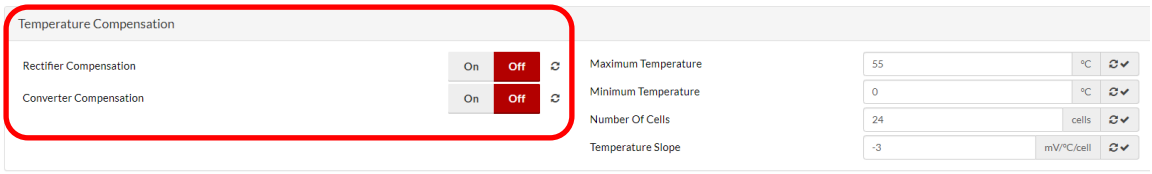




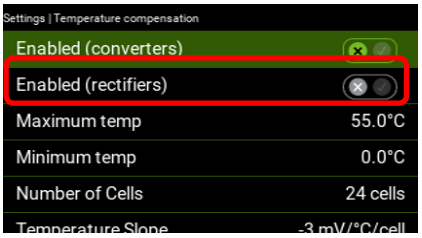
13.8.5 Temperature Compensation

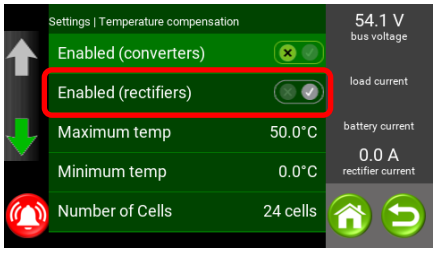
Lead-acid battery manufacturers recommend that the float voltage of the battery is decreased at the temperature increases. The controller will automatically adjust the float voltage of the rectifiers with temperature when the temperature compensation function is enabled.

With Lead-Acid batteries enabled in the Web UI, temperature compensation can be toggled on and off on the Battery>Battery Settings page in the Temperature Compensation section **Rectifier Compensation.**



From the front panel interface navigate to Settings>Temperature compensation>**Enabled (rectifiers)**





To set the **Maximum Temperature**, **Minimum Temperature** and **Temperature Slope** consult the relevant battery specifications.

Temperature compensation works only on the float voltage of the rectifiers connected to the controller. Any converters within the system are not affected by temperature compensation (Note the separate toggle option for Converter Compensation). Nor are equalise, fast charge or other process settings.

When temperature compensation is enabled, the two alarm states, High Float Alarm Bus 1 and Low Float Alarm Bus 1, are automatically varied with temperature along with the float voltage. This prevents false activation of these alarms under high and low temperature conditions.

Note the temperature compensation functions are also adjustable on the EM4x front screen under Settings>Temperature compensation.

Figure 22: Temperature Compensation

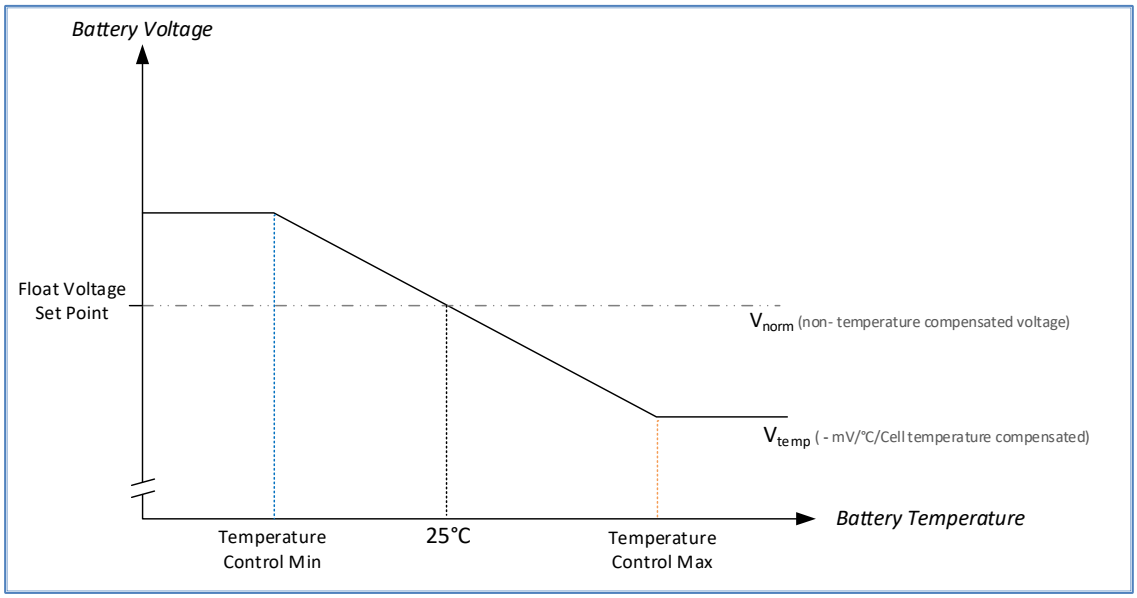


Figure 22 shows the temperature compensation function varies the float voltage of the system based on the float voltage set point, the slope and the measured battery temperature.

The float voltage should be set to the recommended float voltage for the batteries used at 25ºC. The temperature sensor should be placed by the batteries in a position that reflects the average temperature of the batteries.

At battery temperatures greater than the maximum Control Temperature (typically set to 50ºC) and less than the minimum Control Temperature (typically set to 0ºC) the system voltage will no longer change. Between the two control temperatures the voltage relates linearly to the temperature, see Figure 22.

13.8.6 Estimated Time Remaining (ETR)

This is an estimate of the time remaining until end of discharge, based on the system load current or the discharge current. As system load current varies, the estimate is continuously revised.

For lead-acid batteries, as the rate of discharge increases (e.g., going from a 10 hours discharge to s 2 hour discharge), the amount of energy (Ahrs or WHrs) the battery can supply reduces (Lithium batteries are almost linear in their energy capacity with respect to discharge rate). Hence the ETR is calculated using Peukert's equation. This requires the 10hr battery capacity and another capacity at a lower time (e.g. 5hour capacity) to function correctly. The Peukert's equation is as follows:

$$T = \frac{R(Ip)^n}{I^n}$$

Where:

T = time in hours

Ip = current at the specified capacity of the battery (for example If the Battery is rated at 10 discharge rate, then "Ip" is the current at C10 rate of discharge)

I = the discharge current

n = Peukert's exponent

R = the hour rating (i.e. 20 hours, or 10 hours etc)

NOTE: For lead-acid batteries the results are more accurate with new batteries as the Peukert's exponent, n, changes as the battery ages. This exponent is unique to each battery type and calculated in the controller from the two discharge rates supplied.

This is an estimate of the time remaining until end of discharge, based on the system load current. As system load varies, the estimate is continuously revised. This time estimate is formed using Peukert's equation and requires the 10hr battery capacity and the secondary capacity rate time to function correctly.

If multiple battery strings are connected to the system, all settings should be based on the total capacity of all the connected battery strings.

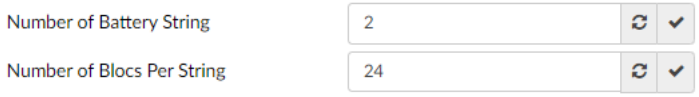
NOTE: For an energypak configured EM4x the SoC of the energypaks is compared to the load and an estimated back up time remaining is calculated based on the LVD setting. This is displayed on the controller front screen and in the Web UI as the **ETR**.

13.8.7 Battery String Configuration

The Battery String Configuration section allows for automated setup of the Battery Conditioning Monitoring (BCM) system. Should a setup of the BCM system not be covered by the automated setup, then the BCM mapping statements need to be written in the Input Configuration.

The Battery String Configuration settings can apply to any battery type depending on the battery cell/monobloc and string implementation.

Enter the **Number of Battery Strings** and **Number of Blocs Per String**.

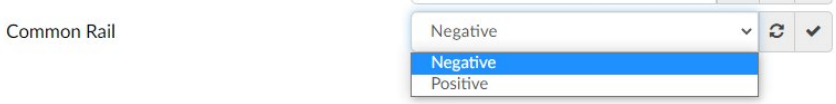


String Imbalance Setpoint is the threshold for an alarm to indicate the current from one string has deviated too far from the other(s). This may indicate a faulty connection or cell is present.

String Asymmetry Setpoint is the threshold to indicate a voltage disparity in a cell in a string of batteries.

String Overcurrent Setpoint is the threshold for an alarm to indicate one string is providing more current than expected – this can indicate a failure in another string, or an unexpected load demand.

Common Rail selection is a feature that changes the way information is displayed in the Web UI, whether positive or negative voltage. It has no system impact.



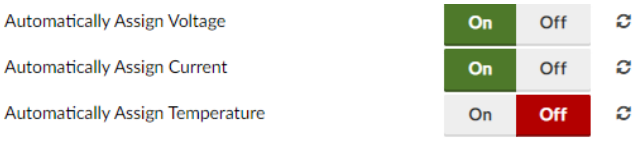
Commonnodes allows the user to auto-configure the battery monitoring system depending on whether the most positive and most negative connections to the battery are measured. In typical Telco +ve earthed systems, the most positive will be very close to the DC Earth, and the most negative will be very close to the Live bus voltage. With Commonnodes **ON** the controller assumes that it should use the common (same) voltages for the most positive and most negative voltages. So, for example:

Number of wires connected to each string for voltage measurement:

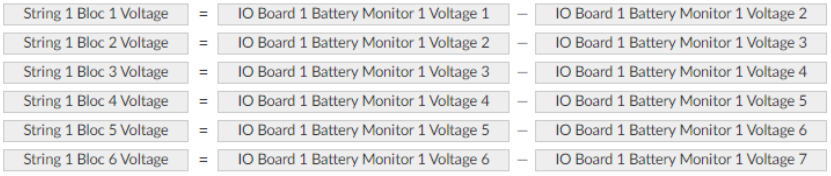
	Commonnodes **ON**	Commonnodes **OFF**
Mid-Point (effectively 2 "blocs" per 48V string)	1	3
12V Monoblocs (4 monoblocs per 48V string)	3	5
2V Monoblocs (24 blocs per 48V string)	23	25

With Commonnodes **OFF** although there are two more sense wires that must be connected to the batteries, this enables more accurate battery voltage as any voltage drop over any cables, shunts or breakers is not included in the measurements.

The **Automatically Assign Voltage**, the **Automatically Assign Current** and **Automatically Assign Temperature** functions when toggled **On** automatically assign the parameter reading from the battery monitor in the input logic.



Which displays in an expression table on the page.



Strings on Battery Monitor

Each battery monitor card can connect up to 5 strings of batteries. There may be circumstances with multiple battery monitor cards with differing numbers of strings per card. The settings here allow the energy manager to represent the strings in sequential order.

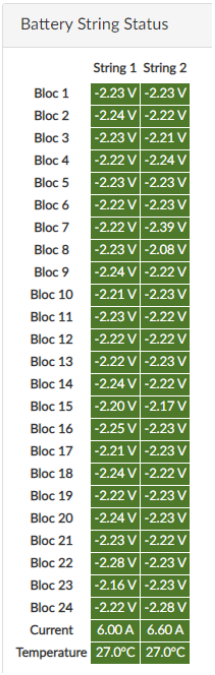
Enable the required Battery Monitors by clicking on the left side tick icon.

Enter the number of strings of batteries connected to the battery monitor.

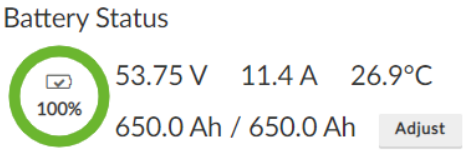
Click the tick icon on the right side to save the setting.

13.9 Battery Status

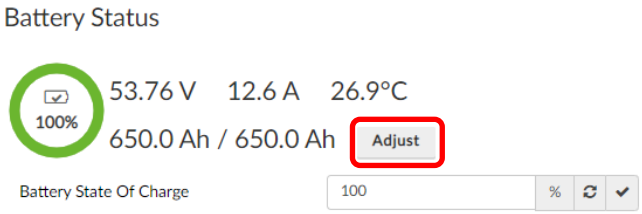
The battery status page provides an overview of the information received from the battery strings.



Along with the Battery Status summary.



Click on the **Adjust** button to manually set an override state of charge for the system.



Forcing a state of charge status is primarily used in system testing.

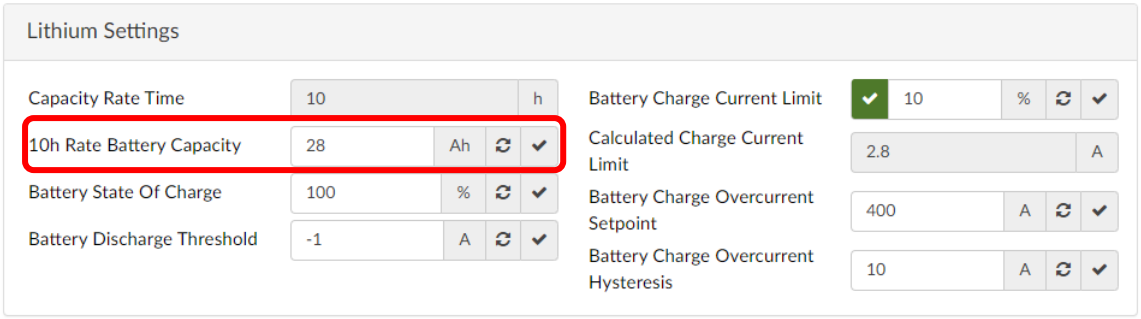
13.10 Lithium Battery Installation

This section describes how to install Lithium batteries that have no communication method with the EM4x, where the battery BMS cannot send or receive information.

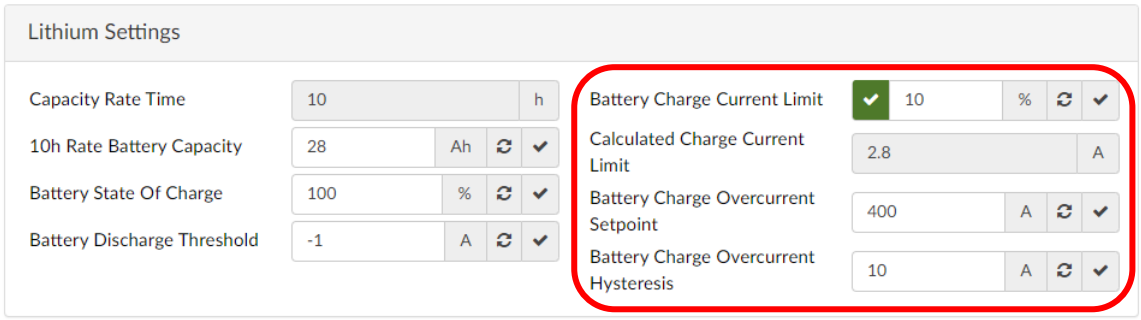
To install Lithium batteries with BMS communication via Modbus RTU see 13.11 Modbus RTU Enabled Battery Installation.

1. Click the **Basic Li** button at Battery>Battery Settings>Battery Type.

Enter the total capacity of all Lithium connected to the system in the **10h Rate Battery Capacity** field in the Battery>Battery Settings>Lithium Settings section.



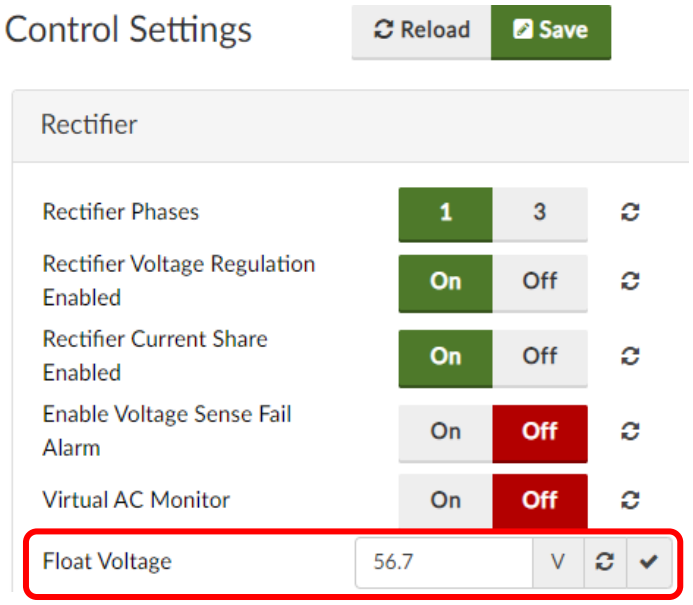
2. Enter the information in the **Battery Charge Current Limit**, **Battery Charge Overcurrent Setpoint** and **Battery Charge Overcurrent Hysteresis** fields as matches the batteries installed.



Battery Charge Current Limit is the figure to prevent over charging. This is noted in the battery data sheet but may wish to be lowered considering battery temperature limits in the operating environment and battery lifespan.

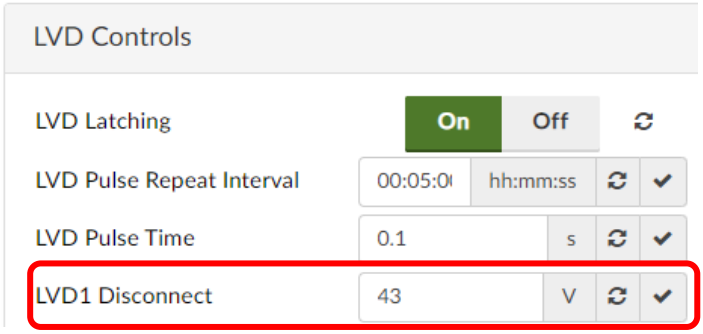
Battery Charge Overcurrent Setpoint is the current to trigger the Overcurrent alarm.
Battery Charge Overcurrent Hysteresis is the current limit allowed above the Battery Charge Overcurrent Setpoint before the Overcurrent alarm is raised. This is to prevent false triggers.

3. Enter the **Float Voltage** in the Control>Rectifier section.

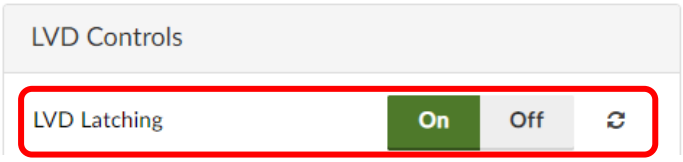


CAUTION **The correct float voltage is critical for lithium battery settings. Battery specifications must be referenced and correctly interpreted with understanding of the battery chemistry. Enatel accepts no responsibility for incorrect values being entered here.**

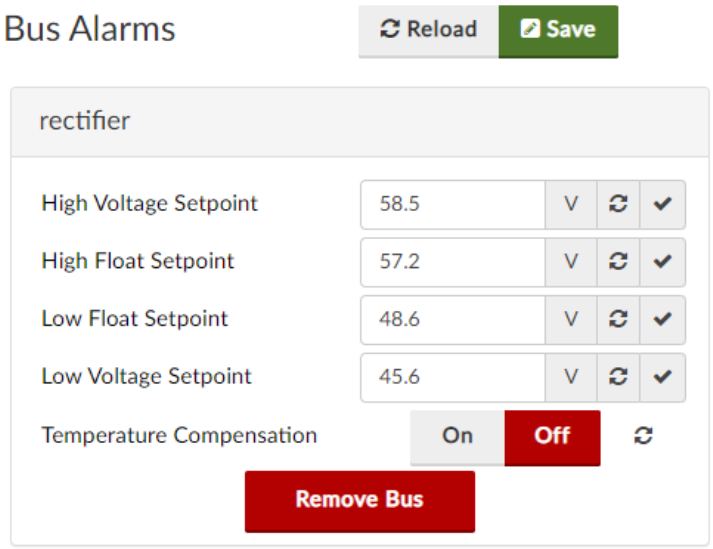
4. Set the battery low voltage disconnect voltage at IO Configuration>IO Boards in the appropriate **LVD Disconnect** field as required.
   NOTE: this setting depends if the lithium battery BMS internal LVD is to be used or EM4x controlled low voltage disconnect functionality is incorporated into the system. If the battery BMS LVD is used this setting is redundant.



   Note: if an EM4x controlled LVD is incorporated in the system **LVD Latching** must be **On**.



5. Set the bus alarms as required at Alarm Configuration>Bus Alarms>Rectifier



   NOTE: High voltage setpoint should be higher than High Float Setpoint. Low Voltage Setpoint should be lower than Low Float Setpoint. Typically the float alarms are used as warnings and the voltage alarms are major system failure notification but this is user dependent.

13.11 Modbus RTU Enabled Battery Installation

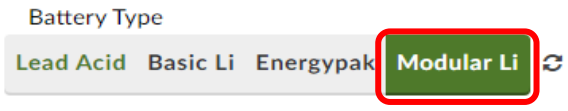
NOTE: Modbus RTU functionality is a license locked feature. See 11.4.3 Unlockable Features.

For lithium and other batteries that are provided with a BMS that can be communicated with via Modbus RTU Enatel supports a limited set of proprietary Modbus registers for specific vendor products. Please contact an Enatel representative for confirmation on the battery models supported and implementation of new battery modules.

The energy manager supports a maximum of 2 Modbus busses.

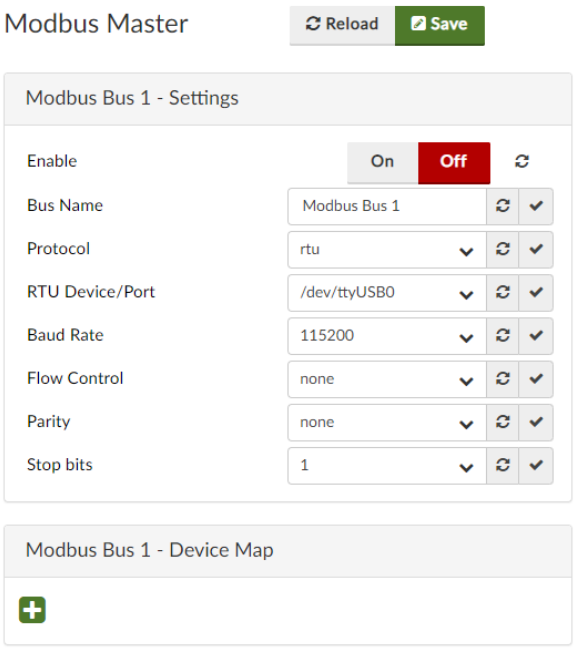
To install a Modbus enabled battery:

1. Click the **Modular Li** button at Battery>Battery Settings>Battery Type.



Note: the **Basic Li** battery button is for 'dumb' lithium batteries without Modbus enabled BMS controls.

2. Navigate to IO Configuration>Modbus Master>Modbus – Settings

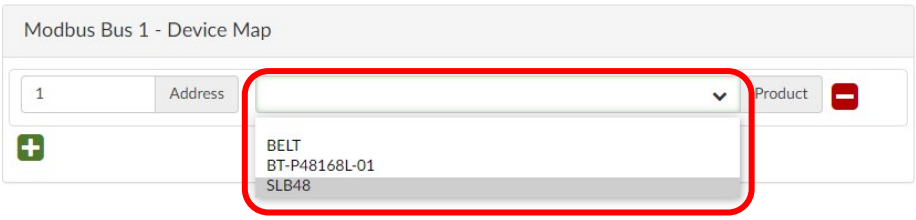


3. Click the Enable button **On** for the required communication bus.
Note: the EM4x currently supports a maximum of 2 Modbus communication buses. If more are required please contact your Enatel representative.

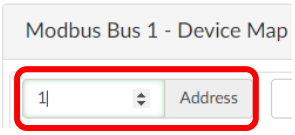
4. Name the bus as appropriate.

5. Select the protocol type. For Modbus RTU busses select **rtu** from the drop down menu.

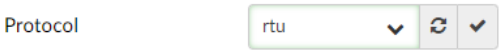
6. Click the + icon to add batteries from the **Device Map**.
7. Select the battery type from the drop down list (if the required battery is not on the list please contact your Enatel representative).



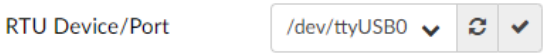
8. Add batteries as required.
9. Match the **Address** field number to the battery module address as displayed on the battery.



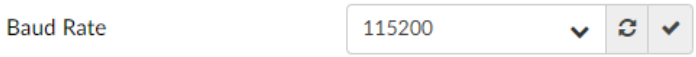
10. Check the correct protocol is set, RTU is default for batteries in the Enatel register list.



11. Select the correct **RTU Device/Port**. Default is 0 with most systems requiring only one bus.
Note: when multiple ports are present USB port number is determined by order of discovery i.e. the chronological order each device is plugged into a USB hub, not the physical location of the hub port. The port count starts at 0.



12. Set the **Baud Rate** to match the battery selected.
Note: check the battery module data sheet for the default rate or match any customized settings.

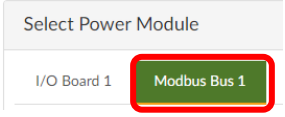


13. Check the battery data sheet and custom settings for **Flow Control**, **Parity** and **Stop Bits** details.

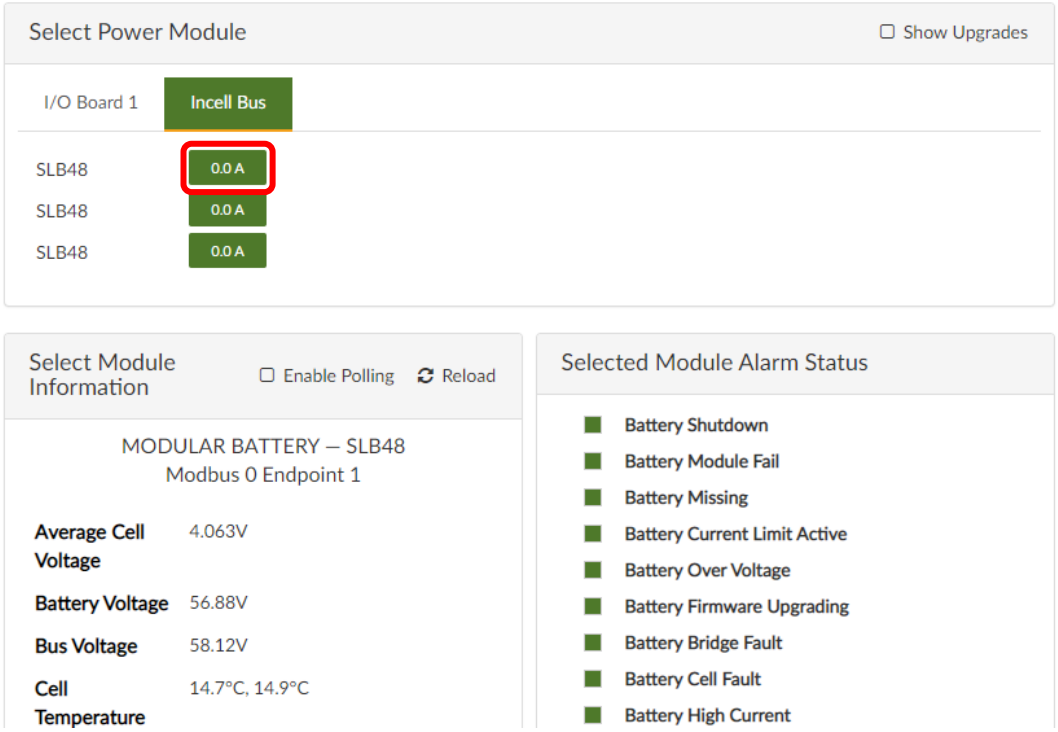
14. Click the **Save** button.

15. Check the Battery Current = Modular Battery Current on the Input Logic page.

16. Check the configured batteries are displayed correctly at Power Modules>Power Modules>Bus Name.
    a. Click on the **Bus** tab.

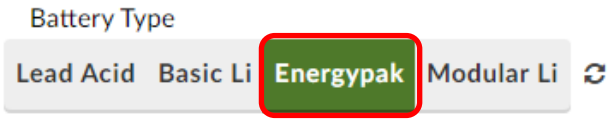


b. Click on a battery to display the battery module details and available alarms.

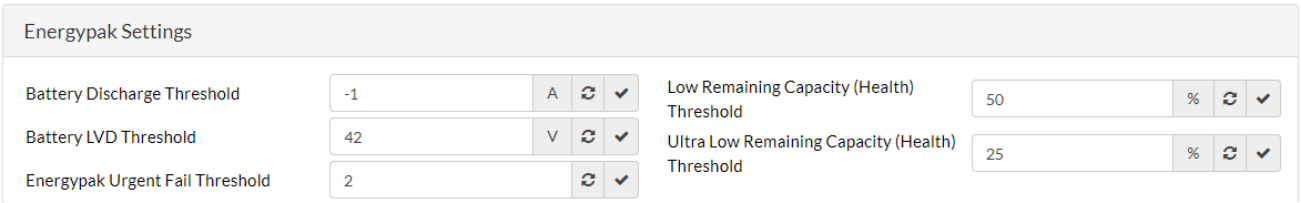


13.12 Energypak Battery Settings

The energy manager must be configured for use with the correct battery type. For energyhub systems with energypaks included in the system do NOT change the Battery Type setting in the Web UI.



On the Battery>Battery Settings page the following fields are available for configuration:



Battery Discharge Threshold: this setting ensures there are no false readings regards battery discharge. This should not require modification.

Battery LVD Threshold: is the voltage at which the discharging energypaks disconnect. This is user selectable between 40.6V and 50V.

Energypak Urgent Fail Threshold: is the number of energypaks that when either missing or failed differentiates between 'Fail' and 'Urgent Fail' alarms plus 'Missing' and 'Urgent Missing' alarms. Many systems are deployed with one or more extra, redundant, energypaks so that a single failure is not deemed critical for instance and the urgency level can be defined by this parameter.

CAUTION **The user must be aware of the consequences of battery State of Health (SoH) with regards their specific load back up requirements and implement their own policy regards the End of Life (EoL) of the battery.**

Low Remaining Capacity (Health) Threshold: the criteria to raise the *Energypak Health Low* alarm. The user should review the system requirements and implement their own battery EoL policy and adjust this alarm accordingly. This alarm is informative, only.

Ultra Low Remaining Capacity (Health) Threshold: the criteria to raise the *Energypak Health Ultra Low* alarm. The user should review the system requirements and implement their own battery EoL policy and adjust this alarm accordingly. This alarm is informative, only.

13.13 Phase Balancing

NOTE: Phase Balancing is a license locked feature. See 11.4.3 Unlockable Features.

NOTE: Periodic battery test must be enabled for DC systems configured with the phase balancing licence unlock feature. Should a periodic battery test fail, phase balancing is inhibited. See Periodic Battery Test.

Enatel's unique, patented Phase Balancing is a license locked feature on the Control page. When enabled with the ancillary ACM boards, the system measures the output of 3 phases and then reactively balances the power of each phase. It also provides a back off feature for 3 phase or single phase mains supply.

Phase balancing can be used to offset the effect of, for example, a single-phase air-conditioner in a mobiles shelter on a 3-phase supply. At the same time it can be used to limit the AC input current and prevent in-coming AC circuit breakers tripping.

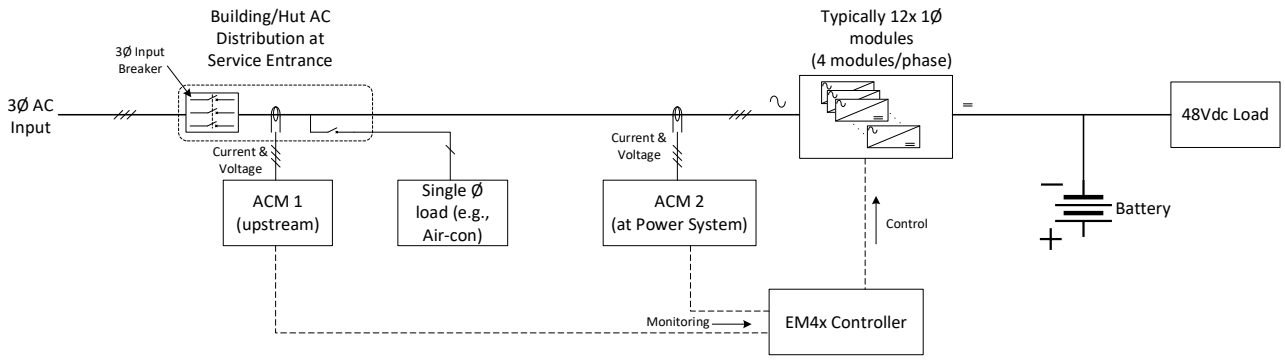
Another application is to protect a 3-phase generator engine. The wear on a genset motor from long term disparate output on each phase is a major factor on asset lifespan.

13.13.1 Dynamic Phase Balancing Setup (including AC Current Limit)

Phase balancing enables the user to present a balanced 3-phase load upstream of the DC power system by varying the output power of rectifiers attached to the imbalanced phase.

In doing this, this feature also enables the user to specify a maximum current of each of the phases. This combined with a rapid speed of response prevents upstream circuit breakers from tripping due to input surge current presented by air-conditioners and the like. The following block diagram shows the positioning of the equipment.

Figure 23: Dynamic Phase Balancing Setup

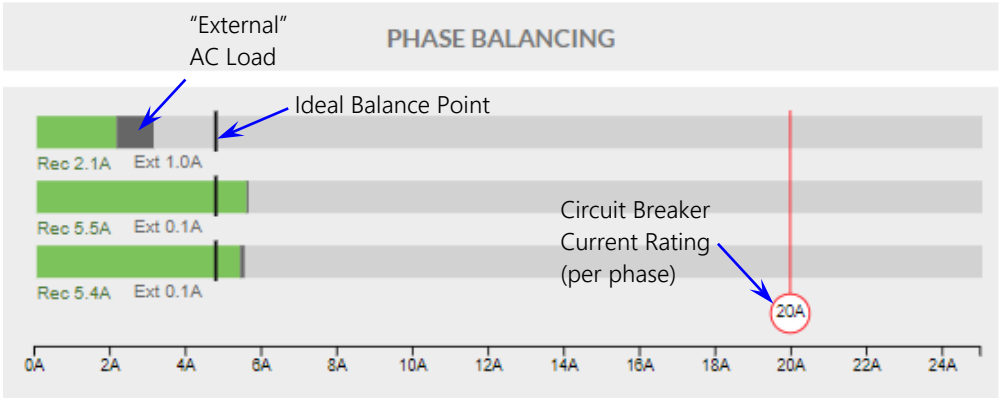


As shown, two Enatel AC Monitors (ACMs) are required, with current transformers at each monitoring point.

As a safety back-up, the user can also specify a "default" arrangement of rectifiers powered from each phase. For example, in a system without Dynamic Phase Balancing there may be 3 rectifiers attached to Phase 1, and 4 rectifiers connected to Phases 2 & 3. Enatel's EM4x Controller lets the user set this up as a default in case

communications with the upstream AC Monitor module is lost (see below for more explanation and setup parameters).

When Phase Balancing is enabled, the EM4x is constantly scanning the upstream phase currents and creating an ideal balance point. On the display, this is shown as the vertical grey lines on the Phase Balancing interface (phases are represented from top to bottom as L1, L2 & L3):

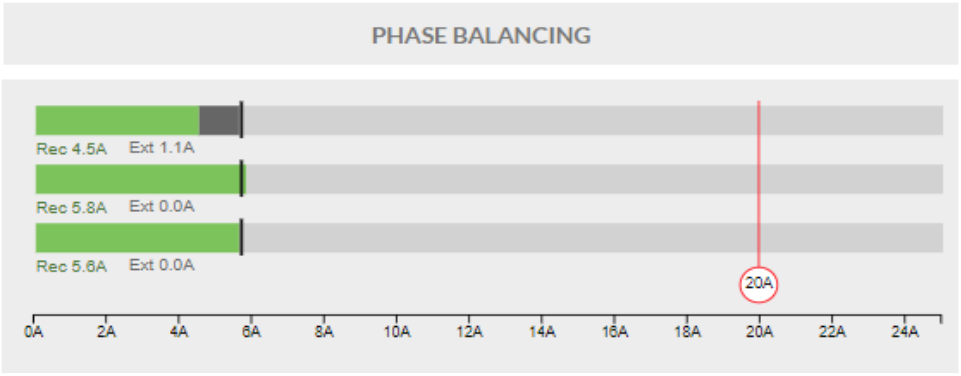


The circuit breaker rating is represented by the red line.

The green bars are the amount of current drawn by the rectifiers for each phase (also displayed numerically as the "Rec" currents).

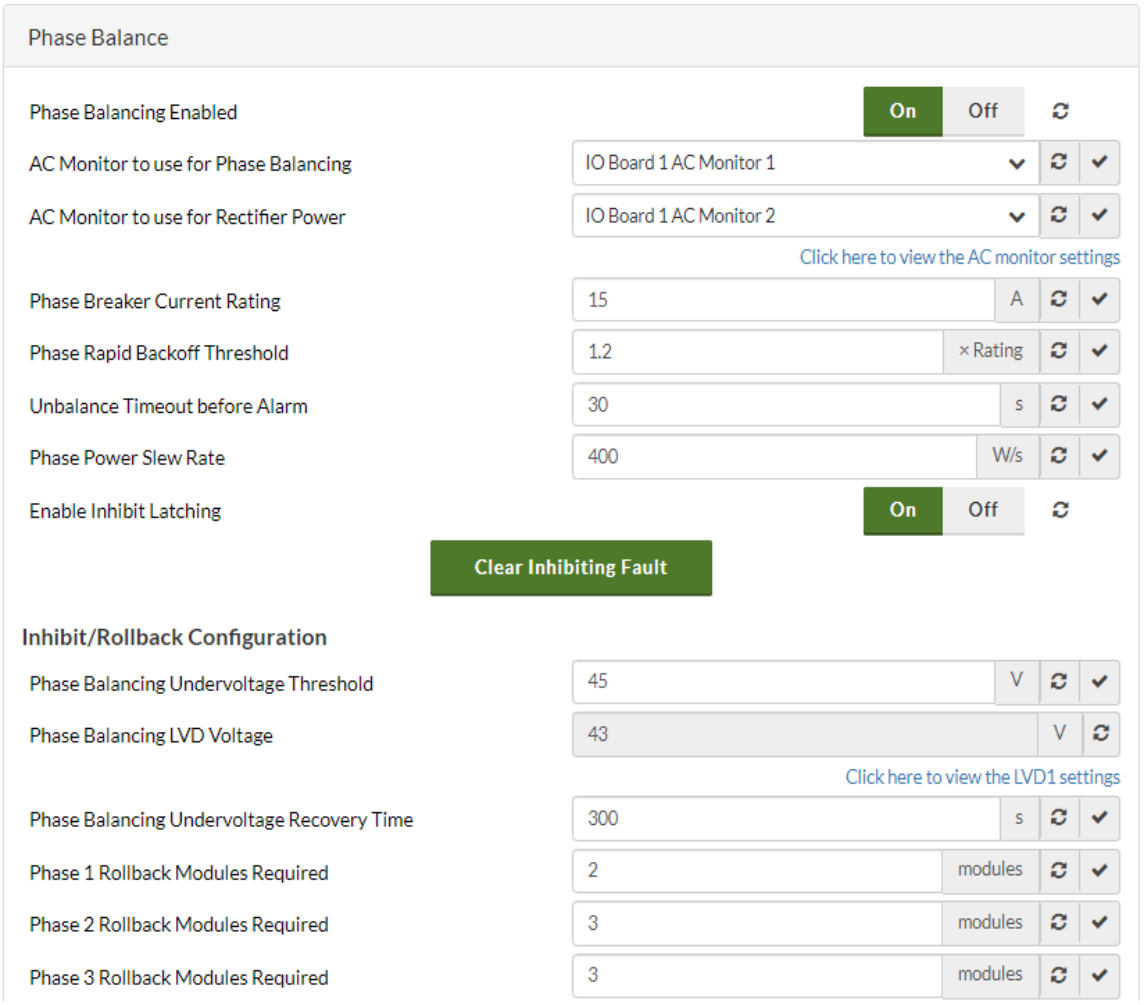
The grey bars are the amount of current drawn by "external" loads to the DC power system (& shown also numerically as "Ext" currents). These will typically be loads such as air-conditioners.

The above screen-shot shows the display during a balancing routine where an unbalanced load has just been applied to phase 1. The EM4x controller has "pulled back" phase 1, thus increasing the load on phases 2 and 3. The balancing routine typically takes some seconds, and after balancing, the display will look like this:



If the load is high enough to approach the circuit breaker rating, a "Rapid Backoff" may occur if a phase is sufficiently overloaded (trigger set by the "Phase Rapid Backoff Threshold"). In this instance the load on the affected phase will back off very quickly to prevent the circuit breaker tripping. The reason for treating this case differently is that during a rapid back-off, there may be more dependency on the battery to provide any shortfall of energy for the load. The normal back-off takes place slowly enough that battery draw is rarely required.

The following section details and explains all the settings with respect to the Phase Balancing function (on the Control page):



Phase Breaker Current Rating

This is the upstream circuit breaker rating. With Phase Balancing active, the EM4x controller limits the current draw to ebb no more than this value. The value chosen here should be the breaker trip current at its highest operating temperature. So, for example, if the breaker is a 50A breaker (at 30°C), then this setting should be in the order of 45.5A. This must be checked against the circuit breaker manufacturer's data.

Phase Rapid Back-off Threshold

This factor is multiplied by the breaker rating. For any imbalance current up to this level, the back-off is relatively slow so that very little (if any) current is drawn from the battery during the balancing routine. If any phase current goes beyond this level, the EM4x causes a rapid back-off in power (& hence current) on that phase. This is so that the upstream breaker does not trip. During the rapid back-off, more battery current may be drawn during the balancing routine.

Unbalance Timeout Before Alarm

If the EM4x is unable to create a phase balanced system, then an alarm is raised called "Phase x Unbalanced" (where x = 1, 2 or 3). To give the system time to settle, this alarm is delayed by the "Unbalance Time Before Timeout". An unbalanced phase is defined as being 10% outside of the ideal setpoint. This is a backend setting, unable to be user modified.

Phase Power Slew Rate

This is the rate at which power is re-applied after an imbalance is detected and a phase has backed off its power. 400 watts per second should suit most circumstances. Without this setting, power is re-applied instantly, so depending on the AC source capability (in particular, generators), it makes sense to limit the slew rate. However, this means that during the re-application of power, the balance of power is taken from the battery.

Inhibit/Rollback Configuration

There are a number of scenarios where Phase Balancing may be inhibited. These are:

- A 3-phase system is not detected (i.e., the system must be 3-phase)
- All battery breakers are open (each breaker is monitored by the EM4x for its ON/OFF state)
- Incorrect phase rotation
- Input logic (programmed) error
- Low DC bus voltage
- Loss/removal of multiple rectifiers
- Loss of communication with the upstream AC Monitor
- Loss of a current transformer (could be a disconnection or broken wire etc.)
- Complete loss of an AC phase
- One minute after the EM4x is turned on or re-started
- Battery Test has failed (implying the battery may not have enough energy to maintain bus voltage during a balancing routine). It is highly recommended that Battery Test is enabled if Phase Balancing is enabled as the battery may be relied on to maintain bus voltage during a balancing routine.

NOTE: that the Rectifier Power Save function **must be disabled** for Phase Balancing to operate. See 13.4.2 Rectifier Power Sav.

In the event that Phase Balancing is inhibited, then it is desirable to still try to prevent the upstream AC breaker tripping. The Inhibit/Rollback feature allows the user to select a default configuration for this scenario.

In the example above, the Rollback condition when Phase Balancing is inhibited is to have 2 rectifiers on Phase 1, and 3 rectifiers on each of Phases 2 & 3. The EM4x does this by simply shutting down the rolled-back rectifiers on the desired phases.

Enable Inhibit Latching

If the Inhibit mode is not latched, then the EM4x will re-enable the Phase Balancing routine as soon as the alarm that has caused the inhibit returns to normal. In some cases such as intermittent communications, it may not be desirable to have the Phase Balancing function continually turning on and off. Hence the user is given the option to have the inhibit latching. Not that in this case it requires manual intervention to reset the alarm. This can be performed remotely if remote communications is available, otherwise it requires a site visit for a local reset.

Phase Balancing Undervoltage Threshold

If the DC bus voltage falls below this value (except during a battery discharge – see next setting for this case), then Phase Balancing is inhibited, and the system operates in the Roll-back configuration. This is to cater for a "bad" battery or to reserve a set battery capacity for back up in case of mains failure.

Phase Balancing LVD Voltage

This field displays the system LVD voltage for reference. It is not editable on this page.

Phase Balancing Undervoltage Recovery Time

If there has been a battery discharge that has taken the bus voltage below the Phase Balancing Undervoltage Threshold, then Phase Balancing is not inhibited for this duration. This gives the battery some time to recover. If the voltage is still low after this time, then Phase Balancing is inhibited, and the system runs in its Inhibit/Rollback configuration.

Phase 1, 2 & 3 Rollback Module Required

As mentioned above, when Phase Balancing is inhibited or in its Roll-back mode, the number of rectifiers "ON" each phase can be selected.

In this example, 2 are on Phase 1, and 3 are on each of Phases 2 & 3.

Phase Balancing Alarms/Notifications

For each phase, there are 3 alarms. These are:

- AC Phase Backoff
  This is pre-set as an informational alarm. While the EM4x is performing a balancing function this alarm/notification is raised.
- AC Phase Clamp
  This alarm occurs when the AC breaker current limit is exceeded and a "Rapid Backoff" is required. If the balanced phase current is below the breaker rating, this alarm will turn off. However, if the balance point is beyond the breaker rating setpoint, the EM4x limits the AC input current to this level, and the balance of energy comes from the battery. This alarm stays on until the AC current falls below the breaker rating setpoint.
- AC Phase Unbalanced
  If, for some reason, the phases are unable to be balanced, this alarm is raised. An example of this may be insufficient rectifier load to create a phase balanced system.

There is also an alarm raised when Phase Balancing is Inhibited.

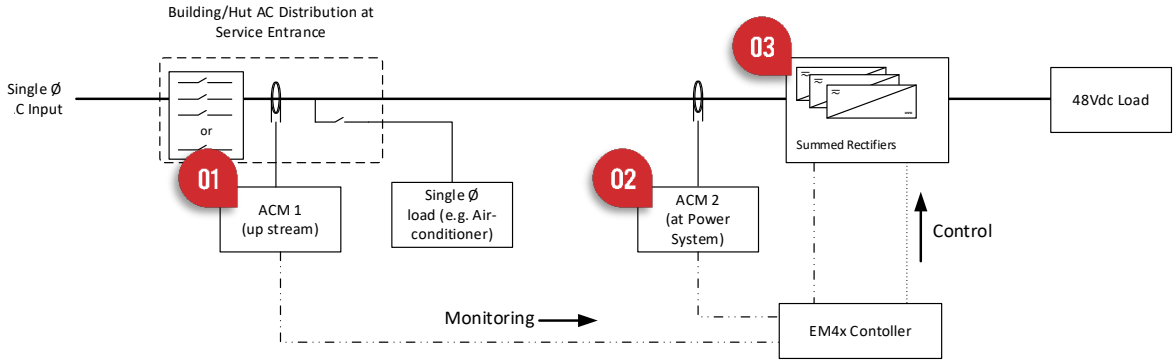
13.13.2 Single Phase Backoff

Single Phase Backoff, AC current limiting for single phase systems, is included in the same license unlock feature as 3 phase systems phase balancing.

Note for single phase supply at Control>Control Settings>Rectifier the **Rectifier Phases** must be set at **1**. This allows Single Phase Backoff to be displayed on the Control page when the Phase Balancing feature is unlocked.

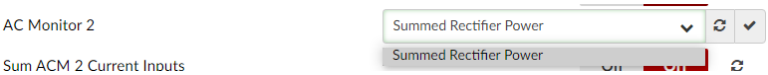
The user should first confirm the AC monitoring location for the appropriate breaker protection.

Figure 24: Single Phase Back Off AC Monitoring



In Figure 24 an AC Monitor at location **01** would be used to protect breakers in the distribution board. Either an AC Monitor at location **02** or the summed rectifier currents at **03** could be used to protect breakers in the power system.

Select the appropriate setting from either the AC Monitor 1 or AC Monitor 2 drop down menu.

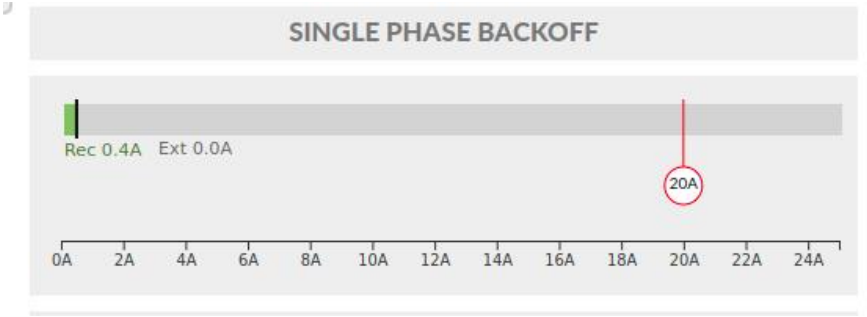


For systems with single phase supply from linked multiple monitored cables toggle the **Sum ACM Current Inputs** to **On**.

NOTE: that the Rectifier Power Save function **must be disabled** for Single Phase Backoff to operate. See 13.4.2 Rectifier Power Sav.

For other parameters refer to the functionality descriptions at 13.13.1 Dynamic Phase Balancing Setup (including AC Current Limit).

When enabled a Single Phase Backoff graph appears on the Overview page.



13.14 Hybrid

NOTE: Hybrid functionality is a license locked feature. See 11.4.3 Unlockable Features.

Hybrid is defined as the interaction in a DC system between renewable energy sources, generators and batteries. The platform to manage hybrid interaction Enatel describes as a SYNERGi system.

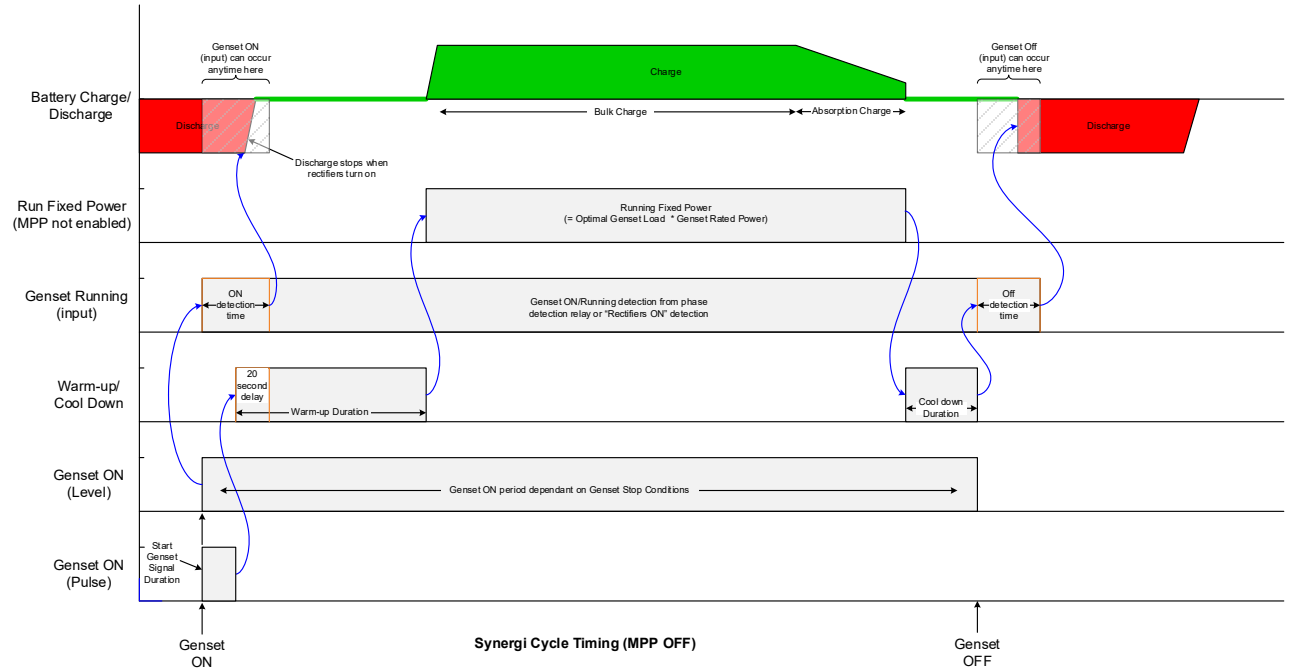
When installing a SYNERGi system there are a significant number of settings to be correlated to make use of SYNERGi's D^{2}GO (Dynamic Diesel Generator Optimisation) which has the Anti-stall and Maximum Power Point (**MPP**) search features. When considering these settings, it is useful to understand the timing of the various events and states that SYNERGi goes through during the Hybrid Cycle.

Two diagrams are shown, one with MPP turned off, and one with MPP enabled. The MPP function can be disabled by toggling **Inhibit MPP** to **Off**, at Hybrid>Hybrid Configuration>MPP Settings.

MPP is commonly disabled when the number of rectifier modules used will not normally be able to stall the generator during bulk battery recharge (the time when power draw is at its maximum).

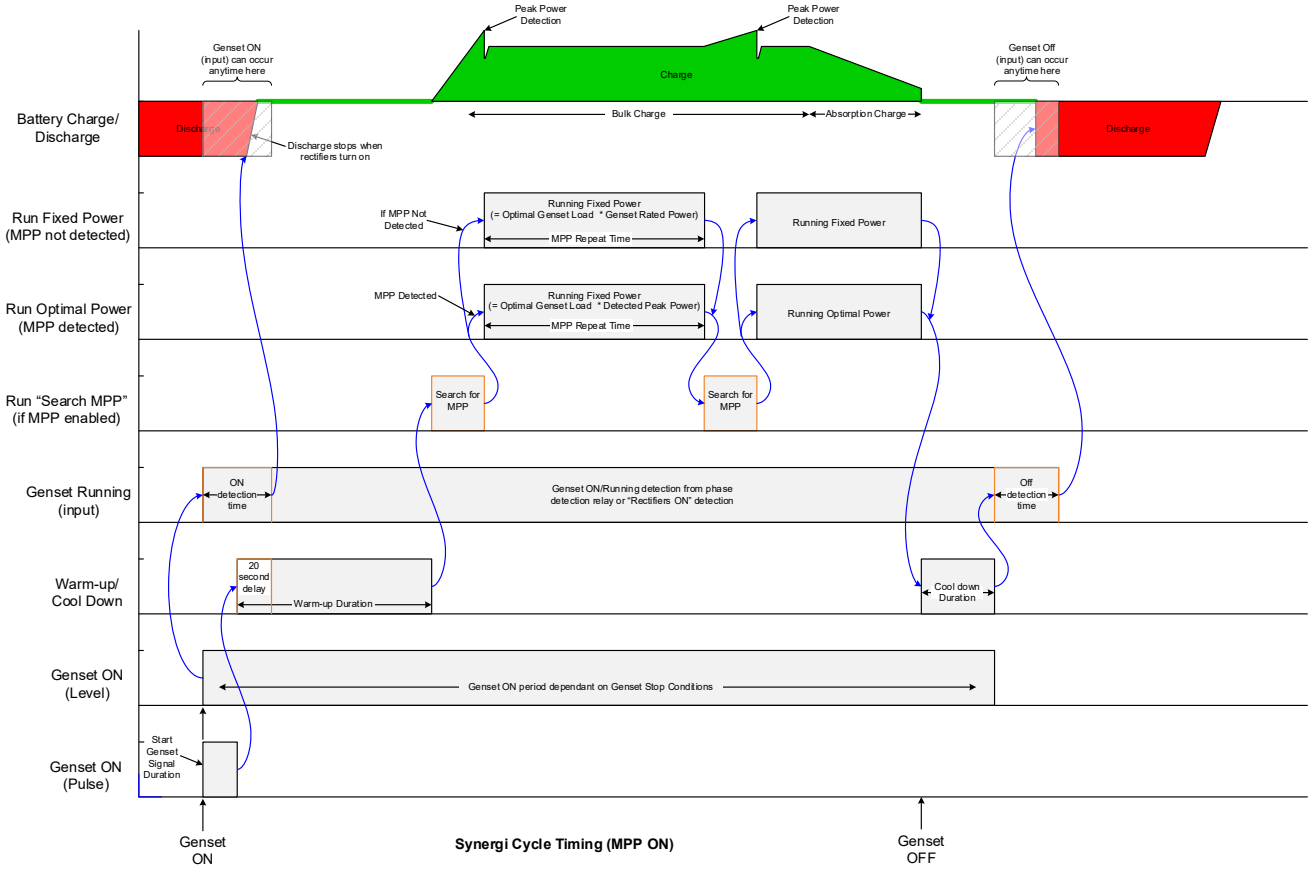
To begin with it is easier to start with describing the timing with MPP **OFF**. The timing diagram is as follows:

Figure 25: SYNERGi Cycle Timing (MPP OFF)



With MPP **ON**, it is a little more complex, in that SYNERGi must cater for both cases of when MPP is detected, and when it is not detected (for example at the end of discharge, in the battery's absorption phase, or when the battery recharge power is not enough to stall/over-load the generator).

Figure 26: SYNERGi Cycle Timing (MPP ON)



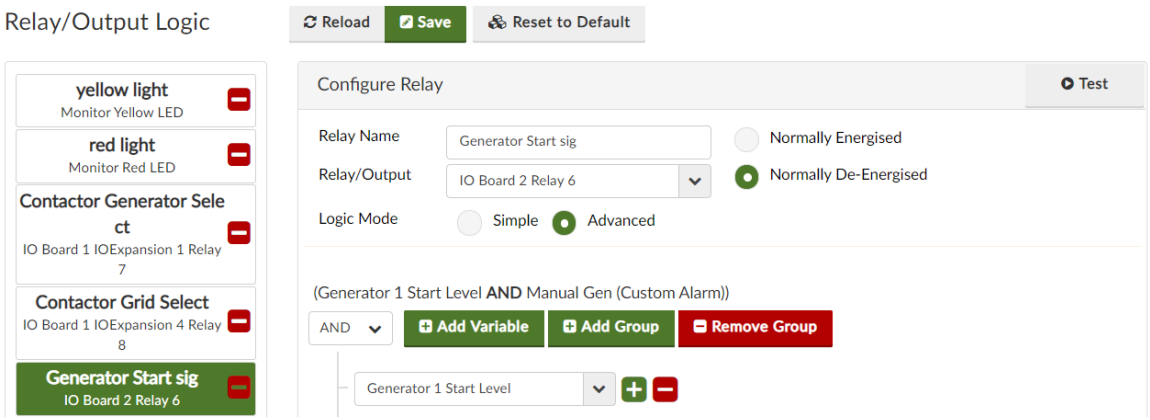
13.14.1 Hybrid Connectivity

Generator Start Level

The is the signal used to control the start and stop of the generator. It is one of the crucial signals for the SYNERGi Hybrid system.

The logic is that as long as this signal is "high", then the generator should start and run.

This signal is usually mapped to one of the relay outputs of the SYNERGi system and is programmed on the Relay/Output Logic page.



Note that the Relay can be programmed to be **Normally Energised** or **Normally De-energised**.

Standard configuration is for the relay to be normally energised. This means that the "Generator Start Level" signal will de-energise the relay. This is considered fail-safe for a Hybrid system, as it means that if the controller fails for any reason, the generator operates regardless.

The next thing to consider is the physical wire connection to the generator. It is highly recommended that the control signal to the generator is wired such that the contacts being open will run the generator, and closed contacts will stop the generator. This is considered fail-safe from the point of view that if ever the genset start/run wires are broken (due to someone cutting them, or vermin eating them, or a bad wiring joint), then the generator will run continuously.

If the generator runs when SYNERGi is not expecting it then a Generator Overrun alarm is raised. This can be used as an indication of a problem at site.

See 10.2.10 Relays 1 to 6 for information on connecting to the relays and contact settings.

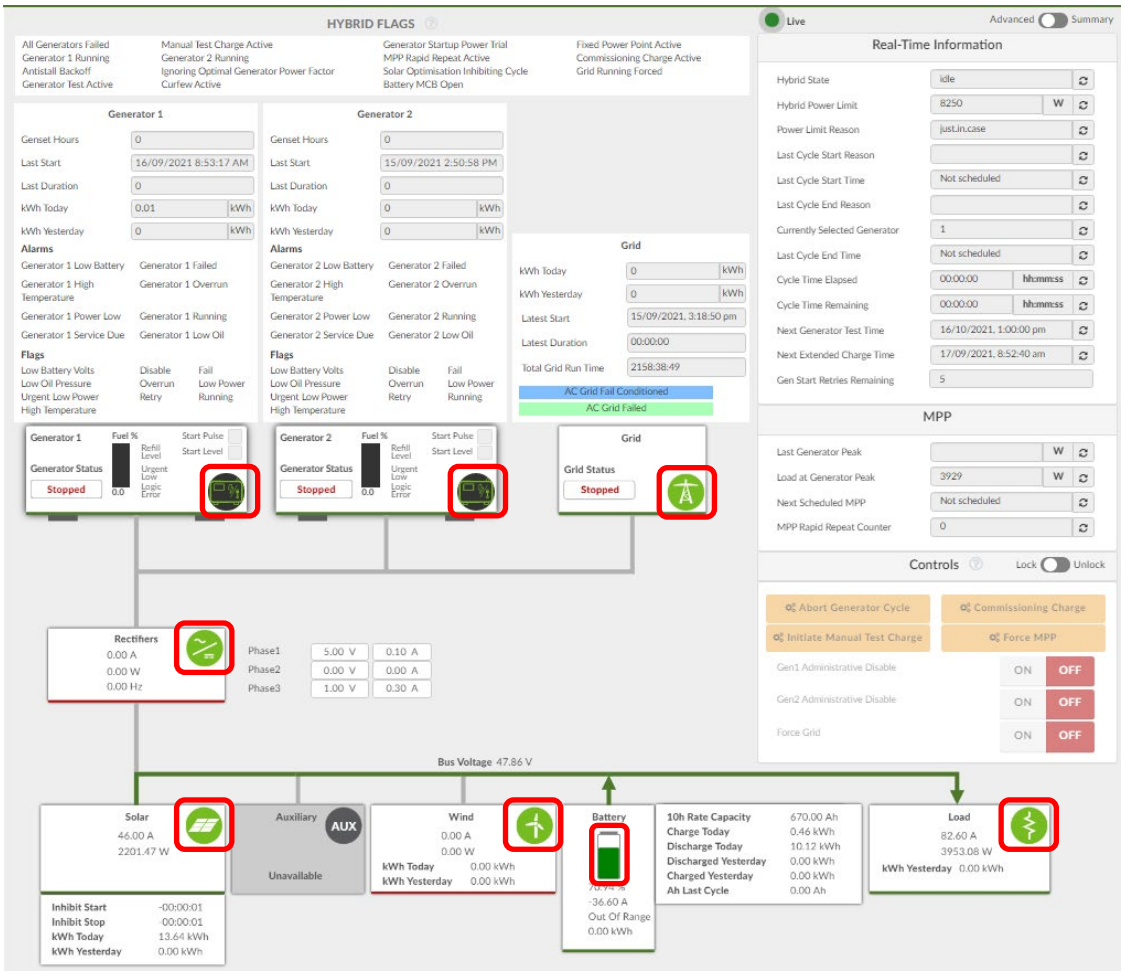
13.15 Realtime Status

This page displays Hybrid activities in real time indicating in each section information as to the current or latest Hybrid functions.

The information provided is calculated from the performance monitored and settings made in the Hybrid Configuration, Hybrid Cycle Setup, Solar Optimisation and Fuel Tank Setup pages along with the fundamental system functions.

Mouse-over the icons for quick links to the respective parts of the Web UI that governs the system as indicated below. When familiar with the functionality the system can be effectively controlled from this page.

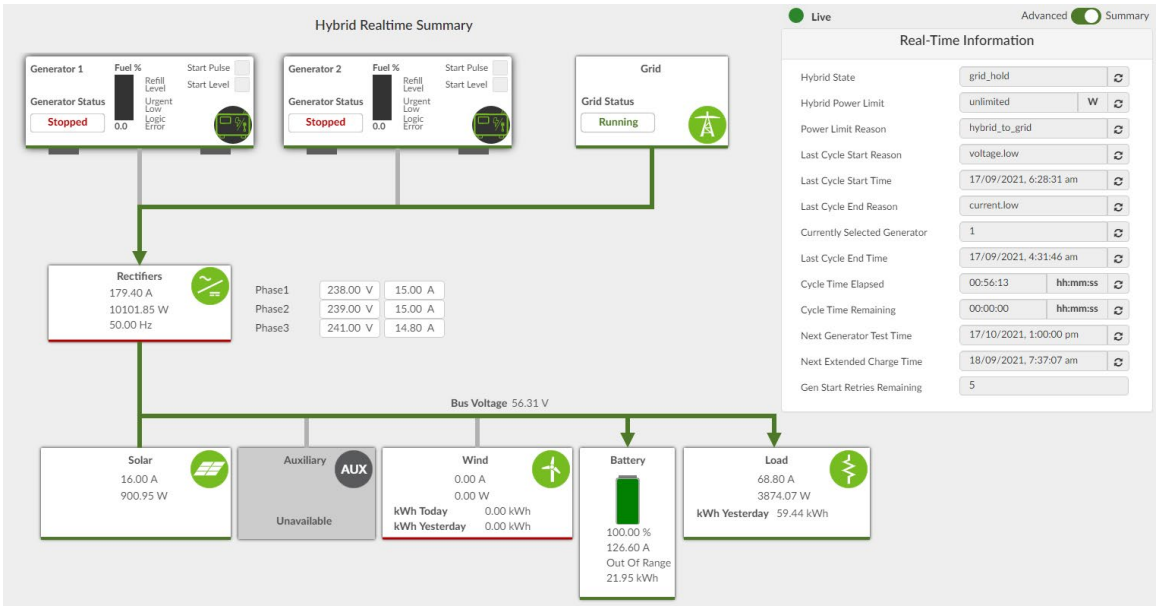
NOTE: greyed-out sections are non-functional in the system (indicating those items are not fitted to this system) and indicated with a remark **Unavailable**.



Note the green arrows indicating active elements and electrical flow direction.

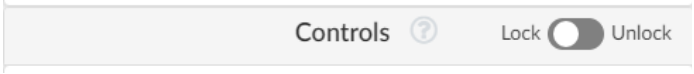
13.15.1 Advanced and Summary Realtime Status Pages

Toggle between page display options for a detailed view of the Hybrid system in the Advanced page or an overview in the Summary page.



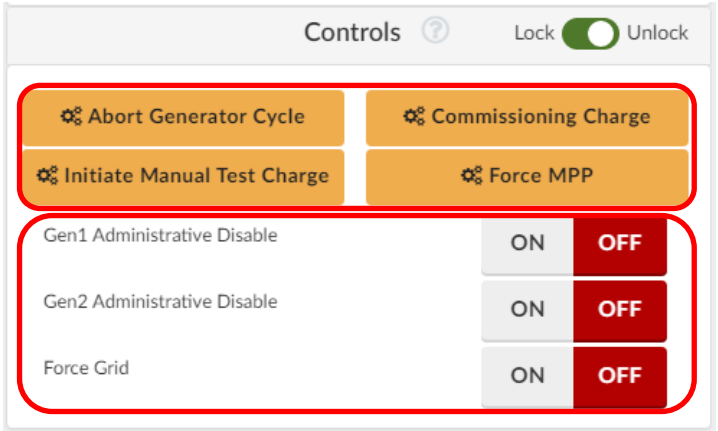
13.15.2 Controls

Hybrid controls are provided in the Realtime page Control section of the Advanced page. The lock toggle is provided to the section so that the controls are not inadvertently triggered.



Unlock the slide toggle to access the Control features.

The 4 Hybrid functionality buttons can be accessed at *enabasic* level. The Generator Administrative Disable and Force Grid functions require *enaadvanced* level access. See 10.1.1 Access Levels.



Abort Generator Cycle

This command stops the generator for this cycle, only. The generator restarts when the next generator start event is triggered. Note that the Abort Cycle also resets the Generator Start sequence if the Generator has been "Locked out".

Initiate Commission Charge

This command starts a commission charge for lead-acid batteries for instances the batteries have not been topped up by the vendor or otherwise not at full charge. See 13.17.3 Commissioning Charge.

Initiate Manual Test Charge

This command begins a test charge. This charge runs for 60 minutes or until the Abort Cycle button is clicked.

Note this only exits on duration end, abort cycle command or generator failing to start. This command over-rides other settings.

Force MMP

Initiates a generator excursion run to locate the maximum power point.

Generator Administrative Disable

A generator override that forces the generator to stop operating. Access level required: *enaadvanced*.

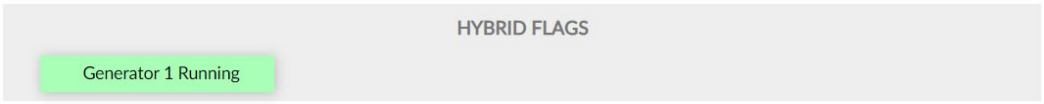
NOTE: this is where the action on the front panel of the energy manager to turn the generator on or off also displays indicating a manual action from the system.

Force Grid

Toggling Force Grid ON is an over-ride command telling the system to ignore all Hybrid function commands and only draw power from the grid.

13.15.3 Hybrid States/Flags

Status flags show at the top of the Advanced Realtime Status page to assist understanding of the generator cycle.



NOTE: these flags do NOT display while the system is on grid.

The states/flags are useful to know especially during troubleshooting. Several are from the alarms that are indicated from the core system such as High Load & Battery MCB Open.

All Generators Failed

If both generators (or Generator 1 if only one generator is enabled) has failed to start after the Start Fail Retries and 1 Hour Retries have been exhausted, SYNERGi does not try any further to start the generator so as to save the starter battery. In this case is will lock itself out and raise this alarm.

The lockout can be reset by clicking the Abort Generator Cycle button (in which case the start attempt counters are reset to zero).

Manual Test Charge Active

The one hour charge of the batteries is active.

Generator Startup Power Trial

This remains highlighted for a period of 20 minutes at the start of the generator charge cycle (the 20 minute period starts at the same time as the Warm-up (i.e., it includes the Warm-up period)).

If the generator stops unexpectedly during this period, the Start Fail Retry and 1 Hour Retry counters continue to decrement. If a generator fails/stops after this period, then those counters are reset to their programmed amounts and the system continues in its normal Hybrid cycle.

In both cases the if the generator stops unexpectedly, the Generator Fail alarm is raised.

Fixed Power Point Active

If MPP (Maximum Power Point detection) is Inhibited, see Inhibit MPP and the generator is operating at the power level set by:

Optimal Generator Load x Generator Rated Power

Then the genset power is said to be optimised and shows as green.

If the maximum power draw of the DC power system is not enough to stall the generator, then it is not possible to load the generator to a sufficient level to detect its maximum output power (near stalling). For example, if there is 12kW of rectifiers and a 15kW genset.

In this case, it is best to run the SYNERGi system with the MPP mode inhibited (but leave the anti-stall enabled to detect lower power events).

When MPP is inhibited, SYNERGi uses the name-plate value entered in the Generator Rated Power field on the Hybrid Configuration page as the generator peak power. It is important that the Generator Rated Power entered is the Standby (not Prime) power and has taken into account de-rating factors such as altitude. It then multiplies this by the Optimal Generator Load as shown above to set the operating power of the generator.

When operating in this mode, Synergi is considered to be Running Fixed Power and is flagged on the Realtime Status page.

Generator Running

This should show if the generator is running as expected during the charge phase of the Hybrid Cycle.

In almost all cases, it is simply the inverse of the Generator Running signal. The reason there is a separate statement for Generator Stopped is in case there are other factors involved in determining whether the generator has stopped.

MPP Rapid Repeat Active

If SYNERGi detects a generator low power event (e.g. it is about to stall, perhaps due to poor fuel of a clogged air filter), and the power has been backed off, SYNERGi then goes into a Maximum Power Point (MPP) detection "Rapid Repeat" mode to check if the fault has cleared.

The first Rapid Repeat occurs less than a minute after the event, and then every 5 minutes after that.

Commissioning Charge Active

Indicates that a Commissioning Charge is in progress. This is initiated from the switch on the SYNERGi front panel (if installed), or from the Hybrid>Hybrid Cycle Setup page.

Battery MCB Open

This alarm is simply reflected from the internal Battery MCB alarm.

Solar Optimizing Inhibiting Cycles

With Solar Optimisation enabled, Synergi prevents the generator starting during the "solar day". This is called Solar Inhibiting Cycles. See 13.18 Solar Optimisation.

Generators Test Active

This is a flag for when SYNERGi performs a Generator Test. When a generator test is done, it is assumed that the generator is NOT to be interrupted by grid during that test. The generator runs even with grid present.

Clicking the Abort Generator Cycle button on the Hybrid>Realtime Status page cancels this state (i.e. turns off the generator and runs on grid).

Grid Running Forced (Fast-to-Grid)

This is a notification of normal operation that occurs when an external control (such as an independent ATS that is NOT controlled by SYNERGi) changes the operating state from generator feed to grid feed.

In this situation the AC Grid Good timer is overridden and grid settings engage immediately. The generator is immediately put into cool down mode. SYNERGi rapidly changes maximum power if so set.

The use case to have a different maximum power is when operating from the grid, it is usually desirable to operate at a higher power limit level to utilise all the energy possible from the grid (as this is usually the cheapest power source). In this case a higher power limit is set than that of the generator.

Note if the grid ceases, and the generator turns on, then the power limit is changed back to the prescribed power limit level set at Generator Rated (Nameplate) Power on the Hybrid Configuration page.

Curfew Active

Indicates an active curfew as set at Hybrid>Hybrid Configuration>Generator Curfew.

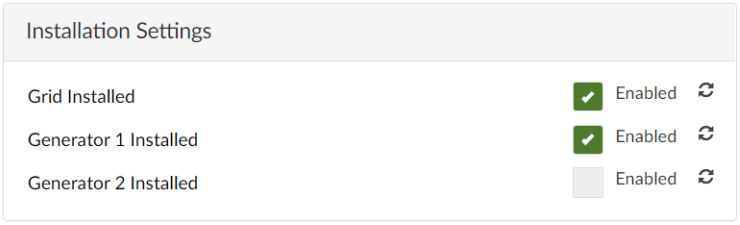
Antistall Backoff

Indicates the correct functioning of the Antistall feature has initiated.

13.16 Hybrid Configuration

13.16.1 Installation Settings

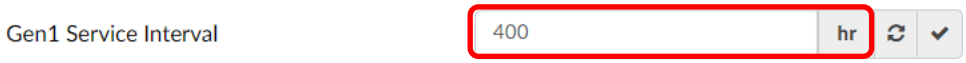
In the Hybrid>Hybrid Configuration>Installation Settings section there are three check boxes to confirm power supply sources to the system.



If these are not enabled the EM4x ignores all input logic associated with the power supply and does not display any information related to each power source.

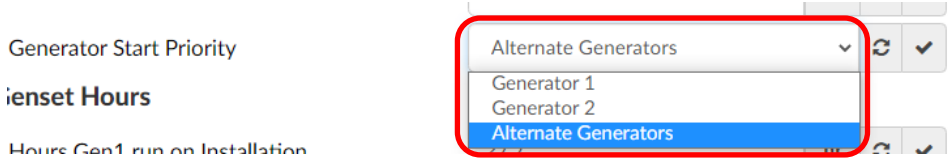
NOTE: the maximum number of generators that can be managed by one EM4x controller is 2.

The period to raise the **Generator Service Due** alarm is set in the **Gen Service Interval** field.



When servicing is complete click on the matching **Reset Service Alarm** button to remove the **Generator Service Due** alarm.

The **Generator Start Priority** can be selected from the drop down menu. Either generator can be selected to be the primary genset or the two generators can share the workload.

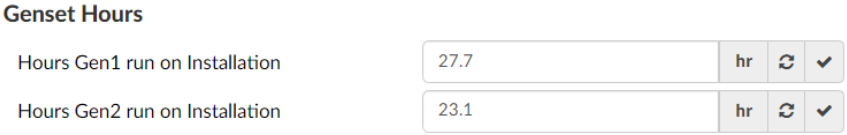


Genset Hours

The **Hours Gen run on Installation** field enables the user to set the SYNERGi controller initial value to match the run hours taken from the generator "hour meter". For example, if a previously used generator is installed that already has 3000 run hours, 3000 is entered into the field.

The SYNERGi controller gives the ability to track generator run hours, based on the number of hours it has seen the generator run for. This includes any run time where the generator may have been manually set to run for. The parameter to detect if the generator running is set in the Input Logic. The detection of a generator running is typically taken from the AC frequency detected by the AC Monitor card being above a certain value (typically >30 or 40Hz).

NOTE: the generator run hours are committed to EPROM memory once every 6 hours. If the energy manager is reset, or loses power, the hour counter may be off by up to 6 hours. This can be reset by entering the correct hours.



13.16.2 Dynamic Generator Power

In the Generator Dynamic Power section at Hybrid>Hybrid Configuration>Generator Dynamic Power the **Antistall** function can be toggled on and off.

It is strongly recommended that the anti-stall feature is always enabled as this means SYNERGi can detect if the generator has gone to a low power state (perhaps due to poor fuel or a blocked air cleaner etc.) and then decrease the SYNERGi power output to compensate, thus preventing the generator stalling and giving the site more up-time.

Nominal AC Frequency

Is either 50Hz or 60Hz.

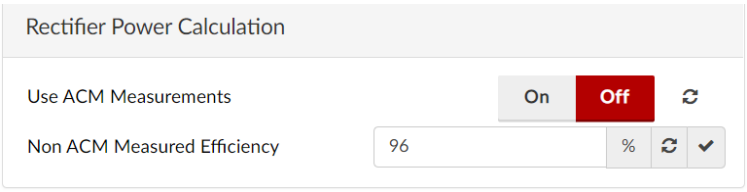
Frequency Deviation Threshold

This is a critical setting which determines the frequency below the nominal AC frequency at which Antistall and MPP is activated. This is not a figure that is typically supplied with a generator. Trial and error can be used to determine the optimal point of efficiency without risk of downtime for a specific generator, usually between 1 and 4Hz.

13.16.3 Rectifier Power Calculation

During processing and calculation, SYNERGi uses both the DC output power and AC input power. The difference between the two is simply the rectifier efficiency.

In the Hybrid>Hybrid Configuration>Rectifier Power Calculation section toggling **On** the Use ACM Measurements setting allows direct reading from the AC Monitor (ACM).



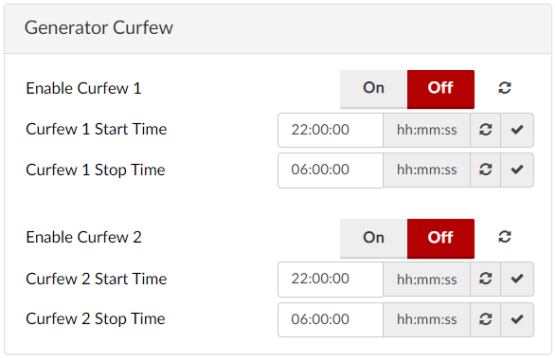
If the AC Monitor is used without Current Transformers (and measures only AC voltage and frequency) toggle the **Use ACM Measurements** to **Off**. The **Non ACM Measured Efficiency** setting then allows the use of an approximation of the rectifier efficiency. For the Enatel range of high efficiency rectifiers, this value is typically set to 96%.

13.16.4 Generator Curfew

The generator curfew settings allow the generators to be prevented from operating during a set period. This is typically done overnight to prevent the generator noise disturbing local residents.

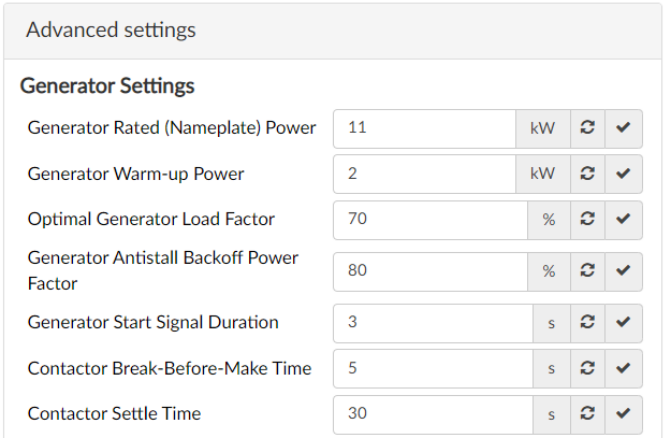
The curfew is over-ridden by the **Start When Voltage Below** setting in the Hybrid>Hybrid Cycle Setup>Extra Low Voltage Start section. It is also over-ridden by **Initiate Commissioning Charge** or **Initiate Manual Test Charge** activation in the Hybrid>Realtime Status>Controls section.

Settings are self-explanatory. **Enable Curfew 1** is the settings for generator 1.



13.16.5 Advanced Settings

Generator Settings



Generator Rated (Nameplate) Power

This is the **name-plate** standby rating of the generator in kW (not kVA).

This MUST be adjusted for local conditions, for example, altitude/temperature etc.

This rating is used for reference when **Inhibit MMP** is **Off**. MMP determines the generator maximum power dynamically if there is enough rectifier load to overload (stall) the generator. If MPP is disabled, then the generator will be limited to the **Optimal Generator Load Factor** multiplied by the **Generator Rated (Nameplate) Power**.

Generator Warm Up Power

This is the maximum power limit allowed during the warm-up phase of a cycle.

Using this feature means that a separate warm-up power contactor does not need to be used in the system.

Note that at initial turn-on, the DC system voltage ramp-up is quite slow, and even the warm-up power takes up to a minute to be fully applied (i.e., the warm-up power will not be seen as a step-load change).

NOTE: If the load is greater than the warm-up power, the battery continues discharging during this period. This is no different to the case where the generator might pull in a load contactor after its built-in warm-up power duration is reached.

Optimal Generator Load Factor

This is the percentage of the detected peak power that the DC load is regulated to after a successful MPP cycle. So, for example, if this value is set to 80%, and the "Generator Rated Power" is 12kW, but the detected peak power is, say 10.5kW, then the maximum power the DC system will allow to be applied to the generator is 8.4kW (not 9.6kW).

Note that the detected peak power is the actual Standby power capability of the generator, not the Prime rating. Given that Prime ratings are usually approximately 80% to 90% of the Standby rating, careful consideration should be given to setting this figure to anything more than 85%.

Note that any load set-point over 60% of this figure will give an optimum efficiency in terms of kWHrs/litre. A higher figure, say 85 or 90% will give a faster battery recharge & thus the generator will use less run hours, but battery life will be reduced due to the increased cycling. Also, at the higher loads there will be increased wear & tear on the generator, and it will have a shorter lifetime. A typical good compromise will be about 65 to 75%. Studies by Caterpillar indicate that the best efficiency/genset life compromise is as low as 60%.

If MPP is disabled, then the SYNERGi Controller simply applies this value to the Generator Rated Power setting without running an MPP cycle. Therefore in the bulk charge phase of the battery recharge, with an optimal load setting of 70%, the generator will be limited to 0.7 x 12 = 8.4kW.

Generator Antistall Backoff Power Factor

A Generator Power Low alarm is raised if the detected peak power is less than this amount. This is the percentage of measured peak power versus the Generator Rated Power and is normally set by the Telco or Site Operator. Enatel recommends a setting of 80%, as any generator that cannot supply 80% of its rated power probably has something wrong with it.

The measured (detected) Peak Power may be the result of a normal MPP excursion or may be the result of a stall event (most likely a stall event).

This alarm setting is an important parameter, and is used in SYNERGi logic in the following way:

- If a stall event occurs, and the detected power is less than the Generator Low Power Alarm Threshold, then SYNERGi immediately backs off system power, and resets its power output to 87.5% (i.e., 7/8) of this detected power.
- If a stall event occurs, and the detected power is greater than Generator Low Power Alarm Threshold, then SYNERGi immediately backs off system power, and resets its power output to Optimal Generator Load multiplied by the detected power.

After the first detected stall event, an MPP excursion is performed immediately (1 minute delay). This takes care of the situation where the stall event may be due to an air-conditioner starting.

SYNERGi then performs 4 more MPP rapid repeats at 10 minute intervals. This allows time for the stall/low power event to clear. SYNERGi then resets the power limit to its optimum level under the following conditions (note that even when MPP is disabled, the following occurs):

- MPP search occurs, and if the detected power is greater than the Generator Low Power Alarm Threshold, SYNERGi resets its power output to Optimal Generator Load Factor multiplied by the detected power.
- MPP search occurs, and if the detected power is less than the Generator Low Power Alarm Threshold, SYNERGi resets its power output to 87.5% (i.e. 7/8) of the detected power.

Take note that as a result of this, after a stall event, then it may be possible to see the output power setting to be at an unexpected level (i.e., not at Optimal Generator Load multiplied by Generator Rated Power).

In the event that an MPP excursion occurs and a Maximum Power Point is not found (maybe due to the battery being in absorption charge, or there not being enough rectifiers to sufficiently load the generator to its stall point), then the Power System Limit is set to Optimal Generator Load multiplied by Generator Rated Power.

Generator Start Signal Duration

This signal serves two purposes.

Firstly, for standard industrial gensets (that require a continuous "on" signal), this signal serves as a delay to detect if the generator has started. See Figure 26.

Secondly, this signal is used if direct control of a starter motor is required (though seldom needed with modern gensets). So, for example, if this is set to 4 seconds, then this signal "*Generator X Start Pulse*" can be mapped to a relay output (see 10.2.10 Relays 1 to 6) to control a starter motor solenoid. The starter motor will then only be powered for this time.

Note that a "*Generator X Start Level*" signal is also issued (at the same time as the Start Pulse) which remains in a "high" state for the duration of the "Generator Running" period. This signal is available in the Input Configuration and Relay/Output logic for mapping to a generator control relay. It is this relay that is wired to the remote start pins in the generator.

Note also that this signal is added directly to the in-built time delay that detects when a generator has started.

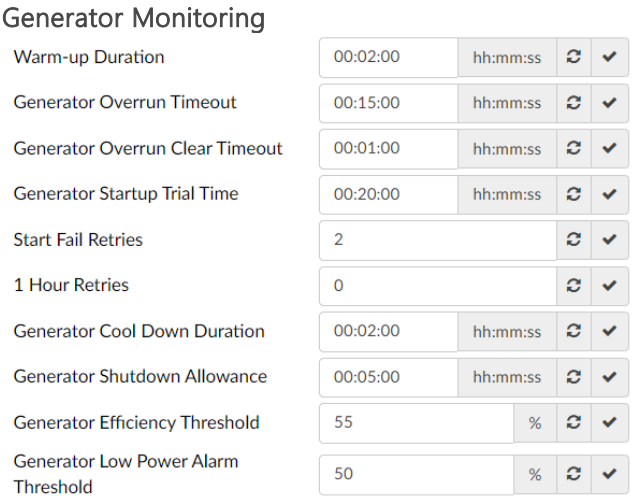
When a Generator Start signal is issued, SYNERGi waits 20 seconds to detect that the generator has actually started (this can be detected directly by relays across one of the input phases, or by detection that the rectifiers have started). In some instances, this time is not long enough. To get around this, the Generator Start Signal (pulse) is added to the detection delay. It is not unusual for this time to be 30 seconds. During this time delay SYNERGi's hybrid cycling is "on hold". Once this time has expired, SYNERGi enters the warm-up phase.

Contactor Break-Before-Make Time

This time period can be adjusted to suit a specific Automatic Transfer Switch (ATS) used to allow for mechanical delay in various ATS designs to switch the contactor.

Contactor Settle Time

This time period is the delay after the contactor has switched before attempting to monitor the system to ensure accurate readings.



Warm Up Duration

The length of time the generator warm up runs for (in minutes).

Note that during this phase, no other "stop-condition" logic is processed. This means that the genset will always run for the Warm Up Duration. SYNERGi only starts applying stop conditions once the warm-up is complete.

Generator Overrun Timeout

This is the period between when a command to stop the generator has been given and if the generator fails to stop, a Generator Overrun alarm is raised. The generator is considered thereon to be in a rogue state.

Generator Overrun Clear Timeout

The period after genset turn off before the Generator Overrun alarm is allowed to clear.

Generator Startup Trial Time

The period during which the genset is still considered in warm up mode and restarts immediately should there be a stall or otherwise. Outside of this time the genset must wait for a start condition to trigger before restarting.

Start Fail Retries

If a generator fails to start, the SYNERGi Controller tries to start the generator for the number of times entered here. If the generator fails to start after these attempts, a Generator Failed alarm is raised.

Entering "0" means the Generator Fail alarm is raised immediately, and a re-start is not attempted. However, if the next field (1 Hour Retries) has a number >0, then the SYNERGi Controller attempts to start the generator every hour for the number of times set.

The reason for these settings is so that the genset will have a fair chance of re-starting, but the starter battery does not get flattened in the process.

1 Hour Retries

If a genset fails to start after the prescribed number of **Start Fail Retries**, then every hour for the number of times entered here, SYNERGi attempts to restart the genset.

Generator Cool Down Duration

The length of time the generator cool down runs for where cool down occurs at the end of the generator cycle.

This only occurs if the cycle is terminated mid-cycle. That is, if the AC mains returns.

It is generally not necessary to cool down the generator at the end of a charge cycle because the battery will be taking a low amount of power, so the genset will be lightly loaded anyway.

Generator Shutdown Allowance

This is the time allowed for the generator to shut down before SYNERGi decides that the generator is in an over-run (or rogue) state and a Generator Overrun alarm is raised. That is, it was told to shut down, but it is actually still running.

This caters for generators with built-in cool-down routines.

Generator Efficiency Threshold

This is the fuel consumption efficiency limit designated for the generator. If this threshold is exceeded then this is flagged on the Realtime status page to inform that the generator is not operating optimally.

Generator Low Power Alarm Threshold

This setting is used to provide warning that a low power event, typically a low voltage start, is imminent. This setting should align with the **Start When Voltage Below** setting in the Hybrid>Hybrid Cycle Setup>Low Voltage Start section. The default setting of the low power alarm threshold is 5 volts above the low voltage start voltage.

MPP Settings

MPP settings

Maximum MPP Duration	00:10:00	hh:mm:ss
Inhibit MPP	On / Off	
MPP Repeat Period	00:02:00	hh:mm:ss
MPP Rapid Repeat Period	00:02:00	hh:mm:ss
MPP Sweep Power Increment	200	W
MPP Sweep Time	00:00:05	hh:mm:ss
Minimum MPP Power Target	5	kW
Maximum MPP Power Target	12	kW

Maximum MPP Duration

Irrespective of other values enabled for stop conditions, if the generator is still running when it reaches the end of the maximum MPP duration time, SYNERGi issues the command to stop the generator.

Inhibit MPP

The MPP function can be disabled by toggling **Inhibit MPP** to **Off**.

Inhibit MPP	On	Off

MPP is commonly disabled when the number of rectifier modules used will not normally be able to stall the generator during bulk battery recharge (the time when power draw is at its maximum).

MPPS Repeat Period

MPPS Repeat Period is the time interval between excursions of the generator load to the point where the **Frequency Deviation Threshold** is met. For example, if set to 60 minutes, then every 60 minutes the battery

recharge current (if the battery will accept the charge) increases to a point where the generator gets overloaded. This means that if the peak load capacity of the generator changes during the generator ON cycle, the DC system will keep track of it. The recommended setting for this parameter is 60 minutes. For testing purposes you may set this to every 5 or 10 minutes, however it is not recommended to leave it at that short a time as this can unnecessarily stress the genset plus it can mask certain Stop sates (for example, Stop on Low Current. If SYNERGi is continually ramping the voltage up, then the current may continually be exceeding the Stop threshold – resulting in the genset running unnecessarily)

An MPP excursion can be triggered manually by clicking the "Force MPP" button on the Hybrid>Realtime Status page.

To disable MPP excursions toggle Inhibit MPP to Off on the Hybrid>Hybrid Configuration page. Normally, disabling MPP is done when there are less rectifiers than the power of the generator, or the maximum genset and DC power ratings are similar. Note that with MPP disabled, the Force MPP function cannot be used.

Note that even with MPP inhibited, if for some reason the generator de-rates in power so that it gets overloaded, the generator control sequence still detects this state and backs off the load accordingly. This is called antistall.

All the generator overload protection can be removed by toggling Off both Antistall and Inhibit MPP on the Hybrid Configuration page.

Note that with both generator MPP and anti-stall disabled, the power system will apply its full load on the generator. This usually occurs during battery recharge. If Battery Charge Current Limit is enabled (at Battery>Battery Settings>Lead Acid Settings), then this may serve to prevent the genset stalling. If not, and the DC power system has a larger power rating than the generator, the generator may stall during recharge.

NOTE: if an anti-stall event occurs, SYNERGi will go into an MPP Rapid Repeat mode.

MPP Rapid Repeat Period

The MPP Rapid Repeat Period is the MPPS Repeat period divided by 5. This means for a 60 minute MPPS setting, then the rapid repeat will be 12 minutes.

This feature is to cater for situations where the stall event might be due to, say, an air-conditioner starting up, or perhaps an air cleaner or fuel blockage that clears itself.

MPP Sweep Power Increment

This sets the power increase after each step up as the MPP runs upwards to search for the stall point. This is used in conjunction with the MMP Sweep Time to ensure a controlled accurate ramp up in generator power. Which in turn sets an accurate MMP.

MPP Sweep Time

This sets the period each MPP Sweep Power Increment is implemented.

Minimum MPP Power Target

This is the power level that the generator starts the ramp up to MMP, saving time in the process.

Maximum MPP Power Target

This is the level to which the hybrid power limit is set while the algorithm is searching for the maximum load point (MPP = Maximum Power Point). This level should be initially greater than the maximum output capacity of all available rectifiers in the DC system.

If this is set to a level below the maximum power capability of the generator, then the system simply remains at this level of power output, not actually detecting generator overload. So this can be used as a way of manually limiting the current if necessary.

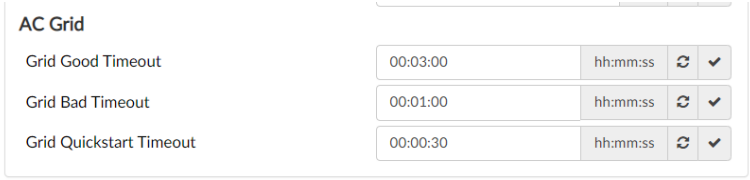
Note that this parameter sets the Hybrid Power Limit parameter on the Hybrid>Realtime Status page (once the algorithm is enacted, this value changes).

It is this **Hybrid Power Limit** that gets dynamically adjusted as a result of the MPP search and is the key element in the Dynamic Diesel Generator Optimisation (D^2GO). It is the key defining parameter that is used to set the Optimal Generator Power.

Also note that in the Control>Current/Power Limit Options section is the **Power/Current Limit Backoff Voltage**. This parameter sets the amount of voltage that the system DC bus will drop by as soon as the generator is loaded to a point where the AC frequency drops below the **Frequency Deviation Threshold**.

Note that with MPP disabled, this setting is not used.

AC Grid



Grid Good Timeout

This is the amount of time SYNERGi allows before deciding that the Grid input is okay.

This time can be used to filter out when the Grid may return only momentarily. For example, if the Grid returns and the genset were to turn off but then the grid immediately fails, the Genset may have to re-start. This parameter stops rapidly turning off and on the genset during a time of particularly intermittent grid.

Grid Bad Timeout

Conversely to Grid Good, the Grid Bad Timeout is used to prevent unnecessarily turning on a genset if the grid is absent for only a few minutes.

Grid Quick Start Timeout

This setting allows quick return to grid when the generator is not running. This is typically when the batteries are in discharge. The issues with preventing repeated turning on and off a generator due to fluctuating grid supply are not a concern, with only a minimal duration to confirm grid return the grid can assume the load.

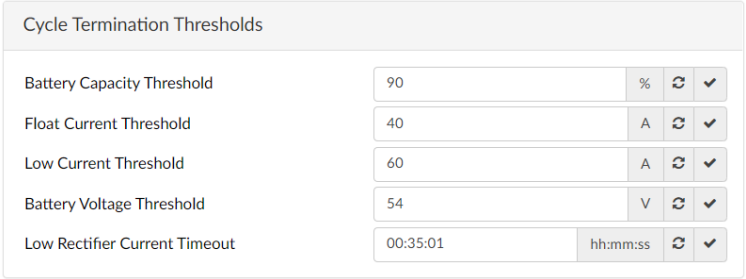
13.17 Hybrid Cycle Setup

There are a number of conditions that can be set up and used to start the generator. Any or all of them can be used concurrently. However, it is usual to choose one particular method for primary control (e.g. bus voltage), and the others as back-up control (e.g. battery capacity) in case the primary control does not work for some reason. The start and stop mechanisms can be mixed as required. That is, a generator can start on a low voltage setting and turn off on a capacity termination setting for example.

13.17.1 Cycle Termination Thresholds

This section defines the various battery charge cycle end points as used when enabled with each start method selection. This section also notes the **Stop On...** settings listed with each start choice and how they correlate.

NOTE: The most efficient choices between the start and stop options are site equipment dependent. Should you be unclear as to how to properly configure a hybrid site please contact your Enatel representative.



Battery Capacity Threshold

The **Battery Capacity Threshold** setting is the battery capacity at which the generator is turned off if **Stop on Battery Capacity > Threshold** is enabled on any of the hybrid start conditions.

A battery is considered full when the Ahrs taken out of the battery are returned to it, multiplied by the factor entered in the **Terminate on Recharge (% of the discharge)** on the Charge page, which is in turn multiplied by the **Battery Capacity Threshold**.

For most applications the **Battery Capacity Threshold** function would be set to 100%, however some applications require partial state of charge cycling which may have this set to 90% or even 80%. Examples would be utilizing the "Extended Charge" functionality; or using non-lead acid batteries such as Lithium ferrous phosphate where 100% charging is undesirable.

There is no time delay on this signal. As soon as the threshold is reached, a "stop" command is given to the generator.

Float Current Threshold

The **Float Current Threshold** setting is used to terminate the battery charge cycle if **Stop on Current < Float Threshold** is enabled on any of the hybrid start conditions, based on the battery reaching a "full" state of charge. It is usually used during the Extended Charge cycle, as it is the extended charge that is usually used to make sure a lead acid battery is fully charged. There are two low battery recharge current termination thresholds. This is to give the user a choice to stop the generator based on a "semi-full" battery recharge, using the **Low Current Threshold**, or when the battery is fully charged - the **Float Current Threshold**.

Note that there is a 10 minute delay imposed on this stop condition. This threshold must be met for a continuous 10 minute period at this stop condition. If the threshold is exceeded any time during this period, the 10 minutes is started again. This is to make sure the charge is not terminated on a false signal due to things like an anti-stall event occurring, where the bus voltage is dropped for a moment and thus the battery current will be briefly zero.

Note importantly that a cycle that is terminated due to this condition causes the battery state of charge to be reset to 100%. This works for any source such as solar input.

Low Current Threshold

The **Low Current Threshold** setting is used to terminate the battery charge cycle if **Stop On Current < Low Threshold** is enabled on any of the hybrid start conditions.

In theory, terminating the battery recharge based on the Sate of Charge (SoC) using SYNERGi's Ahr counting would be the most logical way to cycle the battery based on a partial charge regime (i.e. where you might only want to take the battery to 85 or 90% SoC, thus reducing the time the genset runs in the absorption phase of the recharge). However, due to battery chemistry and errors that can accumulate in Ahr counting at low levels, predicting the actual SoC of the battery during a number of partial SoC cycles is problematic. Hence terminating the recharge of the battery based on current rather than the measured Ahr state of charge can lead to a more consistent cycling.

Note that the **Low Current Threshold** should always be set to a higher level than the **Float Current Threshold**. The float termination level is used to determine that the battery is fully charged and would be usually enabled in the Extended Charge mode.

Note that there are some time delays when the low current stop conditions are met.

Battery Voltage Threshold

The **Battery Voltage Threshold** setting is used to terminate the battery charge cycle if **Stop On Battery Voltage > Threshold** is enabled on any of the hybrid start conditions.

Low Rectifier Current Timeout

This time out is used in a low load situation where the potential to damage a generator exists, where the generator is supplying a load below its normal operating range.

The **Low Rectifier Current Timeout** is initiated from the **Low Current Threshold**.

This duration should be set long enough to avoid false triggers and/or unnecessary generator restarts. Check with your generator vendor also as to the best duration to include to optimize the lifespan of the asset.

Default Inherent Low Float/Low Current Delays

Note to prevent false terminations due to momentary load fluctuations which can sometimes cause battery recharge current to briefly reduce to low levels, default low float/low current delays to the generator Stop command are introduced:

Normally the delay is 2 minutes.

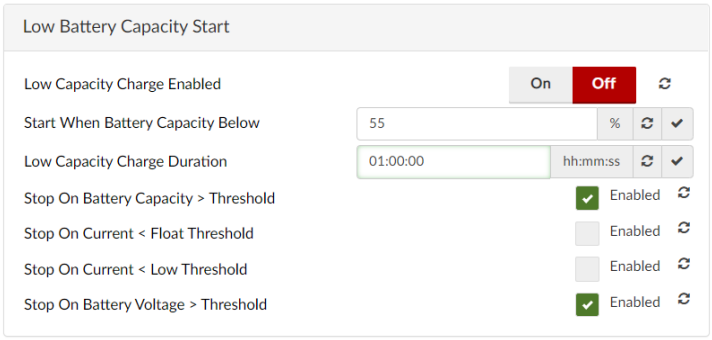
However, after an Anti-stall event, the delay is 3 minutes.

Furthermore, after the system goes from an Equalise voltage to a Float voltage, a delay of 10 minutes is introduced. This is because with a large battery, it can take several minutes before the bus voltage will fall to the float level.

It is important to note that these delays are only introduced when the generator is stopped based on current (amperage).

13.17.2 Low Battery Capacity Start

This section allows the choice of starting the generator on battery low capacity.



Low Capacity Charge Enabled

Toggle **On** to enable a battery low capacity start. There is no priority in the start settings. Whichever situation is encountered first starts the generator.

Start When Battery Capacity Below

This is the percentage of battery full capacity the generator starts. For lead-acid batteries this is highly dependent on the cycle and battery type. A generator powered cycle might use 80% of full capacity, a solar only cycling site 90%. Consult your battery vendor for the most efficient cycling parameters.

For lead acid batteries this is the capacity with respect to the **10h Rate Battery Capacity** set in the Battery>Battery Setting>Lead Acid Settings section. For example, if a 900Ahr battery is used, then if 65% is entered here, the generator will get a start signal when the battery capacity is 585Ahrs.

Low Capacity Charge Duration

This field is used to limit the charge period by time. There is no priority between the duration setting and Cycle Termination Threshold settings. The system stops the generator at the first triggering parameter. In usual practice the duration is used a back up to the cycle thresholds.

Stop On...

For the **Stop On...** descriptions see 13.17.1 Cycle Termination Thresholds.

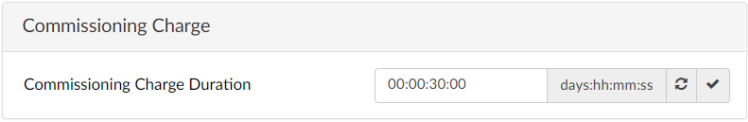
13.17.3 Commissioning Charge

This gives the operator the ability to give a battery an initialisation charge on-site. In most cases, the batteries should arrive at a Hybrid site having had a commissioning charge at the factory or dispatch depot. In instances where this may not have happened, this feature is used so that the installer can set the generator on for the set number of hours here (following the battery manufacturer's recommendations), and then leave the site knowing that after the commissioning charge, the SYNERGi Controller will revert to full Hybrid control.

Note that during Commissioning Charge and any controls from the front panel, the **Battery Capacity Threshold** and the **Low Current Threshold** are not utilized.

Commissioning Charge Duration

Consult the battery specifications to set the **Commissioning Charge Duration**.



NOTE: the commissioning charge is initiated on the Hybrid>Realtime Status page in the Controls section. Click on the **Initiate Commissioning Charge** button.

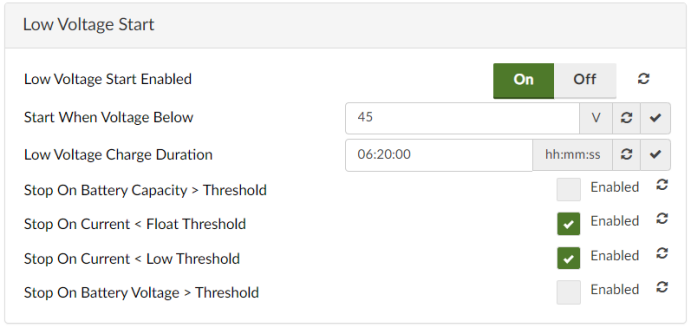
13.17.4 Start Time A & B Setup

These two control settings are used for setting up to two battery charge periods in any one day. The settings are self-explanatory.

NOTE: the times are in 24 hour clock format.

13.17.5 Low Voltage Start

This is used if the generator is to start based on a falling DC bus voltage. This is always higher than the **Extra Low Voltage Start** if both are enabled.



Low Voltage Start Enabled

Toggle **On** to enable a low voltage start. There is no priority in the start settings. Which situation is encountered first starts the generator.

Start When Voltage Below

This setting varies depending on the site equipment, battery type and cycling requirements. It can also be used as a back up to other start conditions.

Low Voltage Charge Duration

This field is used to limit the charge period by time. There is no priority between the duration setting and Cycle Termination Threshold settings. The system stops the generator at the first triggering parameter. In usual practice the duration is used a back up to the cycle thresholds.

Stop On...

For the **Stop On...** descriptions see 13.17.1 Cycle Termination Thresholds.

13.17.6 Extra Low Voltage Start

This section provides generator start/stop parameters used when the normal generator settings are turned off due to a solar created genset inhibit period. The start/stop conditions of the generator use these settings to align with the requirements of a SYNERGi solar cycle.

See 13.18 Solar Optimisation for details.

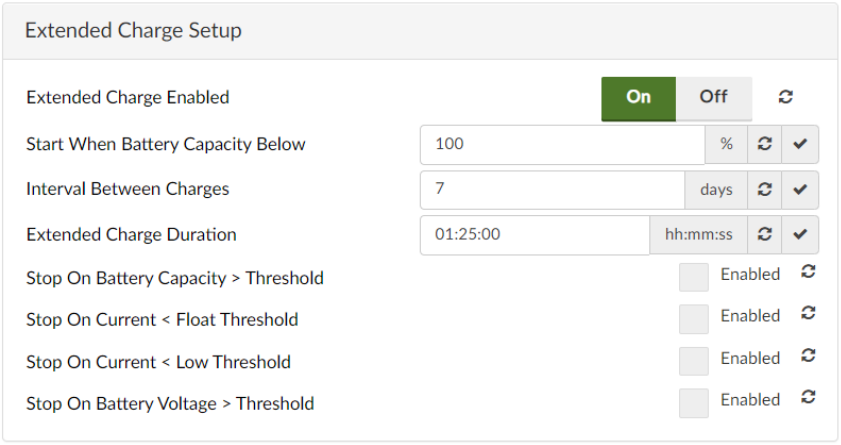
See 13.17.1 Cycle Termination Thresholds for explanation of the genset start/stop features.

ELV Charge Duration

This field is used to limit the charge period by time. There is no priority between the duration setting and Cycle Termination Threshold settings. The system stops the generator at the first triggering parameter. In usual practice the duration is used a back up to the cycle thresholds.

13.17.7 Extended Charge Setup

This is used if it is required to have the generator "top-up" the battery after a certain period. It may be used to ensure the battery can be 100% recharged at least "once in a while". This is especially the case when partial state of charge cycles are used.



Start When Battery Capacity Below

This is a setting such that if the battery is charged above this state, the Extended Charge will not be implemented. This feature can be employed if there are renewable energy sources such as wind and solar. This prevents the generator running unnecessarily.

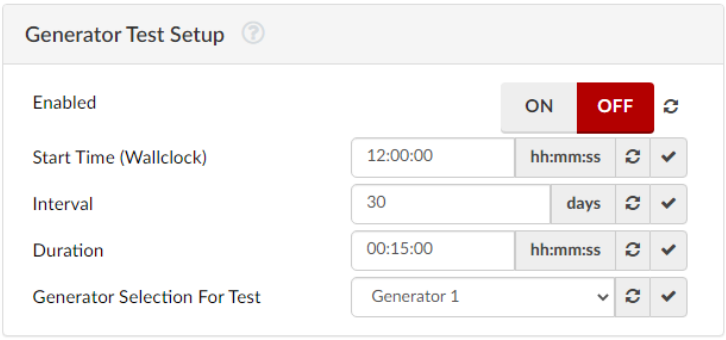
The start time and interval fields are self-explanatory. Generally it is best practice to terminate the test by either **Extended Charge Duration** or **Stop On Current < Float Threshold**. Note that lead-acid batteries requiring an extended charge typically need a considerable time (>1 hour) for this. Check with the battery vendor for details.

13.17.8 Generator Test Setup

On sites where there are large amounts of solar or renewable energy sources, a generator is sometimes used for emergency back-up.

In that case (and in situations where it may be desirable to run the generator for a period of time no matter what), the **Generator Test Setup** forces the generator to run without any other stop parameters except **Duration**.

NOTE: this can be used in conjunction with Extended Charge as an extra extended charge option.



When setting up these parameters consider the amount of fuel available and its use-by date. Also check with the generator vendor for a suitable interval and duration to run the generator for asset life-span efficiency.

NOTE: Generator Selection For Test enables the forced running of one generator in preference to another.

Battery Recharge Inefficiency

During recharge, a battery needs to have more amp-hours put back into it than were taken out of it during the discharge phase. The value here must be entered upon consulting the battery manufacturer's data. The figure used for a 600Ahr tubular gel battery (OPzV) might typically be 106%.

During discharge, the Ahr counting works by reading the current through the battery shunt and multiplying it by the time. However, during recharge, the SYNERGi divides the Ahr counting (on a continuous basis) by the Inefficiency Factor to put proportionately more Ahrs back into the battery.

If this figure is too high, it is possible that the batteries may not accept that amount of recharge, and this figure may never be reached, which will result in an extended wasteful run of the generator. That is why usually the "Stop on Low Battery Current" is enabled on the hybrid cycle controls.

If this figure is set too low, then the battery may not get fully charged each cycle. That is why usually both Low Battery Capacity and Low Voltage start-ups are enabled. The Low Battery Capacity may be used at the primary cycle control, and the voltage as the back-up in case the battery "stair-cases" down in voltage with each hybrid cycle.

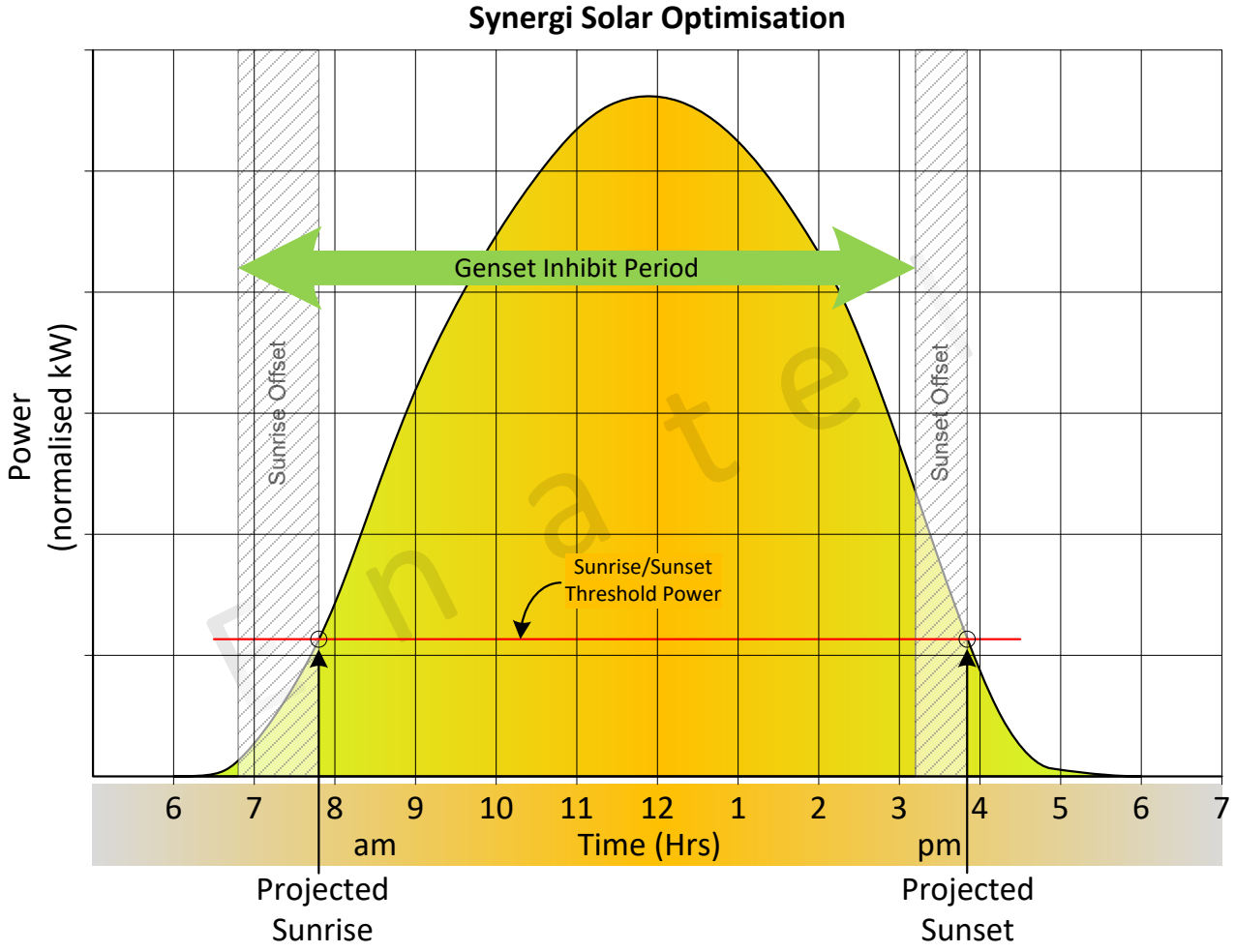
13.18 Solar Optimisation

The purpose of Solar Optimisation is to ensure that on a Solar/Generator Hybrid site the generator does not run unnecessarily, especially in anticipation of sunrise, first thing in the morning.

Rather than relying on accessing online forecasts or similar SYNERGi simply looks at the earliest sunrise over the last 10 days to know when to turn off the generator. SYNERGi then creates an extra-low voltage start criteria during the solar day to start the generator if required.

A graphical representation of the logic is shown here:

Figure 27: Solar Optimisation



As shown in Figure 27, SYNERGi creates a Genset Inhibit Period. This includes offsets to optimize the period the generator should run.

Sunrise Detection Threshold Power

This figure is both the sunrise detection threshold and the sunset threshold (i.e. it informs SYNERGi when a solar day has ended). It should be set as low as feasible for the solar array installed considering equipment requirements and factors that may cause false end-of-day readings such as storms.

Sunrise Offset

Is a settable time prior to sunrise so that the generator stops before sunrise to save fuel. Default is one hour.

Sunset Offset

A settable time where the Inhibit Period ceases prior to actual sunset – this can be useful if there has been little sun during the day, and therefore there is no reason to run the battery down to a lower capacity than necessary.

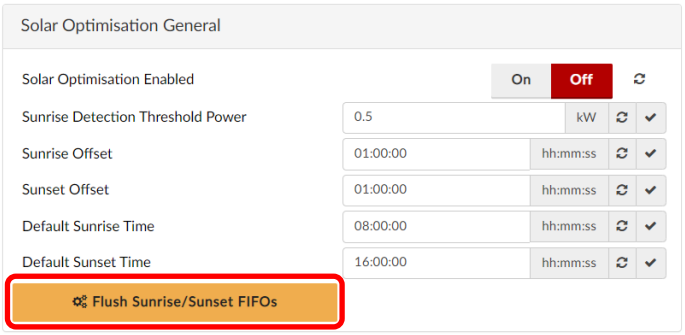
Default Sunrise and Sunset

These are the preliminary figures to start the solar day calculation, only. They are replaced as soon as measured data is available. See also 13.18.1 Solar Optimisation Debug.

SYNERGi looks at the earliest time over the last 10 days to decide on the sunrise settings and the latest time for the sunset. In this way the seasons are followed throughout the year.

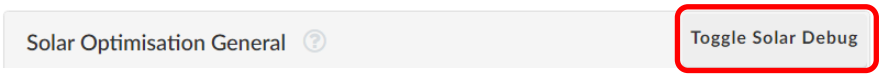
Flush Sunrise/Sunset FIFOs

Click on the **Flush Sunrise/Sunset FIFOs** button (FIFO = first-in first-out) to remove any historical data when looking to restart the sunrise and sunset time calibration.

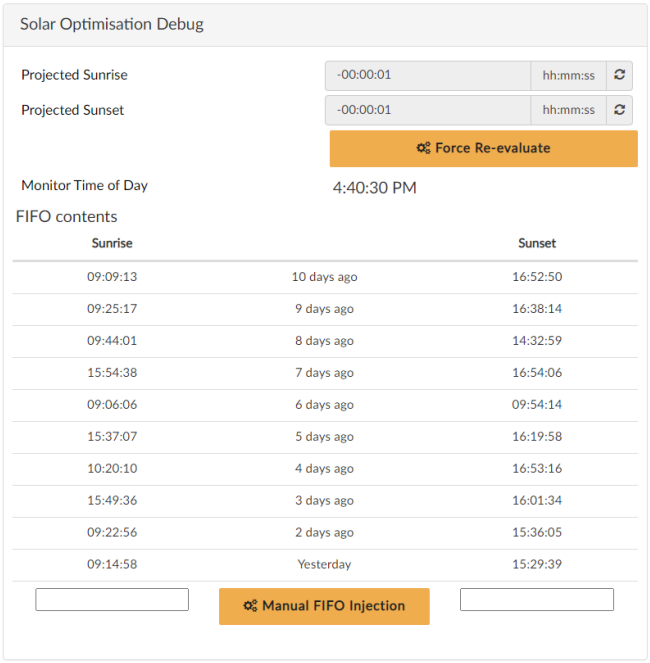


13.18.1 Solar Optimisation Debug

1. Click on the **Toggle Solar Debug** button to view the history of sunrise/sunsets.

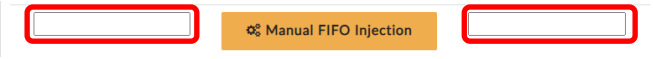


2. The Solar Optimisation Debug section displays.



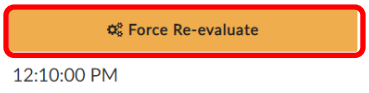
Should the Hybrid solar day period require resetting:

Enter designated sunrise and sunset times into the respective fields at the bottom of the section to recalibrate the **Projected Sunrise** and **Projected Sunset** times.



Click on the **Manual FIFO Injection** button to queue new sunrise and sunset times.

Click on the **Force Re-evaluate** button should the new sunrise and sunset time be required to take affect immediately (rather than waiting till the next designated recalculation time).

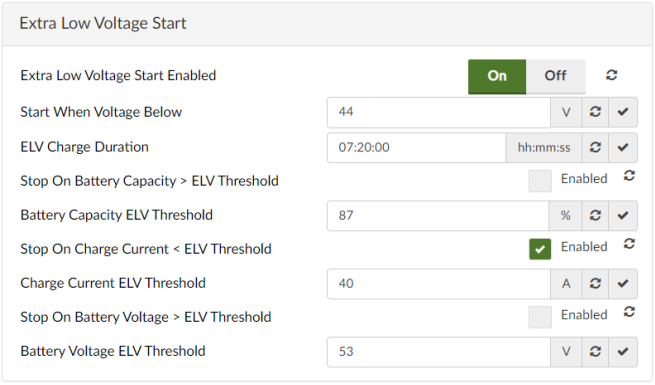


Comment on Extra Low Voltage Start

The option to select an extra-low voltage start threshold for the generator is provided on the Hybrid>Hybrid Cycle Setup page, with programmable genset stop conditions that can be either:

- charge duration,
- battery capacity, and/or
- low battery charge current,

These stop conditions, if enabled, are completely independent to the normal genset stop conditions set on the Hybrid Cycle Setup page. This gives the operator a large amount of flexibility to optimise the settings based on overall network requirements or site specific requirements.



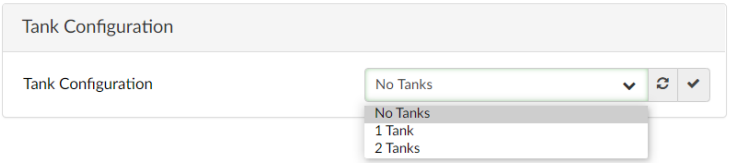
NOTE: should you reset the EM4x, all settings revert to the factory defaults.

13.19 Fuel Tank Setup

Up to 2 fuel tanks can be setup. The drop down menu at Hybrid>Fuel Tank Setup>Tank Configuration allows set up for:

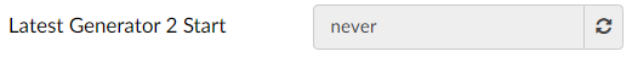
- No tanks;
- 1 Tank (which can be shared between 2 generators);
- 2 Tanks (which can be split between 2 generators or both used for 1 generator);

depending on the input logic associated with the setting.



Note that with the **1 Tank** setting, it is assumed that this is always assigned to Generator 1. Both tanks have the same setting designations except for the tank 1 and tank 2 assignment.

If **No Tanks** are selected, then on the Hybrid>Realtime Status page the **Latest Generator Start** field displays **never**.



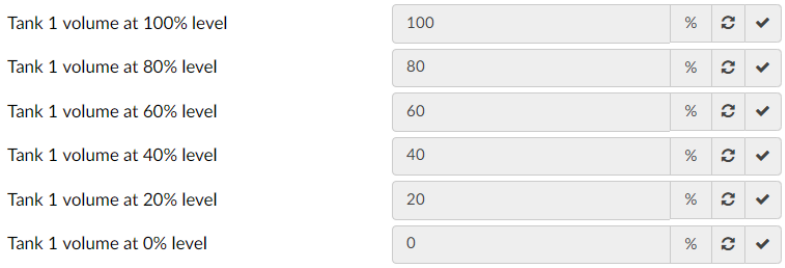
Tank Sensor Reading at 100% and 0% Level

When the fuel tank is full, this field is manually entered from the **Fuel Tank Sensor** field reading to provide a basis for real time fuel volume calculations.

Similarly the sensor reading at 0% level is default 0 to provide the fuel tank volume calculation range from full to empty.

Tank Volume % Level

To cater for odd shaped tanks, where the level detected by a float sensor may not have a direct correlation to fuel volume remaining, enter the tank profile in the Level = Volume settings.



Tank Capacity at 100% volume

Enter the maximum volume of fuel in the tank here.

Tank refill volume

Is the fuel volume the **Refill Fuel Tank** alarm is raised.

Tank alarm volume

Is the fuel volume the **Fuel Tank Low** alarm is raised.

Fuel Tank sensor

Is the current fuel level as interpreted by the EM4x for calculation purposes. When the tank is full this figure is entered into the **Tank sensor reading at 100% level** field to provide the basis for volume calculations.

Tank computed level, volume and contents

These figures are calculated from the **Fuel Tank sensor** reading and the other settings on the Fuel Tank Setup page.

13.19.1 Hardware Interfacing of Fuel Sensors

For assistance to include a hardware interface for a site specific fuel sensor please contact your Enatel representative.

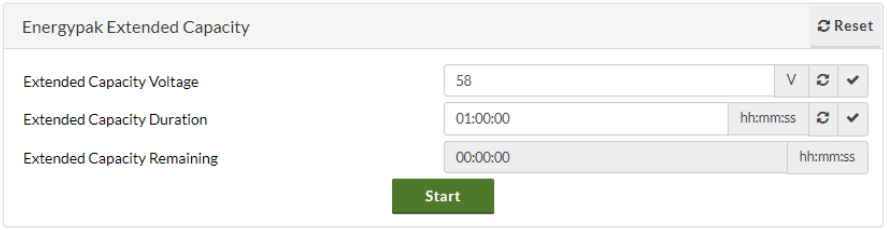
13.20 Energypak Extended Capacity

NOTE: Extended capacity is a license locked feature. See 11.4.3 Unlockable Features.

The energypak extended capacity mode is a feature that enables charging of the energypak beyond the default maximum voltage of 57.6V (4.05V/cell) to a potential maximum of 58.8V (4.2V/cell) for a time limited duration.

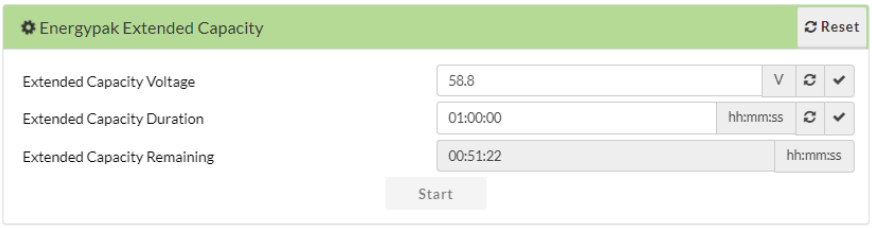
NOTE: Extended capacity mode takes priority over any other user controlled energypak activity. Initiating this mode overrides functions such self-discharge testing or GTO.

The feature is located on the **Charge** page in the Energypak Extended Capacity section.



To utilize:

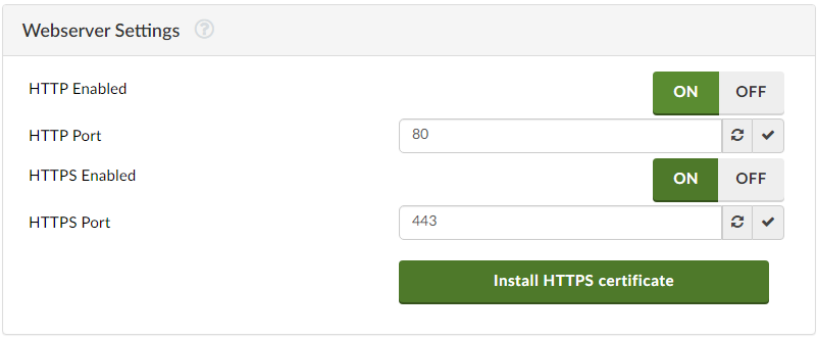
2. Set the required voltage in the **Extended Capacity Voltage** field
3. Set the time period in the **Extended Capacity Duration** field. Note that the system requires some time to charge the energypak to the required voltage which depends on the load and rectifier capacity. Maximum duration is 24 hours.
4. Click on the **Start** button.
   NOTE: section header bars turn a light green when active



To manually stop the extended capacity mode click on the **Stop** button at the top of the **Charge** page.

13.21 Webserver Settings

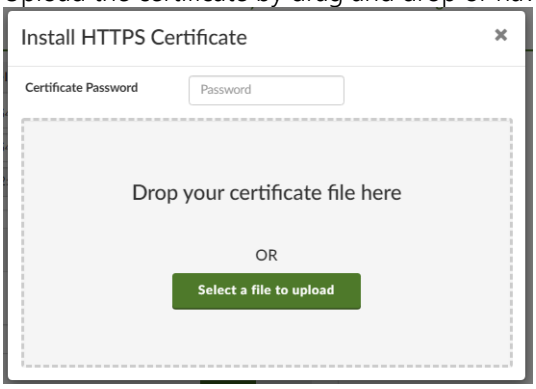
NOTE: any changes to this section require a system reboot to take effect. See 11.4.6 Restart Monitor.



The Webserver section provides for the inclusion of a custom https certificate in the EM4x.

1. Click the **Install HTTPS certificate** button.
2. Enter the password generated with the certificate creation.

3. Upload the certificate by drag and drop or navigate to the file using the **Select a file to upload** button.



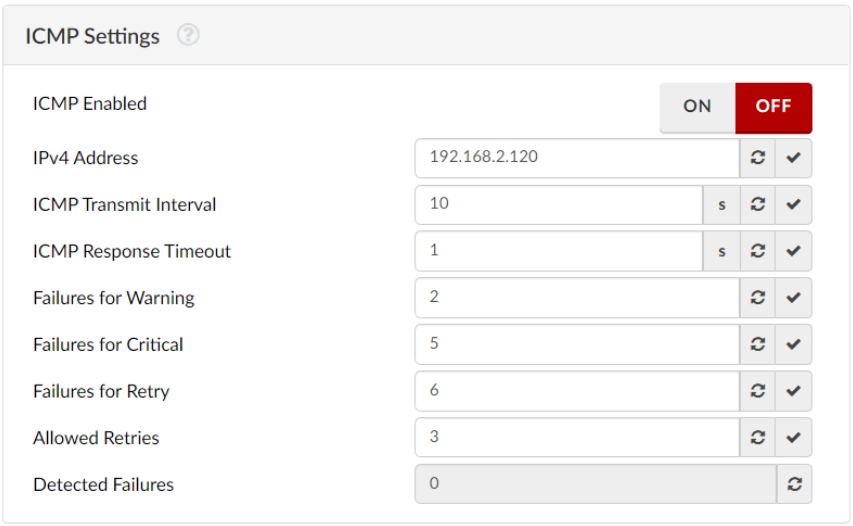
4. Reboot the system. See 11.4.6 Restart Monitor.

13.22 ICMP Ping and Reset

The EM4x can ping Internet Control Message Protocol (ICMP) echo request packets to the target host (typically a modem). On failure of return of ping the EM4x then raises alarms. An alarm can be configured to attempt to restart a modem from a relay. Which can save a truck roll to turn a crashed modem on and off.

This section details how to configure such a modem reset function.

At Settings>Network Settings>ICMP Settings enter the required parameters:



ICMP Enabled: once the required parameters are entered toggle ICMP Enable **ON**.

IPv4 Address: is the IP address of the device to be pinged.

ICMP Transmit Interval: is the time between transmitting a ping to the modem. Note the system pings the modem continuously without stopping once enabled.

ICMP Response Timeout: is the period without a return of ping that the system determines that a ping return failure has occurred. Note this time must be less than the ICMP Interval setting.

Failures for Warning: is the number of failed ping returns to raise the Ping Failed Warning alarm. This provides a buffer to determine there is no false triggers.

Failures for Critical: is the number of failed ping returns to raise the Ping Failed Critical alarm. Note that this must be more than the Failures for Warning entry. Note that this figure is the total number of pings from zero, not in addition to the number of pings for Failures for Warning.

Failures for Retry: is the number of ping failures before the system resets the Detected Failures to zero and all alarms are turned off. When there is still failure of return of ping the alarm cycle is looped through. Note this figure must be equal or more than the Failures for Critical entry.

Allowed Retries: is the number of Failure for Retry loops of alarm cycles the system attempts before allowing the Detected Failures to continuously count. In effect this is the number of times the system attempts to restart the modem.

To manually attempt a restart of the modem toggle ICMP Enable Off and On and the Detected Failures begins again at 0. Note setting this to zero does not stop the controller from attempting to retry pings.

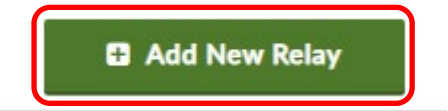
Detected Failures: counts the total times the system has failed to detect a return of ping since the last count start.

NOTE: the Detected Failures count resets to zero once a ping return occurs so that the system automatically resets itself once the relay and modem are set up and communicating correctly.

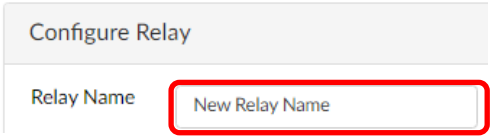
13.22.1 Configuring a Modem Restart from the Ping Failed Critical Alarm

To configure a modem restart using the Ping Failed Critical alarm:

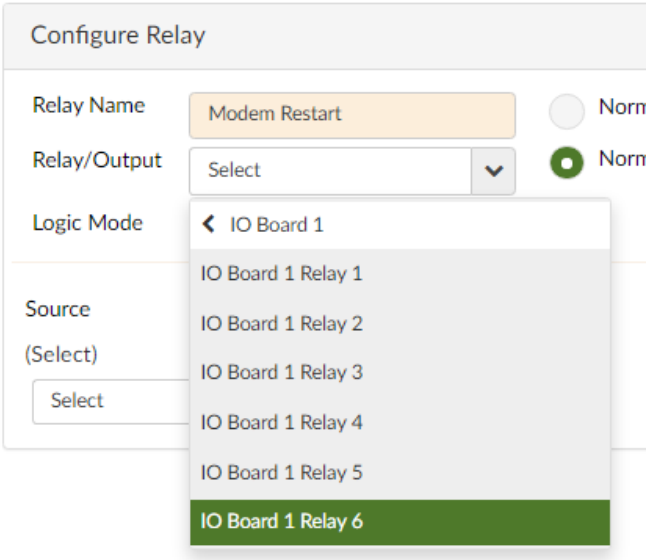
1. Navigate to the Relay/Output Logic page.
2. Click the **Add New Relay** button.



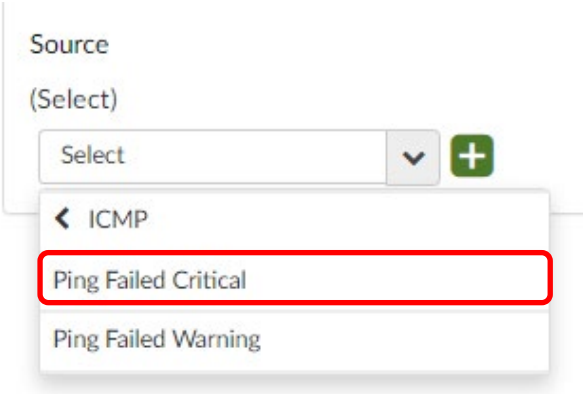
3. Enter the **Relay Name** in the Configure Relay section.



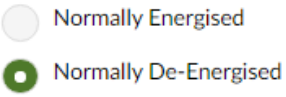
4. Select the required relay from the **Relay/Output** drop down menu.



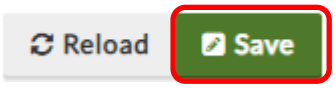
5. Select **Ping Failed Critical** from the **Source** drop down menu: Alarms>ICMP>Ping Failed Critical.



6. Select either **Normally Energised** or **Normally De-Energised** for the relay state as appropriate for the modem restart functionality.



7. Click the **Save** button.



13.23 Modbus TCP Server

Toggle Enable Modbus Server **On** to allow the energy manager to function as a Modbus TCP server via Ethernet.

Enter the correct TCP Port as required.

NOTE: enabling Modbus TCP master is managed at IO Configuration>Modbus Master.

14 THE WEB UI SOFTWARE COMPONENTS

14.1 Connection

See 10.1 Energy Manager Connectivity and the Web UI for information on how to connect to the energy manager Web UI.

Access Levels

There are 3 access levels for the energy manager Web UI:

enaguest:	can only view status of system
enabasic:	reduced privilege, can view settings and system status
enaadvanced:	this user has normal full control access of the system

The default password for all levels = **ena123**

14.2 EM4x Software Overview

The user interactable software elements to the energy manager are:

1. The energy manager configuration ***.em4x** file which contains input logic and all parameters that defines the fundamental functionality of the energy manager and customized features as required for each application. This can be managed independently of the energy manager firmware and is **not** over-written when installing new firmware. See 14.3 Configuration File.
   NOTE: installing a new configuration file over-writes the existing input logic and alarm configuration of the following items 2 and 3.
2. The input logic dedicated file ***.enl** which contains only the input logic of the energy manager. This is a component of the *.em4x configuration file which can be managed independently. See 14.4 Input Logic File.
3. The alarm configuration file **alarmconfig.em4x** which is also a component of the energy manager configuration file used to provide convenient modification of the alarm configuration parameters, only. See 14.5 Alarm Configuration File.
4. The energy manager firmware ***.ena** file where the firmware software of the energy manager, the IO boards and energypaks (not the rectifiers) is incorporated into the energy manager firmware and managed through the Web UI. The energy manager EM4x firmware is a ***.ena** file that contains:
   a. EM4x firmware
   b. energypak firmware
   c. I/O board firmware (this board is treated as a separate peripheral to the EM4x, multiple IO boards can be connected to the EM4x)

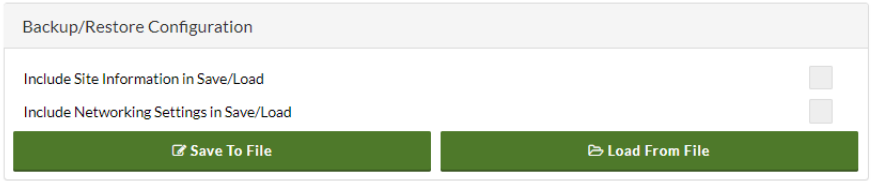
   NOTE: The rectifier firmware is neither Web UI nor customer accessible and is managed at the factory level. See 14.6 Firmware.
5. The bootloader firmware ***.enb** file which is included as a separate upload file if upgrades to this feature are required. See 14.7 Bootloader Upgrade File.
6. The SNMP MIB file ***.mib** which is downloaded for use to obtain the energy manager SNMP traps remotely in a NOC or otherwise.

14.3 Configuration File

The custom variables of the controller such as the dedicated input logic and the specific parameters of each system are stored in a ***.em4x** configuration file. The variables of this file define each system's functionality and associated peripherals' functionality.

The configuration file can be used to replicate custom settings across multiple DC system sites or used to back-up the configuration of individual sites.

This feature is located under the Settings>General Settings page of the Web UI. The login access level required is *enaadvanced*.



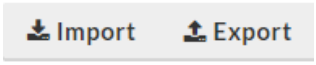
The two options **Include Site Information in Save/Load** and **Include Networking Settings in Save/Load** are enabled to allow site specific details to be included in the configuration file. Should a generic configuration file be required to replicate a configuration across different sites these check boxes are not enabled.

NOTE: loading a new configuration file over-writes the existing input logic of the system and the alarm configuration.

NOTE: enabling **Include Network Settings in Save/Load** over-writes the existing network settings when loading a new configuration file. Be careful not to take the system off-line.

14.4 Input Logic File

The input logic *.enl file is managed by the **Import** and **Export** buttons on the Input Logic page. The login access level required is *enaadvanced*.

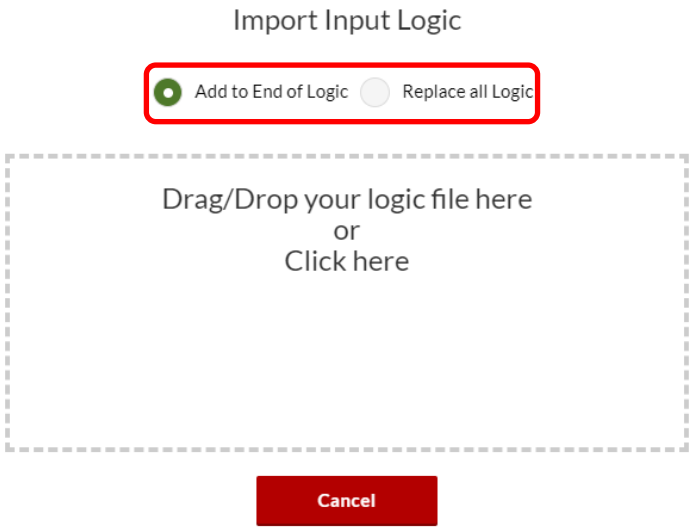


14.4.1 Importing Input Logic

Importing a new input logic file has two options:

1. **Add to End of Logic** the new file input is appended to the existing input logic.
2. **Replace All Logic** the existing input logic is completely over-written.

CAUTION **This requires care in use as system critical functions are defined in the input logic.**



NOTE: it is recommended to export the current *.enl file as back up before attempting an import.

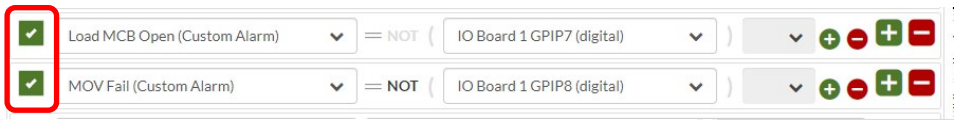
NOTE: if a site has customized input logic it is recommended to save a back up of the input logic either as an *.enl file or more generally as included in a back up configuration file which includes the sites specific energy manager settings.

14.4.2 Exporting Input Logic

Clicking the **Export** button downloads the complete input logic file.

To select individual components of the Input Logic to export:

1. Enable the required expression check boxes.



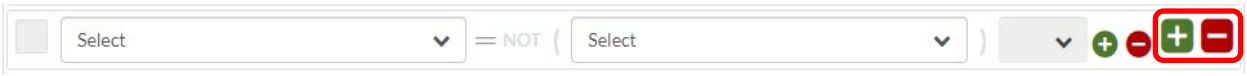
2. Click the **Export** button.

14.4.3 Authoring Input Logic

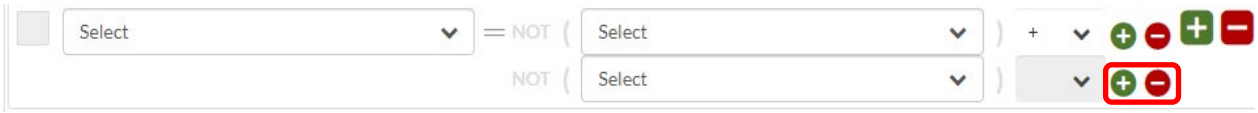
This section describes the tools (rather than the process) that the Web UI provides to author input logic under the section Input Logic>Logic Expressions. See 15 Creating Custom Features for examples of using input logic.

NOTE: the input logic functions as sequential operations.

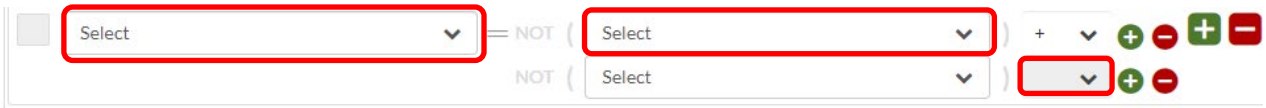
To create or remove expressions use the large square **+ -** icons.



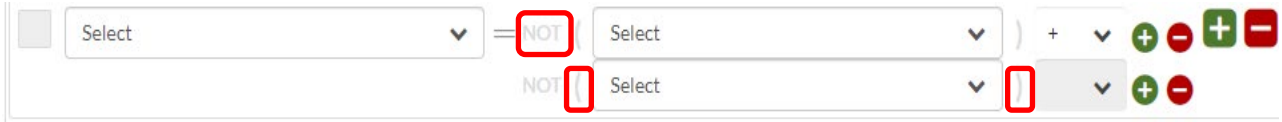
To create or remove additional expression conditions use the small round **+ -** icons.



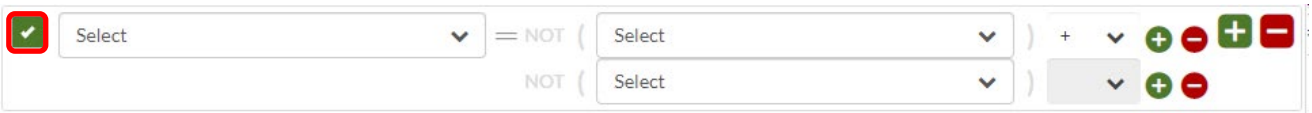
Values can be entered from the drop-down lists provided.



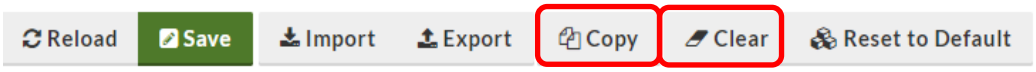
Note the greyed-out options. Click on these to toggle the features. Up to 3 brackets can be nested.



Enable the check box to select an expression.

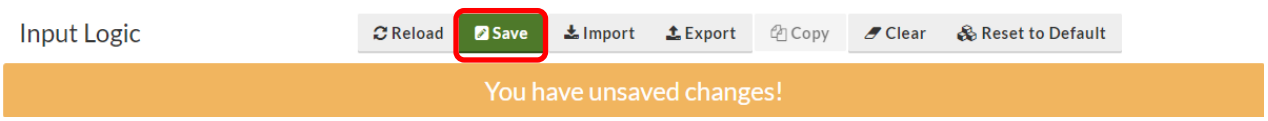


Use the **Copy** button to copy a selected expression. Use the **Clear** button to remove a selected expression.

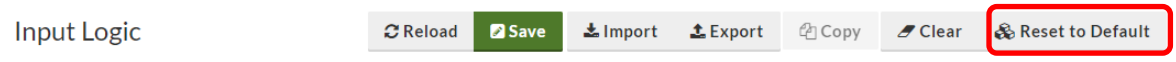


Note the prompt informing of unsaved changes.

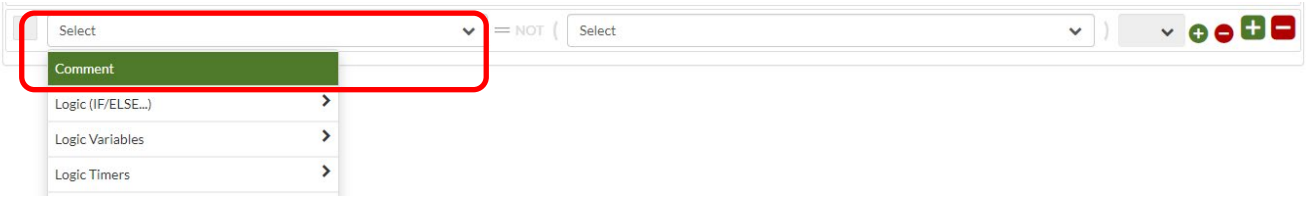
NOTE: navigating away from the Input Logic page without clicking on the **Save** button **loses all changes made**.



At need the **Reset to Default** button can be used to return factory default settings however it is recommended that a backup configuration or input logic file be made prior to modifying the input logic and reinstalling this preferred.



Note the **Comment** option in the expression drop down list.



Selecting **Comment** allows descriptive text to be entered to provide insight as to the function of sections of the input logic.

For further information on using the input logic see 15 Creating Custom Features.

14.5 Alarm Configuration File

The **alarmconfig.em4x** file can be imported and exported on the Alarm Configuration>Alarm Configuration page.

The alarm configuration file holds the specific parameters of each alarm setting. It is a subset of the configuration file and does not need to be backed up independently. It is a convenient method to unify custom alarm settings across multiple sites without impacting other aspects of the system settings.

14.6 Firmware

14.6.1 Introduction

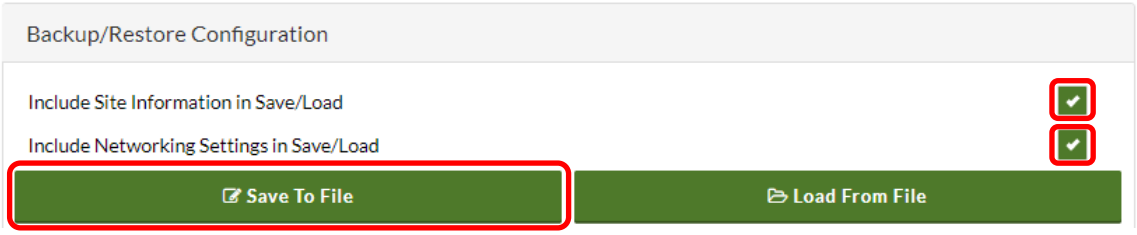
From time to time new firmware is made available to upgrade the energy manager. The file format is ***.ena**. The login access level required is *enaadvanced*.

NOTE: a firmware file includes not only the latest firmware for the controller but also for IO boards and energypaks. If new firmware is included for the energypak an alarm is raised *"Energypak Firmware Upgrade Available"*. See 14.6.3 Upgrading Non-Controller for how to upgrade the energypak and IO boards.

NOTE: Should new firmware be made available for system components it is recommended to upgrade their firmware.

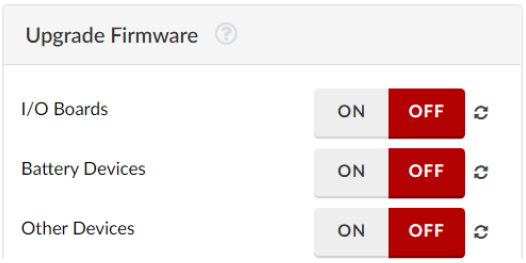
14.6.2 EM4x Firmware Upgrade Procedure

Before upgrading the firmware it is recommended to back up the configuration file located in the Web UI at Settings>General Settings>Backup/Restore Configuration. A firmware file upgrade does not overwrite the system configuration file, network or other user defined settings, this is a precaution against an interrupted upgrade or similar, only. Note for this back up the **Include Site Information in Save/Load** and **Include Network Settings in Save/Load** options should be enabled.



To upgrade the EM4x firmware:

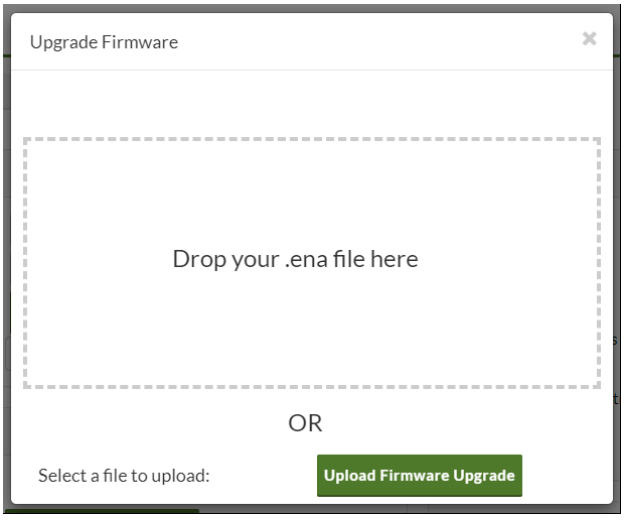
1. Open the Settings>General Settings page.
2. Confirm which ancillary devices are to be upgraded during the process. Toggle the required device ON.



NOTE: as of ena firmware release 7.0 **Battery Devices** includes energypak only and there are no **Other Devices** that auto-upgrade firmware.

3. Click on the **Start Upgrade** button.

4. Upload the new *.ena firmware file by either drag and drop or selection with the **Upload Firmware Upgrade** button.



5. The firmware upgrade automatically completes for the EM4x and those ancillary devices enabled. During the process the EM4x reboots and as the final action the Web UI reloads.

NOTE: should the firmware upgrade fail, re-enter the minimized Web UI and repeat the upgrade process.

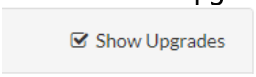
14.6.3 Upgrading Non-Controller Firmware

The *.ena firmware file incorporates firmware for energypaks and IO boards. If a new version firmware is detected for either the energypak or IO board when a firmware upgrade is undertaken a **"... Firmware Grade Available"**

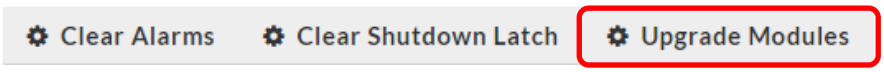
alarm is raised to indicate availability and the item icon on the Power Modules>Power Modules page is indicated by a light green colour.

To upgrade the ancillary software:

1. Upgrade the *.ena firmware as detailed at 14.6.2 EM4x Firmware Upgrade Procedure (if not already done so).
2. Navigate to the Power>Power Modules page.
3. Click the **Show Upgrades** check box.

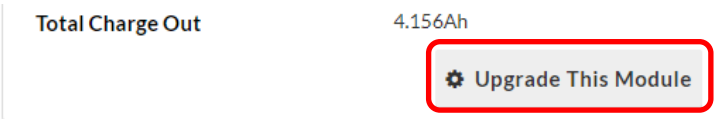
   

   The **Upgrade Modules** button appears.
4. Click the **Upgrade Modules** button to begin the upgrade process.

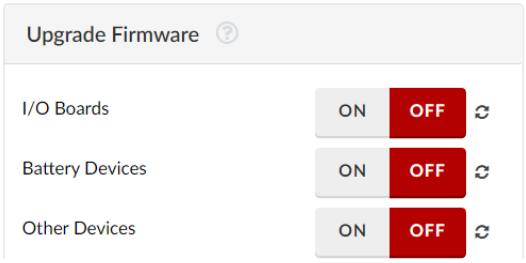
   All modules and ancillary cards requiring new software are upgraded one after the other using the **Upgrade Modules** button. This can take considerable time for highly populated systems.
   NOTE: An energypak firmware upgrade can take 5 minutes or more per module and a firmware upgrade has priority of any other action.

   To upgrade only one module or ancillary card, on the Power>Power Modules page click on the required item. At the bottom of the module information display click on the **Upgrade This Module** button.

Firmware updates can be configured to be installed automatically during an EM4x firmware update depending on customer preference.

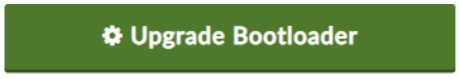
At Settings>General Settings>Upgrade Firmware the options to automatically upgrade non-EM4x firmware can be toggled ON and OFF.



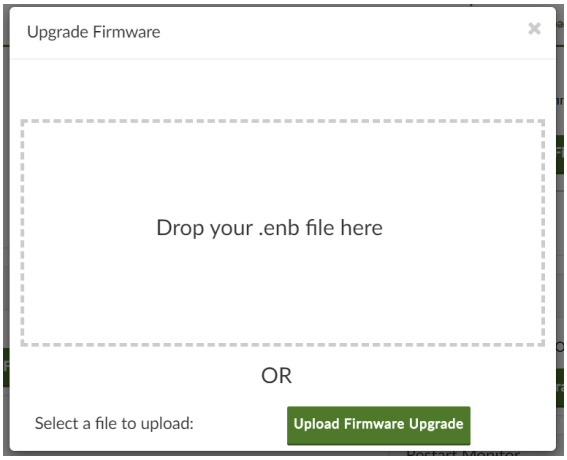
14.7 Bootloader Upgrade File

To upgrade the bootloader independently of the firmware a ***.enb** file is provided.

1. Click on the **Upgrade Bootloader** button in the Settings>General Settings>Upgrade Firmware section.

2. Upload the new *.enb firmware file by either drag and drop or selection with the **Upload Firmware Upgrade** button.

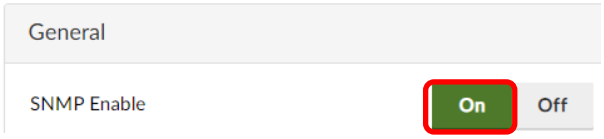


14.8 MIB File

The energy manager MIB file **em4x.mib** can be downloaded on the Settings>SNMP settings page.

To download the MIB file:

1. Check SNMP Enable is **On**.



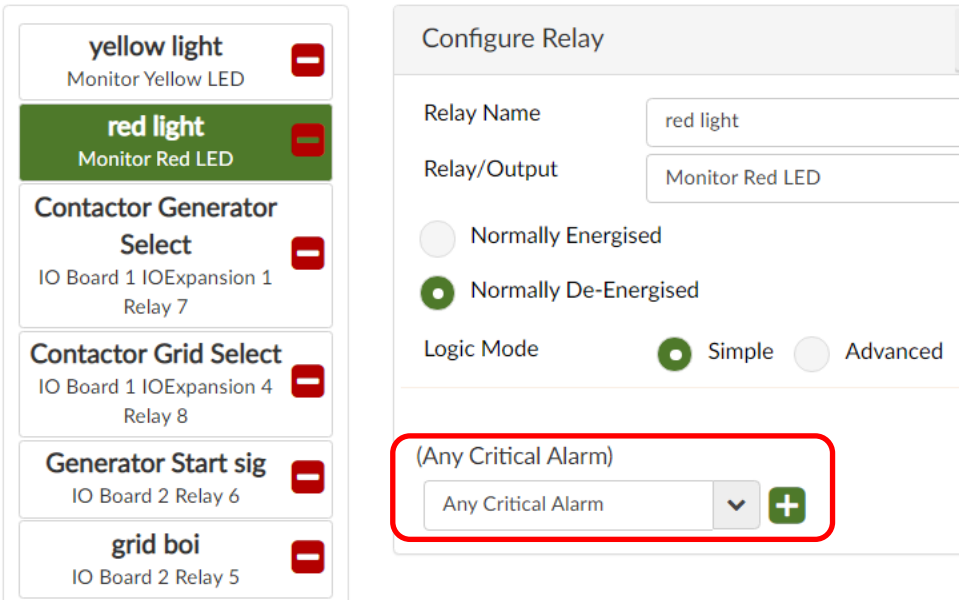
2. Click the **Download MIB** button.

14.9 Relay/Output Logic

Refer to the Relay/Output Logic page Configure Relay section of the Web UI to understand the how the Alarm Configuration is mapped to the EM4x LEDs.

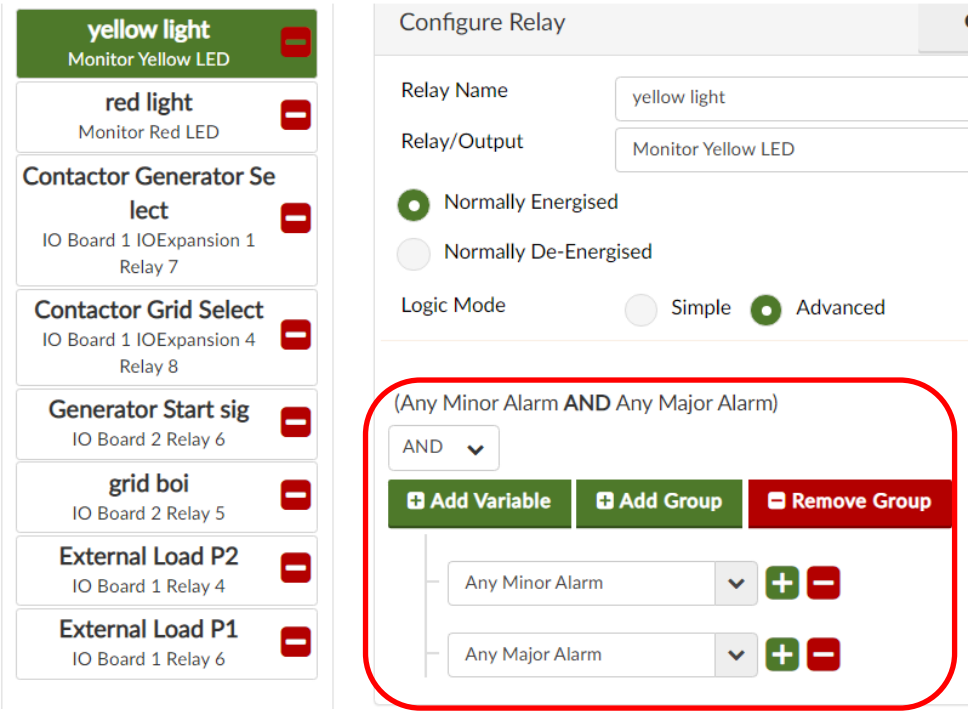
NOTE: the Alarm Configuration>Alarm Configuration page of the Web UI displays the priority setting of each alarm. See 14.5 Alarm Configuration File.

14.9.1 EM4x Red LED Urgent Alarm Mapping



Comment: For reference only. Actual system alarm mapping may vary.

14.9.2 EM4x Yellow LED non-Urgent Alarm Mapping



Comment: For reference only. Actual system alarm mapping may vary.

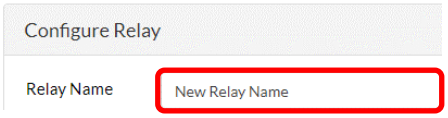
14.9.3 Adding a New Relay

See 10.2.10 Relays 1 to 6 for hardware connection.

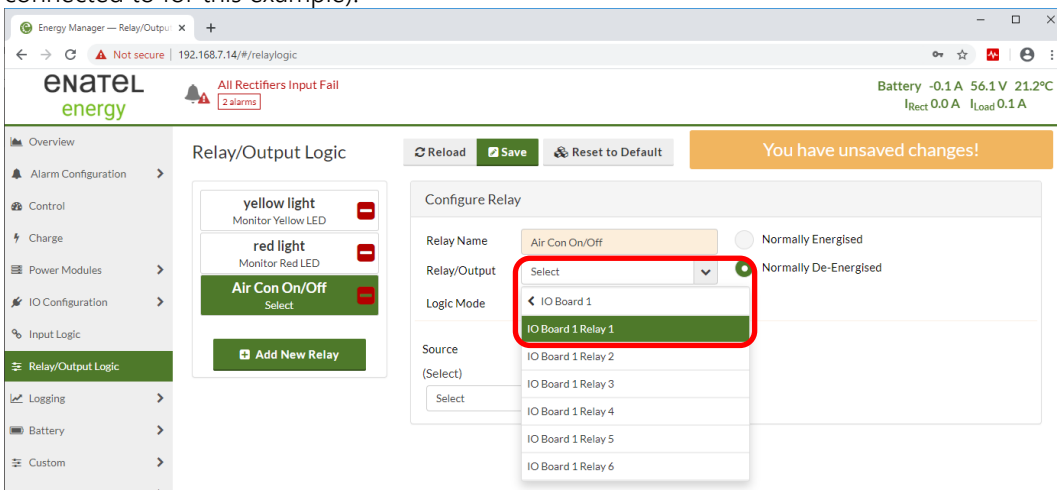
Access level required: *enaadvanced*.

1. Click on the **Add New Relay** button on the Relay/Output Logic page.

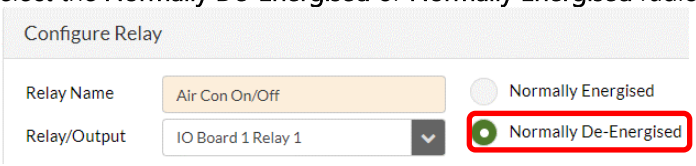
2. Enter the new **Relay Name** in the Configure Relay section.



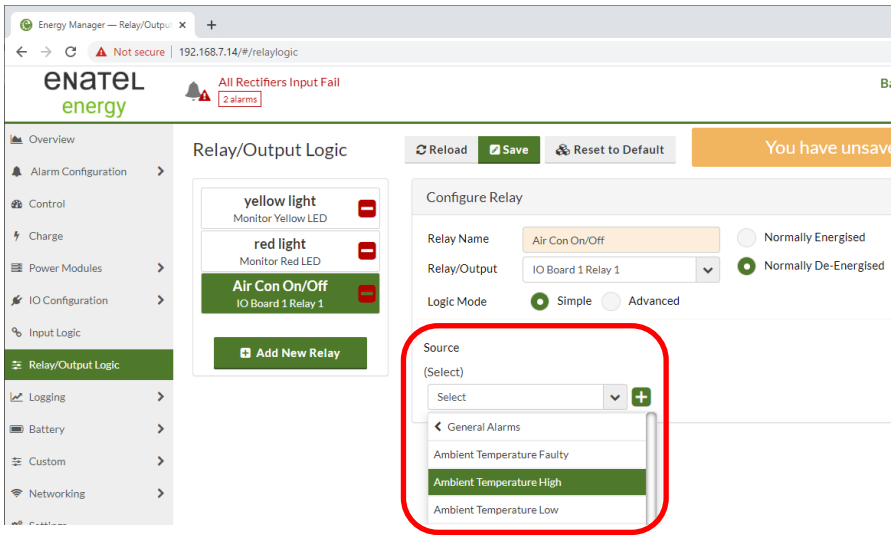
3. Assign the **Relay/Output** via the drop down menu to IO Board 1 Relay 1 (where the related feature is connected to for this example).



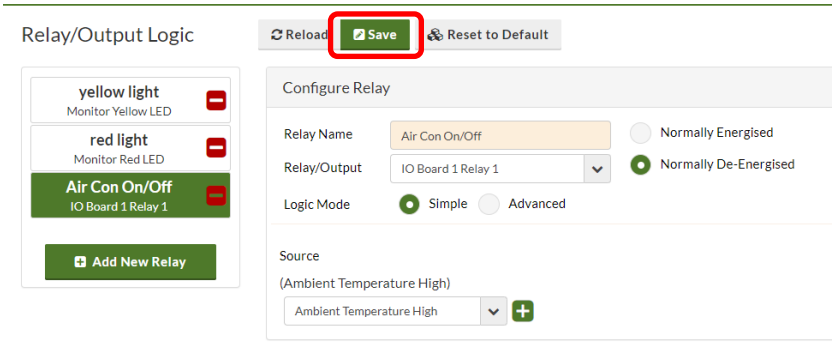
4. Select the **Normally De-Energised** or **Normally Energised** radio button as required.



5. Assign the **Source** to the feature required. In this case an alarm.



6. Click on the **Save** button.



See 15 Creating Custom Features for further details and examples.

14.9.4 Reset to Default

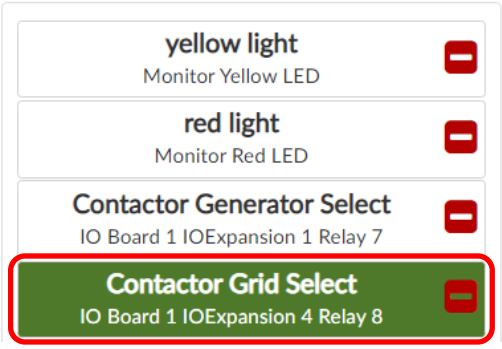
Click the **Reset to Default** button to remove custom relay and output mapping and return to the factory default.

NOTE: save the configuration file prior to resetting to default to keep a record of the existing settings. See 14.3 Configuration File.

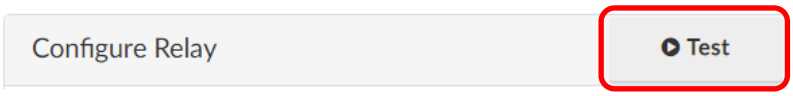
14.9.5 Relay Test

To test a relay is functioning:

1. Select the required relay.



2. Click on the **Test** button.



Important: whatever is configured to run from the relay, such as an air conditioner, a generator turn on or similar is activated by this test. Related LEDs/buzzer functions of the energy manager are also activated.

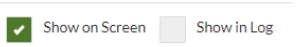
NOTE: the test runs for 60 seconds.

15 CREATING CUSTOM FEATURES

This section describes the creation of custom features such as utilizing the relays and output logic for site specific functions. Access level required: *enaadvanced*.

The general process when authoring custom features in the energy manager in sequential order is as follows:

1. Create any custom alarms, variables or metering as required under the Custom menu.
   NOTE: to get a variable to display on the Overview page or in the Logs it must be declared as a Custom Variable. Enable the **Show on Screen** and **Show in Log** check boxes at Custom>Custom Variables as required when creating a Custom Variable.

2. Add any new relays required on the Relay/Output Logic page.
3. Author input logic on the Input Logic page.
   NOTE: custom alarms and relays do not show on the Input Logic drop down menus until created and saved into the system.

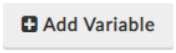
To assist understanding a variety of example custom features are demonstrated. See 15.4 Custom Features: Example 1.

15.1 Custom Variables

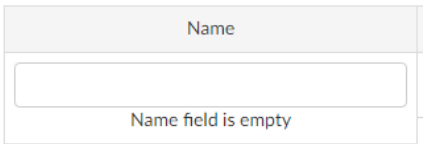
Custom variables can be created at Custom>Custom Variables.

Access level required: *enaadvanced*

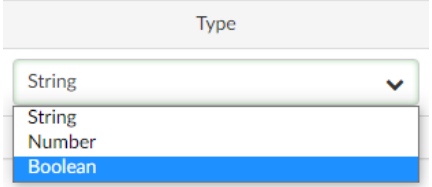
1. Click on the **+Add Variable** button.



2. Enter a name in the **Name** field.

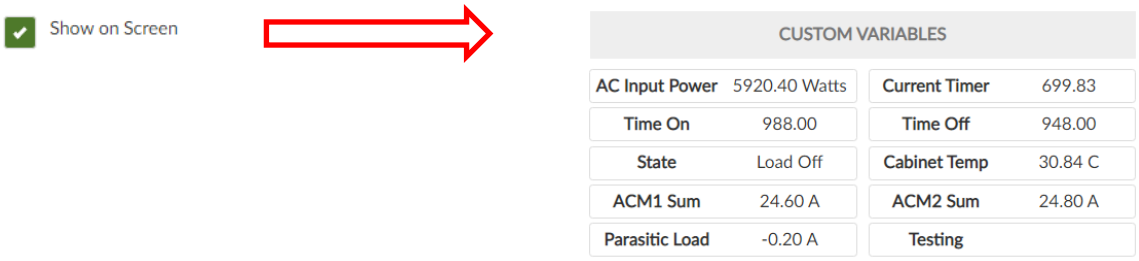


3. Select the type of variable from the **Type** drop down list.



4. Enter the accuracy and units as required.

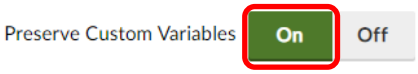
5. Enable **Show on Screen** to have the custom variable display on the **Overview** page.



15.1.1 Preserve Custom Variables

When Input Logic is saved, or the Restart Control Systems button at Settings>General Settings>Restart Monitor is clicked, custom variable counters such as a timer are reset to 0.

To keep the present values of custom variables in these situations toggle Preserve Custom Variables **On**.



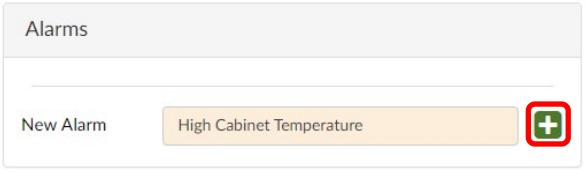
15.2 Custom Alarms

To create a custom alarm navigate to Custom>Custom Alarms.

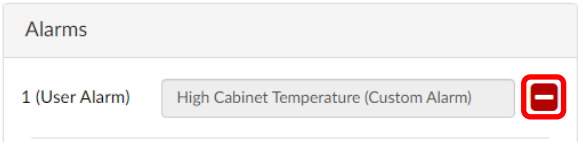
Access level required: *enaadvanced*

1. Enter an alarm name in the **New Alarm** field.

2. Click the icon.



3. Click the icon to remove a custom alarm.

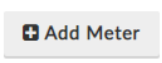


15.3 Custom Energy Metering

To create a custom energy meter navigate to Custom>Custom Energy Metering.

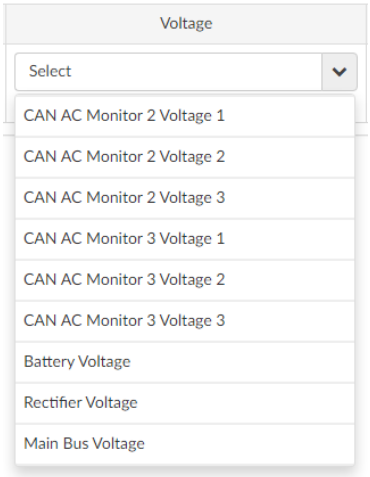
Access level required: *enaadvanced.*

1. Click on the **Add Meter** button.

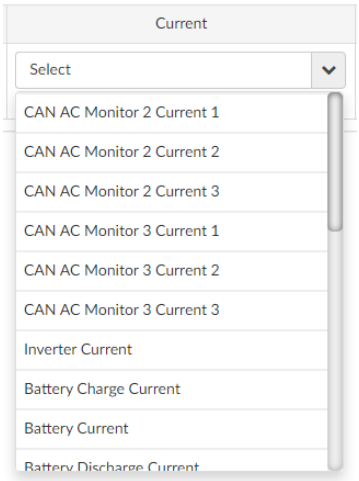


2. Enter a meter name in the **Name** field.

3. Select a voltage source from the **Voltage** drop down list.



4. Select a current source from the **Current** drop down list.



5. Click the **Save** button.

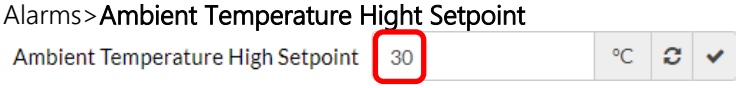
15.4 Custom Features: Example 1

A relay is created to turn an air-conditioner on and off depending on the ambient temperature. The Ambient Temperature High alarm is used to turn on the air-conditioner.

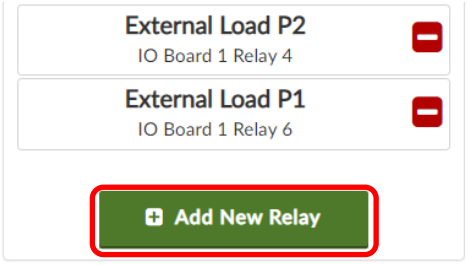
Comment: the ambient temperature variable already exists and is assigned in the Input Logic expressions as the sensor usually comes supplied with the Enatel power system.

Comment: for this example the air-conditioner is connected to Relay 1 on the energy manager IO board. See 10.2.10 Relays 1 to 6.

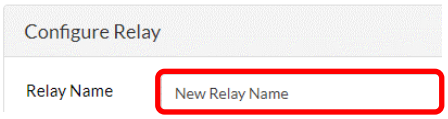
1. Set the Ambient Temperature High alarm to the required temperature at Alarm Configuration>System Alarms>**Ambient Temperature Hight Setpoint**



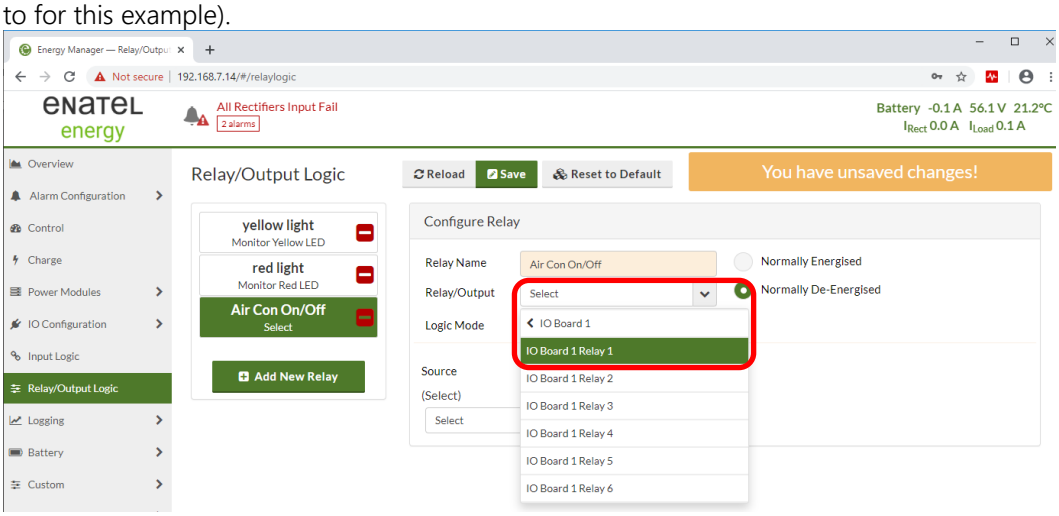
2. Click on the **Save** button or the tick icon to save the changes.
3. Click on the **Add New Relay** button on the Relay/Output Logic page.



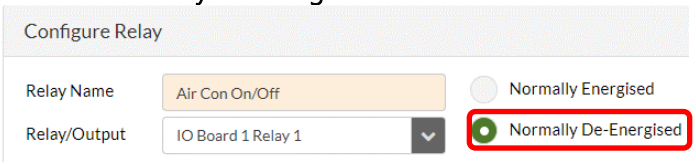
4. Enter the new **Relay Name** in the Configure Relay section.



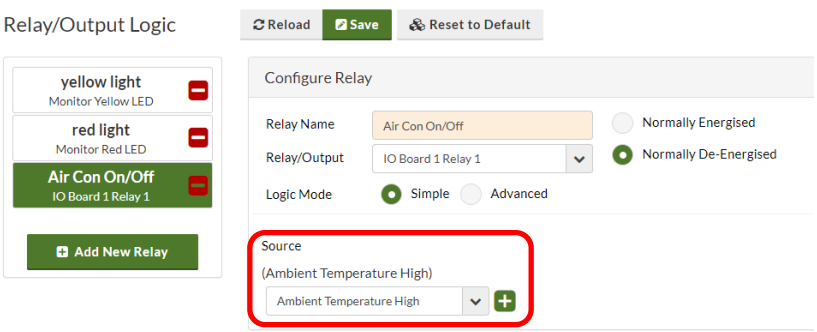
5. Assign the **Relay/Output** via the drop down menu to IO Board 1 Relay 1 (where the air-con is connected to for this example).



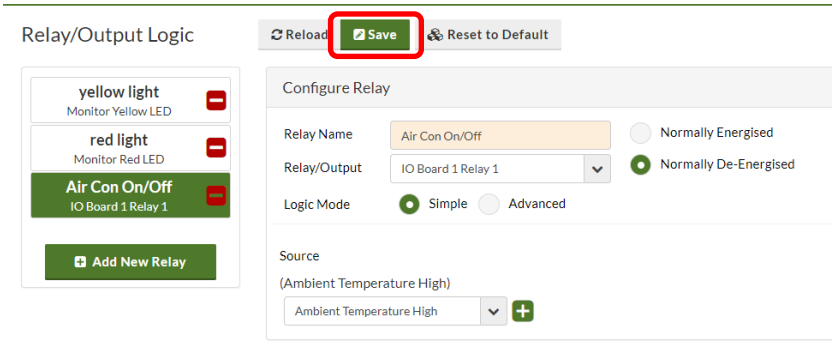
6. Select the **Normally De-Energised** radio button.



7. Assign the **Source** to the **Ambient Temperature High** alarm.



8. Click on the **Save** button.



Comment: example 1 is now complete. As the Ambient Temperature High alarm triggers or de-activates the relay energizes or de-energizes to turn the air-conditioner on and off. Note however in actual application further conditions would usually be applied to this function.

One option to apply a condition to the air-conditioner turning on or off would be to use the Ambient Temperature Hysteresis function of Alarm Configuration>System Alarms. The Ambient Temperature High Setpoint alarm is raised at the number set, the alarm clears at the Ambient Temperature High Setpoint minus the Ambient Temperature Hysteresis. Note however the hysteresis applies to both the Hight Setpoint and the Low Setpoint.

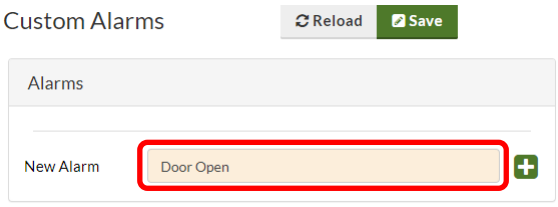
As set below the air conditioner turns on at 30°C and turns off at 23°C

15.5 Custom Features: Example 2

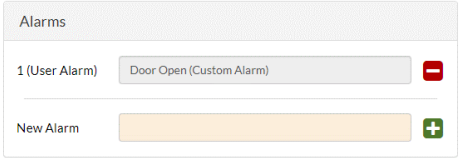
In this example a custom alarm is created to indicate that a door has been opened.

Comment: for the example the door circuit is connected to GPIP2. See 10.2.9 General Purpose Inputs.

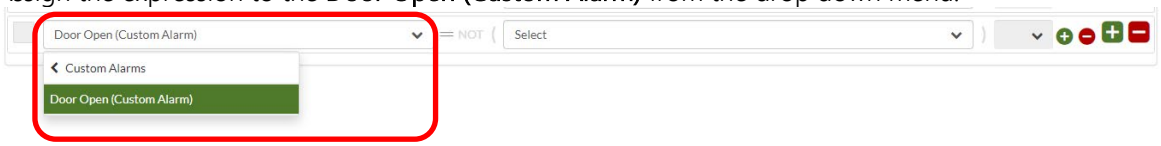
1. Enter the alarm name in the **New Alarm** field at Custom>Custom Alarms.



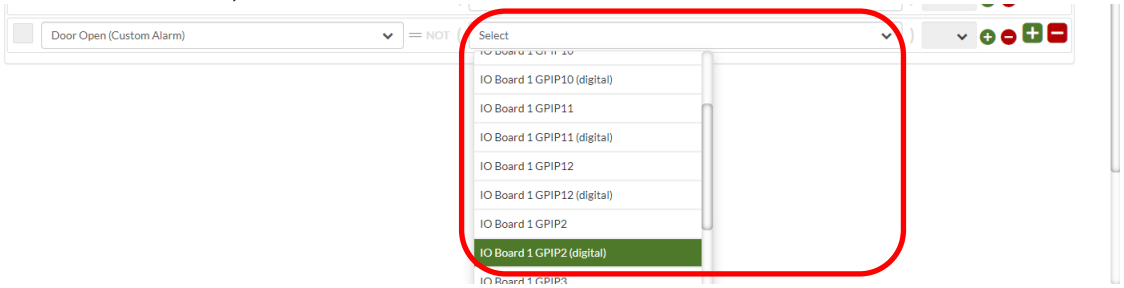
2. Click on the plus icon ⊞ to save the new alarm.



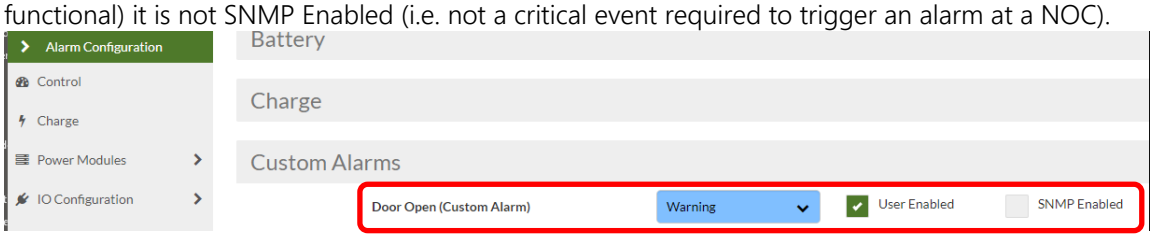
3. Create a new logic expression on the Input Logic page. See 14.4.3 Authoring Input Logic.
4. Assign the expression to the **Door Open (Custom Alarm)** from the drop down menu.



5. Assign the Door Open alarm to **IO Board 1 GPIP2 (digital)** from the drop down menu (where the door circuit is connected to).



6. Click on the **Save** button.
7. Configure the Door Open alarm at Alarm Configuration>Alarm Configuration>Custom Alarms. *Comment:* in this example the Door Open alarm is considered a Warning, it is User Enabled (i.e. it is functional) it is not SNMP Enabled (i.e. not a critical event required to trigger an alarm at a NOC).



8. Click on the **Save** button.

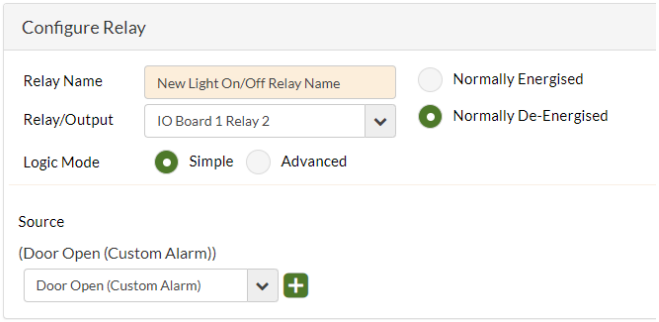
Comment: this example is now complete. As the GPIP2 changes state so does the Alarm.

15.6 Custom Features – Example 3

In this example a light turns on when the door opens. Note the custom Door Open alarm is already created in Example 2.

Comment: for this example the light is connected to Relay 2 (note in Example 1 the air-conditioner is already connected to Relay 1). See 10.2.10 Relays 1 to 6.

1. Click on the **Add New Relay** button on the Relay/Output Logic page.
2. Enter **Light On/Off** in the **Relay Name** field.
3. Select **IO Board 1 Relay 2** in the **Relay/Output** field. Note IO Board 1 Relay 1 is greyed out if already assigned as in Example 1.
4. Select the **Normally De-Energised** radio button. In this case we want the circuit to energize to turn on the light.
5. Select the **Door Open (Custom Alarm)** as the **Source**.



6. Click on the **Save** button.

15.7 Custom Features – Example 4

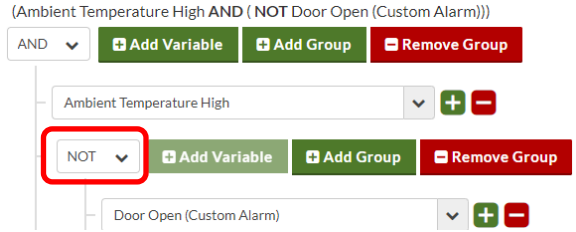
In this example the air-conditioner is turned off while the door is open (rather than attempting to cool the world). Note the custom relay Air Con On/Off has been created in Example 1, the Door Open alarm created in Example 2.

1. Select the Relay/Output Logic>**Air Con On/Off** relay (as previously created in example 1)
2. Select the **Advanced** Logic Mode radio button.

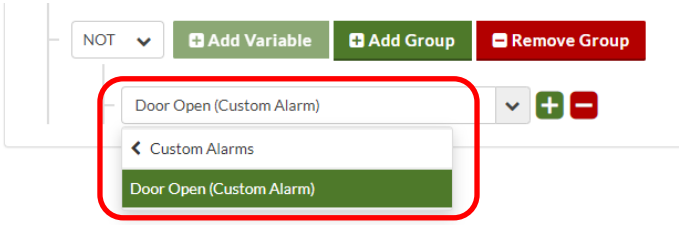
3. Set the logic to AND.

4. Click on the **Add Group** button.

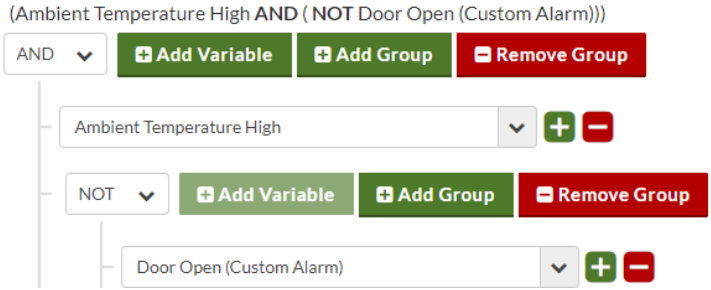
5. Select the **NOT** logic option.



6. Select **Door Open (Custom Alarm)**.



7. Click on the **Save** button.
   Note the completed logic tree and the written expression above it:



Comment: the examples are now complete. The air conditioner turns on at a particular temperature and off at another. There is a door open alarm which turns on a light when the door opens and turns the air-conditioner off when the door is opened.

16 Alarms and Related Operation

16.1 Bus Alarms

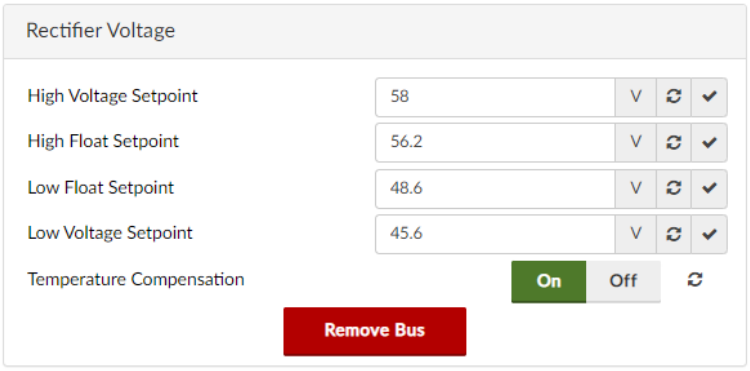
At Alarm Configuration>Bus Alarms specific alarms related to each bus voltage are set. These are dependent on system requirements and battery type. For lead-acid batteries customers usually enter these settings during

installation after referencing the site battery specifications. For lithium batteries these settings are usually managed at the factory.

High and Low Float Setpoints are typically notifications, only. High and Low Voltage Setpoints may have system operation triggered to these thresholds depending on customer requirements and battery type.

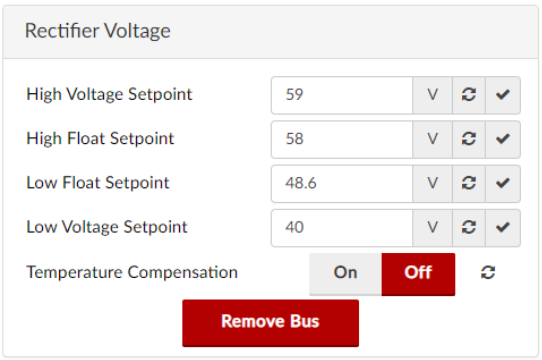
Note that these alarms include the bus name in front of the alarm when displayed.

A typical lead-acid setting is as follows.



Note that **Temperature Compensation** is enabled for lead-acid.

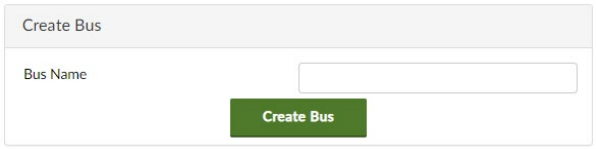
A default lithium battery energypak setting is as follows.



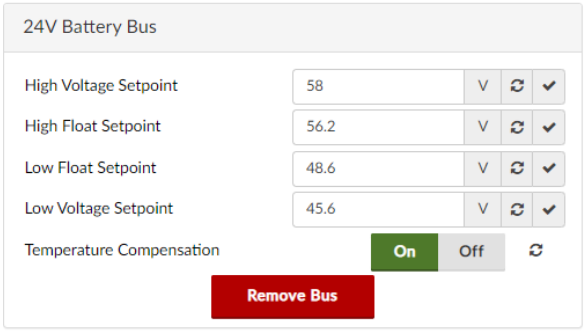
For an energypak **Temperature Compensation** is not enabled.

16.1.1 Create Bus

While it is uncommon to include a new voltage bus in the system after shipment the option for new bus alarms is provided here.



1. Enter a bus name.
2. Click on the **Create Bus** button.
3. Enter the required settings.



4. Click on the **Save** button.

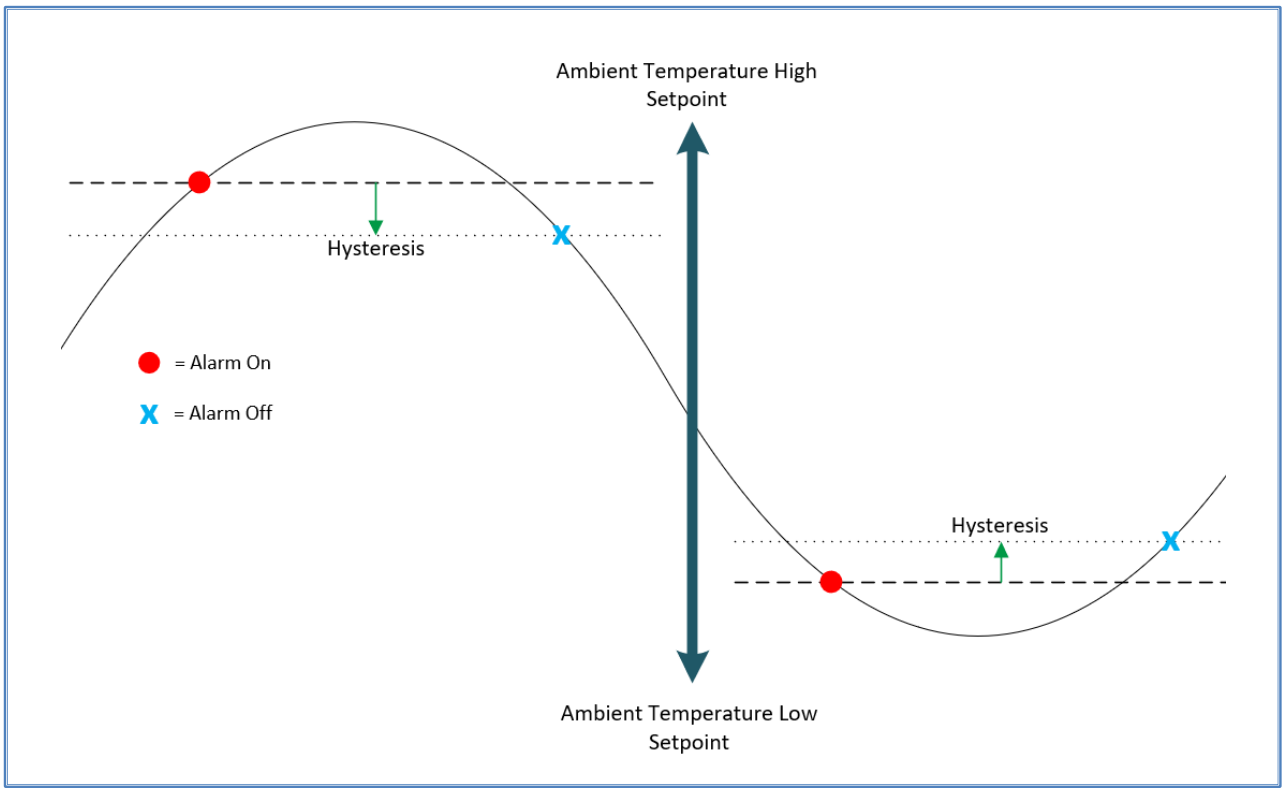
16.2 System Alarms

16.2.1 Ambient Temperature

At Alarm Configuration>System Alarms the **Ambient Temperature Hight Setpoint** and **Ambient Temperature Low Setpoint** are warning alarms to indicate temperature thresholds as detected by the placement of the ambient temperature sensor. See 10.2.8 Temperature Sensor (Optional).

The **Ambient Temperature Hysteresis** provides an interval below the High Setpoint and above the Low Setpoint to deactivate each alarm to assist prevention of false readings. See Figure 28.

Figure 28: Temperature Hysteresis



NOTE: the energypaks have their own dedicated internal temperature sensors with behaviour controlled by the energypak firmware.

16.2.2 Battery Temperature

At Alarm Configuration>System Alarms the **Battery Temperature Hight Setpoint** and **Battery Temperature Low Setpoint** are warning alarms to indicate temperature thresholds as detected by the placement of a battery temperature sensor. See 10.2.8 Temperature Sensor (Optional).

Note this is lead-acid battery specific, the energypak and lithium batteries report battery temperature by their dedicated comms.

Battery Temperature Hysteresis provides an interval below the High Setpoint and above the Low Setpoint to deactivate each alarm to assist prevention of false readings. See Figure 28. Battery temperature hysteresis works by the same method as the hysteresis for the ambient temperature.

16.2.3 System Load

The **Load Current High Setpoint** is an alarm setting only. That is, the alarm is raised when the load current is over the parameter set but no other system action is taken.

16.3 Alarm Configuration

The alarm levels of the energy manager are set by default as noted at Alarm Configuration>Alarm Configuration.

The level definitions are:

Table 1: Alarm Level Description

Critical	a system critical fault that indicates product or function failure
Major	a significant fault that requires resolution
Minor	a fault that does not immediately threaten system functionality
Warning	indicates a situation that precedes a serious event, details of which vary on a case by case basis
Information	an indication of a normal system operation event

The alarm levels are user configurable in the Web UI under Alarm Configuration>Alarm Configuration.

NOTE: an alarm level setting can be subjective and varies depending on customer requirements. For example, a customer may request that any alarm that requires a site visit be defined as a critical alarm. Please be aware that the Enatel default alarm level list is not universally utilized.

16.3.1 Alarm Options and Test

At Alarm Configuration>Alarm Configuration the user options for each alarm are:

User Enabled: enabled this checkbox allows an alarm to trigger. There may be specific or general situations an alarm may want to be turned off.

SNMP Enabled: enabled this checkbox allows the alarm trap to be transmitted using SNMP. End users may restrict SNMP alarm transmission to a limited priority suite of notifications.

Test On: clicking on the **Test On** button triggers the alarm so it can be transmitted via SNMP trap to test communication infrastructure is working correctly. The alarm also displays in the logs to confirm event recording is correct. Note that the test button triggers an alarm even if the User Enabled check box is unchecked.

Test Off: clicking on the Test Off button turns the trap test off.

16.4 Energy Manager Alarm List, Description and Action

All energy manager related alarms noted under Alarm>Alarm Configuration are listed below with a description and a remark as to expected action required on the alarm being raised. Alarms are specific to the battery type the system is configured with, refer to 16.4.1 Energyhub & Energypak Alarms for the energyhub/energypak alarms.

Table 2: List of Alarms

Alarm	Description	Action
WEB UI Alarm Configuration>AC Monitor (with ACM card fitted to associated IO Board)		
AC Monitor Current High	Any one of the phase currents has exceeded the value in the setting IO Configuration>AC Monitors>AC Monitor X> Current High Setpoint	This alarm is informational, actioning dependent on AC supply e.g. if grid or generator fault.
AC Monitor Frequency High	The frequency of the AC supply has exceeded the value in the setting IO Configuration>AC Monitors>AC Monitor X> Frequency High Setpoint	This alarm is informational, actioning dependent on AC supply e.g. if grid or generator fault.
AC Monitor Frequency Low	The frequency of the AC supply has dropped below the value in the setting IO Configuration>AC Monitors>AC Monitor X> Frequency Low Setpoint	This alarm is informational, actioning dependent on AC supply e.g. if grid or generator fault.
AC Monitor Missing	An AC Monitor that is expected to be present in the system is not detected.	Check power and comms to the AC Monitor card.
AC Monitor Voltage High	Any one of the phase voltages has exceeded the value in the setting IO Configuration>AC Monitors>AC Monitor X> Voltage High Setpoint	This alarm is informational, actioning dependent on AC supply e.g. if grid or generator fault.
AC Monitor Voltage Lost	Any one of the phase voltages has dropped below the value in the setting IO Configuration>AC Monitors>AC Monitor X> Voltage Lost Setpoint	This alarm is informational, actioning dependent on AC supply e.g. if grid or generator fault.
AC Monitor Voltage Low	Any one of the phase voltages has dropped below the value in the setting IO Configuration>AC Monitors>AC Monitor X> Voltage Low Setpoint	This alarm is informational, actioning dependent on AC supply e.g. if grid or generator fault.
AC Monitor Voltage 1 Lost	Phase 1 voltage has dropped below the value in the setting IO Configuration>AC Monitors>AC Monitor X> Voltage Lost Setpoint	This alarm is informational, actioning dependent on AC supply e.g. if grid or generator fault.
AC Monitor Voltage 2 Lost	Phase 2 voltage has dropped below the value in the setting IO Configuration>AC Monitors>AC Monitor X> Voltage Lost Setpoint	This alarm is informational, actioning dependent on AC supply e.g. if grid or generator fault.

Alarm	Description	Action
AC Monitor Voltage 3 Lost	Phase 3 voltage has dropped below the value in the setting IO Configuration>AC Monitors>AC Monitor X> Voltage Lost Setpoint	This alarm is informational, actioning dependent on AC supply e.g. if grid or generator fault.
Virtual ACM Voltage Lost	The virtual ACM (there is no ACM card in this instance) voltage reading from the rectifiers has been lost.	This alarm should be raised in conjunction with an "All Rectifier Input Fail" when the virtual ACM is enabled and is informational in this instance.
WEB UI Alarm Configuration>Battery		
Battery Asymmetric	With a BCM fitted (or BCM functionality programmed), the battery bloc voltages are monitored and the voltage of the blocs compared (Blocs may be 2V, 4V, 6V, 12V or 24V (for mid-point)). This alarm indicates the threshold defined for the allowed voltage difference between the blocs is exceeded. If this feature is not customised, the default setting is 2V. See Battery>Battery Settings>String Asymmetry Setpoint.	Investigate a potential battery fault (e.g., loose terminal) or a battery nearing its end of life.
Battery Charge Overcurrent	The total DC battery recharge current is monitored and causes an alarm to activate when the threshold is exceeded. See Battery>Battery Settings>Battery Charge Overcurrent Setpoint	The cause should be investigated and resolved. Note this alarm is an indicator only and does not adjust the system parameters to prevent this occurrence. This would be set by the Battery Current Limit. There should be consistency between the Battery Charge Overcurrent alarm and the actual Battery Current Limit setting.
Battery Configuration Error	This is typically an issue with the setup of the BCM card. The battery configuration has a fault. The settings are not saved.	Troubleshoot the issue to resolve. See Battery>Battery Settings>Battery String Configuration
Battery Discharge	An indicator that the system batteries are discharging. Threshold for this is set in Battery>Battery Settings>Battery Discharge Threshold	Notification only - Normal operation.

Alarm	Description	Action
Battery Imbalance	With a BCM fitted (or BCM functionality programmed), individual battery string currents can be monitored (provided a battery shunt per string is fitted) and compared which causes an alarm to activate when the difference between the string currents exceeds the threshold. See Battery>Battery Settings>String Imbalance Setpoint.	The cause should be investigated and resolved, this typically indicates a faulty battery or string (e.g., loose terminal). Note this alarm is an indicator only and does not (i.e., cannot) adjust the system parameters to prevent this occurrence.
Battery String Overcurrent	With a BCM fitted (or BCM functionality programmed), individual battery string currents can be monitored (provided a battery shunt per string is fitted). This alarm indicates that one particular battery string is drawing more current than is set in Battery>Battery Settings>String Overcurrent Setpoint.	The cause should be investigated and resolved, this typically indicates a faulty battery or string (and potentially not the string that is causing the alarm). Note this alarm is an indicator only and does not (cannot) adjust the system parameters to prevent this occurrence.
Battery Temperature Faulty	This implies a defective battery temperature sensor.	Investigate wiring and/or replace the sensor as required or fix any configuration error.
Battery Temperature High	With a battery sensor fitted the threshold has been exceeded. The threshold is user configurable (default +40°C). See Alarm Configuration>System Alarms.	Investigate cause and resolve, however the battery temperature is usually not within the control of the Power System.
Battery Temperature Low	With a battery sensor fitted the temperature is below the threshold. The default Enatel setting is 0°C but is user configurable. Alarm Configuration>System Alarms.	Investigate cause and resolve.
WEB UI Alarm Configuration>Battery Monitor		
Battery Monitor Missing	With a battery monitor fitted and enabled the card is not recognized in the system.	Investigate the comms and power wiring.
WEB UI Alarm Configuration>Charge		
Battery Test Failed	An attempted battery test has failed to complete. (Bus voltage has dropped more quickly than anticipated)	Investigate the cause. This may have been over-ridden by an external event that was given priority or could be a significant fault.
Battery Test in Progress	A battery test is underway, this is informative only.	Note that if used for energypak enabled systems (as opposed to lead-acid batteries) this tests all the energypaks one at a time. Do NOT attempt this test with no load on the system.

Alarm	Description	Action
Battery Test Lockout Timer Active	A battery test cannot be undertaken during this time due to being deliberately locked out. The duration is set at Charge>Battery Test>Battery Test Lockout Period	Informative only, no action. A lockout occurs if there has been a battery discharge within the time specified. This allows the battery to be fully charged before a test commences.
Equalise	The lead-acid battery equalize function is active.	Normal operation, informational only.
Fast Charge	The lead-acid battery fast charge function is active.	Normal operation, informational only
GTO Hold Active	While GTO has been active either of the Hold Battery Voltage Above or Hold Battery Charge Above limits set for battery discharge are reached. The load is no longer being supplied by the batteries.	Refer to Charge>Grid Tariff Optimisation (GTO)>Hold Battery Above or Hold Battery Charge Above for the discharge limits.
GTO Limiting Grid Power	Grid Tariff Optimisation is active and the rectifiers are being current limited to allow the batteries to supply the load.	Information only, no action
GTO Schedule Configuration Error	There is a logic error in the timing schedule set for Grid Tariff Optimisation.	Refer to Charge>Grid Tariff Optimisation (GTO) for the scheduling settings.
Manual Equalise	The lead-acid manual equalise function is active.	Normal operation, informational only.
WEB UI Alarm Configuration>DC Busses		
Bus Float High	The bus is higher voltage than normal, but not yet critical. A warning that the system is not operating within expected bounds.	Refer to Alarm Configuration>Bus Alarms. This is typically set by the factory for lithium systems, for lead-acid batteries this will be set by the customer. Note: the name for this alarm is configurable and states the bus name in front of the alarm name.
Bus Float Low	The bus is lower voltage than normal, which in typical usage indicates that the batteries are now in discharge.	Refer to Alarm Configuration>Bus Alarms. This is typically set by the factory for lithium systems, for lead-acid batteries this is set by the customer. Note: the name for this alarm is configurable and may state 'Rectifier' or other designation in front of the alarm name.
Bus Voltage High	The bus is at a voltage level high enough to be deemed critical.	Refer to Alarm Configuration>Bus Alarms for the setting. This is typically set by the factory for lithium systems, for lead-acid batteries this is set by the customer. For the energyhub, this should be referenced against other energypak alarms. Note: the name for this alarm is configurable and may state 'Rectifier' or other designation in front of the alarm name.

Alarm	Description	Action
Bus Voltage Low	The bus voltage is low indicating discharge to a level deemed to be critical, typically as a warning that the batteries are shortly to reach low voltage disconnect.	Refer to Alarm Configuration>Bus Alarms. This alarm level is usually to be set by the customer to meet their own expectations. Note: the name for this alarm is configurable and may state 'Rectifier' or other designation in front of the alarm name.
WEB UI Alarm Configuration>DC Converter		
12V All Input Fail	DC input supply has failed at a system/bus level.	This is typically an external event to be monitored.
12V Urgent Fail	Multiple converters have failed. Fail is default 1 module while the Urgent Fail alarm indicates multiple modules failing. This threshold value is set at Control>**DC Converter Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	Converters are not user serviceable and must be replaced.
12V Urgent Missing	Multiple converters previously recognized in the system are missing from their shelf position. Note moving a converter from one location to another raises this alarm. Missing is default 1 module and Urgent Missing indicates multiple modules missing. This threshold value uses the same field as Control>**DC Converter Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	If this has occurred in normal maintenance (as opposed to theft of a module for example) the alarm can be cleared by clicking on the **Clear Alarms** button on the Overview page.
24V All Input Fail	DC input supply has failed at a system/bus level.	This is typically an external event to be monitored.
24V Urgent Fail	Multiple converters have failed. Fail is default 1 module while the Urgent Fail alarm indicates multiple modules failing. This threshold value is set at Control>**DC Converter Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	Converters are not user serviceable and must be replaced.

Alarm	Description	Action
24V urgent Missing	Multiple converters previously recognized in the system are missing from their shelf position. Note moving a converter from one location to another raises this alarm. Missing is default 1 module and Urgent Missing indicates multiple modules missing. This threshold value uses the same field as Control>**DC Converter Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	If this has occurred in normal maintenance (as opposed to theft of a module for example) the alarm can be cleared by clicking on the **Clear Alarms** button on the Overview page.
48V All Input Fail	DC input supply has failed at a system/bus level.	This is typically an external event to be monitored.
48V Urgent Fail	Multiple converters have failed. Fail is default 1 module while the Urgent Fail alarm indicates multiple modules failing. This threshold value is set at Control>**DC Converter Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	Converters are not user serviceable and must be replaced.
48V Urgent Missing	Multiple converters previously recognized in the system are missing from their shelf position. Note moving a converter from one location to another raises this alarm. Missing is default 1 module and Urgent Missing indicates multiple modules missing. This threshold value uses the same field as Control>**DC Converter Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	If this has occurred in normal maintenance (as opposed to theft of a module for example) the alarm can be cleared by clicking on the **Clear Alarms** button on the Overview page.
60V All Input Fail	DC input supply has failed at a system/bus level.	This is typically an external event to be monitored.

Alarm	Description	Action
60V Urgent Fail	A converter has failed. Fail is default 1 module while the Urgent Fail alarm indicates multiple modules failing. This threshold value is set at Control>**DC Converter Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	Converters are not user serviceable and must be replaced.
60V Urgent Missing	Multiple converters previously recognized in the system are missing from their shelf position. Note moving a converter from one location to another raises this alarm. Missing is default 1 module and Urgent Missing indicates multiple modules missing. This threshold value uses the same field as Control>**DC Converter Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	If this has occurred in normal maintenance (as opposed to theft of a module for example) the alarm can be cleared by clicking on the **Clear Alarms** button on the Overview page.
Converter Auxiliary Fail	This indicates that the converter secondary power circuit (internal to the converter) has failed	This is not user serviceable and the unit should be replaced.
Converter Brownout	The converter DC input voltage has dropped low enough that the output has become insufficient for the load. The exact voltage this occurs at can vary depending on the size of the load.	Monitor situation and resolve if consistent, however this is not normally within the control of the Power System.
Converter Current Limit	A module current limit which the converter is being held at is active and functioning.	A system notification, only.
Converter EEPROM Fail	The converter EEPROM has failed.	This is not a user serviceable part and the converter must be replaced.
Converter Fan Fail	The converter fan has failed. The converter can be restarted to see if the issue persists.	If the fan is non-functional this is not a user serviceable part and the converter must be replaced.

Alarm	Description	Action
Converter Input Fail	DC supply to the specific converter has failed. One converter failing amongst multiple converters connected to the same bus may imply an internal fault in the converter.	Understand reason for input fail, if external. Check if other alarms are raised in conjunction.
Converter Missing	A converter previously recognized in the system is missing from its shelf position or comm's are lost to it. Missing is default 1 module and Urgent Missing indicates multiple modules missing. This threshold value uses the same field as DC Converter Urgent Fail found at Control>**DC Converter Urgent Fail Threshold**.	Note moving a converter from one location to another raises this alarm. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 converter in a large system of 10, for example. The alarm can be cleared by clicking on the **Clear Alarms** button on the Overview page.
Converter Module Fail	A converter fault has caused the converter to stop operating. Converter Module Failed is default 1 module and the Converter Urgent Fail alarm indicates multiple modules failing. This threshold value is set at Control>**DC Converter Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 converter in a large system of 10, for example.	This is a non-user serviceable part and a faulty converter must be replaced.
Converter Over Temperature	The converter has shut down due to the converter's internal temperature exceeding its operational limits.	By default this is a non-latching state, as such once the fault condition has been resolved the converter will return to normal operation. If latching is enabled, the state needs to be manually cleared by clicking on the Power Modules>Power Modules>Clear Shutdown Latch button.

Alarm	Description	Action
Converter Over Voltage	The DC output Over Voltage Shutdown voltage threshold has been exceeded and the Converter has shut itself down. See Control>Converter Voltage Setpoint	This is an extremely rare alarm, and could be due to the converter module itself losing control and trying to push the output voltage beyond limits, or (more likely) due to an external influence on the DC bus (e.g., surges, someone accidentally shorting another voltage source onto the bus). By default this is a non-latching state, as such once the fault condition has been resolved the converter will return to normal operation. If latching is enabled, the state needs to be manually cleared by clicking on the Power Modules>Power Modules>Clear Shutdown Latch button.
Converter Postmate	The post-mate pin on the converter connector has failed to engage. (Pre- and post-mate pins are used to ensure the output capacitors in the converters do not cause arcing of the connector pins as the converter is inserted into a live system (hot-plug).	This is usually due to a converter not being inserted fully into a system. Ensure the converter is pushed "hard" into the system. If the problem persists, check the pins on the backplane by inserting a different converter into that position. If the Postmate alarm "follows" the converter, it may need to be replaced.
Converter Shutdown	A specific converter has shut itself off due to an external command from Input Logic, or directly by a user from the Power Modules>Power Modules>Shutdown command.	This is a notification only and normal operation.
Converter Soft Starting	The converter is starting. During start-up it goes through a soft start mode in order to ramp up output current in a controlled manner.	This is a notification only and normal operation.
Converter Temperature Sensor Fail	A temperature sensor internal to the converter module is non-functional.	The converter can be restarted to check if the issue persists. If the temperature sensor has failed this is not a user serviceable part and the converter must be replaced.
Converter Upgrading	The converter firmware is in the process of upgrading. Do NOT disconnect the converter.	Status notification, only.
Converter Voltage Sense Fail	The measured output voltage is more than 4V away from setpoint this alarm is raised.	This is likely a hardware fault and should be investigated.

Alarm	Description	Action
WEB UI Alarm Configuration>Fan Controller		
IO Board Fan Controller Fan Fail	A fan recognised in the system is not operating.	The fan requires replacement.
IO Board Fan Controller Missing	A fan controller expected in the system is missing.	Check comms connections along with IO Board and Fan Controller board configuration in the Web UI.
WEB UI Alarm Configuration>General Alarms		
Ambient Temperature Faulty	The ambient temperature sensor of the EM4x is not functioning correctly.	Check the sensor connection in the EM4x and configuration in the EM4x Web UI. If hardware is damaged contact your Enatel rep for replacements.
Ambient Temperature High	Ambient (room) temperature is higher than the limit set.	With ambient temperature sensor fitted. See the Alarm Configuration>System Alarms page, Ambient Temperature High Setpoint
Ambient Temperature Low	Ambient (room) temperature is lower than the limit set.	With ambient temperature sensor fitted. See the Alarm Configuration>System Alarms page, Ambient Temperature Low Setpoint
Clock Adjustment Requires Reboot	The EM4x internal clock is requesting a reboot to finalize setting adjustments.	A reboot should be undertaken as soon as possible.
Control Loop Startup	This alarm indicates the EM4x has rebooted during start up. It is a notification for internal system logging only. This alarm should only show for a short moment during start up.	If the alarm is continuously on please contact your Enatel sales rep.
Control loop time exceeded	A diagnostic flag that typically is raised only intermittently. It provides insight for troubleshooting various issues.	Information only.
Database Too New	The EM4x internal database is detected as being a newer version than battery modules in the system can utilize.	The energypak firmware must be upgraded. This is mandatory.
Database Upgrade Required	The EM4x internal database is detected as being out of date.	Upgrade the EM4x firmware. This is mandatory.
EM4x Monitor Boot	A notification that the reboot request is successful and the EM4x is about to restart.	Information only.
Firmware Upgrade Failed	The upgrade process when uploading a firmware file has failed.	A repeat may be tried. A corrupted firmware file may be the cause. Contact your Enatel representative for assistance.
Invalid System Voltage - Check input Logic	The system is reporting a voltage that it interprets as impossible.	Check the input logic - this should only occur with customer modifications of logic that have created an erroneous reading.
Load Current High	A notification that the load current has exceeded the limit set at Alarm Configuration>System Alarms>Load Current High Setpoint.	This is a notification only, the implications depend on the site load requirements and if this has been custom configured.

Alarm	Description	Action
Rectifier Current Limit Active	This is a system limit, the total output of the bus will not exceed that number.	A system notification, only, that indicates the feature is active and functioning. Set at Control>Rectifier Current/Power Limit>Rectifier Current Limit.
Rectifier Power Limit Active	A notification that the power limit feature is enabled and active. That is, the combined power of all rectifiers is being limited (rather than limiting individual rectifiers).	See the Control page, Rectifier Current/Power Limit section for details. Note: a typical usage might be where an upstream AC breaker needs protection.
Rectifier Voltage Sense Fail	The voltage sense on the bus has failed. Typically a hardware failure of the voltage sense wires of the EM4x and the DC bus. In this circumstance the EM4x selects a rectifier and continues to monitor voltage from it. Note that this alarm can be enabled or disabled on the Control page.	A system level hardware fault that may be attempted to be repaired by qualified personnel.
User Lua Script Error	There is a Lua Script Error which is the EM4x firmware editor. This requires factory support.	Please contact your Enatel representative. A reboot may be attempted.
Factory Lua Script Error	There is a Lua Script Error which is the EM4x firmware editor at the factory level.	This requires factory support to resolve. Please contact your Enatel representative. An update of the latest firmware release can be tried.
WEB UI Alarm Configuration>Hybrid		
AC Grid Fail Conditioned	The grid has failed for longer than a period set at Hybrid>Hybrid Configuration>Grid Bad Timeout. The AC Grid Failed alarm occurs first – the additional "Conditioned" alarm confirms the AC fail is not momentary.	This could be normal operation. Check cause as required.
AC Grid Failed	As indicated by GPIP mapped alarm or AC Monitor alarm. This indicates grid fail immediately without waiting for a time out.	This could be normal operation. Check cause as required.
All Generators Failed	SYNERGi has attempted the number of generator start retries as set at **Start Fail Retries** and **1 Hour Retries** on the Hybrid Configuration page and locked out the generator.	Investigate cause of the generator failure to start: fuel level or otherwise. To unlock the generator click on the **Abort Generator Cycle** button on the Hybrid>Realtime Status page
Antistall Backoff	This is normal operation where a potential stall event has been detected and the generator backs off the power output.	
Battery Missing	Indicates a battery previously detected in the system is no longer present.	Check comms to the battery, battery MCBs or physical status of the batteries.
Commissioning Charge Active	Normal operation. The batteries on site are being charged by the generator for a duration set at Hybrid>Hybrid Cycle Setup>Commissioning Charge Duration and initiated by the **Initiate Commissioning Charge** button on the Realtime Status page.	None but note that multiple other SYNERGi functions are overridden during this state.

Alarm	Description	Action
Curfew Active	Normal operation where the generator is prevented from running for a set time, usually at night.	User controlled at Hybrid>Hybrid Configuration>Generator Curfew.
Fixed Power Point Active	Normal operation: when **MPP Inhibit** is **On** the hybrid system runs to a calculated maximum power point.	
Fuel Tank 1 Logic Error	Input logic error.	Check the input logic.
Fuel Tank 1 Low	Fuel level warning as set at Hybrid>Fuel Tank Setup>Tank 1 alarm volume.	Note this alarm is typically set at a lower fuel level than the Refill Fuel Tank alarm.
Fuel Tank 2 Logic Error	Input logic error.	Check the input logic.
Fuel Tank 2 Low	Fuel level warning as set at Hybrid>Fuel Tank Setup>Tank 2 alarm volume.	Note this alarm is typically set at a lower fuel level than the Refill Fuel Tank alarm.
Generator 1 Failed	Has attempted the number of retries as set at **Start Fail Retries** and **1 Hour Retries** on the Hybrid Configuration page and locked out the generator.	Investigate cause of the generator failure to start: fuel level or otherwise. To unlock the generator click on the **Abort Generator Cycle** button on the Hybrid>Realtime Status page
Generator 1 High Temperature	Alarm as mapped from the input logic setting as user configured on a site by site basis.	Action as determined by customer's response process.
Generator 1 Low Battery	Alarm as mapped from the input logic setting as user configured on a site by site basis.	Action as determined by customer's response process.
Generator 1 Low Oil	Alarm as mapped from the input logic setting as user configured on a site by site basis.	Action as determined by customer's response process.
Generator 1 Overrun	The generator has been given a shutdown command but failed to turn off.	The generator is in a rogue state. A manual shutdown can be attempted.
Generator 1 Power Low	Generator power is below the threshold set at Hybrid>Hybrid Configuration>Generator Low Power Alarm Threshold.	This threshold is usually set to indicate a malfunctioning generator and the cause should be investigated (blocked air filter or otherwise).
Generator 1 Running	Normal operation status flag.	Information only.
Generator 2 Failed	Has attempted the number of retries as set at **Start Fail Retries** and **1 Hour Retries** on the Hybrid Configuration page and locked out the generator.	Investigate cause of the generator failure to start: fuel level or otherwise. To unlock the generator click on the **Abort Generator Cycle** button on the Hybrid>Realtime Status page.
Generator 2 High Temperature	Alarm as mapped from the input logic setting as user configured on a site by site basis.	Action as determined by customer's response process.
Generator 2 Low Battery	Alarm as mapped from the input logic setting as user configured on a site by site basis.	Action as determined by customer's response process.
Generator 2 Low Oil	Alarm as mapped from the input logic setting as user configured on a site by site basis.	Action as determined by customer's response process.

Alarm	Description	Action
Generator 2 Overrun	The generator has been given a shutdown command but failed to turn off.	The generator is in a rogue state. A manual shutdown can be attempted.
Generator 2 Power Low	Generator power is below the threshold set at Hybrid>Hybrid Configuration>Generator Low Power Alarm Threshold.	This threshold is usually set to indicate a malfunctioning generator and the cause should be investigated (blocked air filter or otherwise).
Generator 2 Running	Normal operation status flag.	Information only.
Generator Service Due	The service period for the generator has expired where the hours run is greater than the service interval set.	The generator should be serviced and the alarm cleared at Hybrid>Hybrid Configuration>Installation Settings.
Generator Startup Power Trial	Normal operation, the duration as set at Hybrid>Hybrid Configuration>Generator Startup Trial Time such that if the generator stalls it restarts and goes through the warm up process rather than waiting for the next hybrid cycle initiation.	Information only.
Generator Test Active	Normal operation as user enabled at Hybrid>Hybrid Cycle Setup>Generator Test Setup.	Information only.
Grid Running Forced	Normal operation as set in the input logic where the hybrid cycle has been overridden.	Information only.
Ignoring Optimal Generator Power Factor	The generator power has fallen below the Minimum MPP Power Target. The generator does attempt to search for the MPP.	This could be an indicator of a potential generator fault. Usually the Minimum MMP Power Target is set at a level the generator power is expected to achieve.
MPP in Progress	Normal operation.	Information only.
MPP Rapid Repeat Active	Normal operation. The period is as set at Hybrid>Hybrid Configuration>MPP Rapid Repeat Active.	Information only.
Manual Test Charge Active	Normal operation where the generator has been set to run for a test duration.	Information only.
Previous MPP Failed	Normal operation. The generator does not have enough load on it to stall.	Information only.
Refill Fuel Tank 1	A warning regards the fuel level as set at Hybrid>Fuel Tank Setup>Tank 1 refill volume.	Response as determined by end user guidelines.
Refill Fuel Tank 2	A warning regards the fuel level as set at Hybrid>Fuel Tank Setup>Tank 2 refill volume.	Response as determined by end user guidelines.
Solar Optimisation Inhibiting Cycle	Normal operation where generator use has been overridden by the renewable energy source.	Set at Hybrid>Solar Optimisation>Solar Optimisation Enabled.

Alarm	Description	Action
Solar Optimisation Start After Stop Time	A logic error where the start time is incorrectly set, after the stop time.	Check the FIFO settings at Hybrid>Solar Optimisation>Solar Optimization Debug (click on the Solar Optimisation General section header to see the Debug section)
Sunrise Detected	Normal operation. Active anytime the solar modules are outputting more power than the **Sunrise Detection Threshold Power** setting on the Solar Optimisation page.	Information only.
WEB UI Alarm Configuration>IO Board		
IOBoard 1 Firmware Upgrade Available	During a firmware upgrade of the EM4x it has detected that there is a new version of the IO firmware available.	It is recommended to upgrade the IO firmware. Refer to 14.6.3 Upgrading Non-Controller Firmware.
IOBoard 1 Missing	IO board 1 which has been configured in the system and expected to operate is not detected.	Check control wiring (and connectors) to the I/O board. Investigate, if the cause is a faulty IO board this must be replaced.
WEB UI Alarm Configuration>IO Expansion		
IO Board IO Expansion Missing	An IO Expansion Card configured to be present in the system is not detected.	Check comms and power connection to the IO Expansion Card.
WEB UI Alarm Configuration>Input and Relay/Output Logic		
Input Logic Error	There is an error in the input logic of the EM4x configuration software. This can be reviewed in Input Logic page. This should only occur if custom input logic is entered by an end user.	Do NOT attempt to modify the default factory logic. If this error occurs after programming some Input Logic, carefully examine the logic statements and correct the offending statement. If needed, attempt to reload the default logic by clicking on the Input Logic>**Default** button. If this fails please contact your Enatel sales rep.
Relay Logic Error	There is an error in the relay logic of the EM4x configuration software. This can be reviewed in the Relay/Output Logic page for relay settings, or otherwise the Custom menu settings or the Input Logic page. This should only occur if custom relay logic is entered by an end user.	Do NOT attempt to modify the default factory logic. If this error occurs after programming some Relay Logic, carefully examine the logic statements and correct the offending statement. If the factory Relay/Output Logic page has been modified by accident, please contact your Enatel sales representative.

Alarm	Description	Action
WEB UI Alarm Configuration>LVD		
IOBoard 1 LVD 1, or IOBoard 1 LVD 2, or IOBoard 1 LVD 3	This indicates that the threshold for tripping/activating the contactor for LVD1 has been exceeded and the corresponding LVD contactor has been sent a signal to "open". Note on LVD Alarms: The contactors Enatel uses always have auxiliary contacts on them to indicate the contactor is actually open or closed. These contacts are fed back to internal GPIPs, and usually have the alarm name "LVD Open". This serves as a confirmation that the LVD contactor has actually obeyed its command to "open".	Normally the threshold for tripping the LVD will be based on low voltage. However the LVD contactor can also be activated by temperature and/or time.
WEB UI Alarm Configuration>MCB Alarms		
Battery MCB Open	Notification that the battery circuit breaker (or fuse) is open.	Ensure the MCB status is correct for intended operation. Also check the correct number of battery MCBs is enabled. See IO Configuration>MCBs>Number of Battery MCBs
WEB UI Alarm Configuration>Phase Balancing		
AC Phase (1, 2 or 3) Backoff	This is pre-set as an informational alarm. While the EM4x is performing a balancing function this alarm/notification is raised.	Informational - no action required.
AC Phase (1, 2 or 3) Clamp	This alarm occurs when the AC breaker current limit is exceeded and a “Rapid Backoff” is required. If the balanced phase current is below the breaker rating, this alarm will turn off. However, if the balance point is beyond the breaker rating setpoint, the EM4x limits the AC input current to this level, and the balance of energy comes from the battery. This alarm stays on until the AC current falls below the breaker rating setpoint.	If this alarm persists, it means there is insufficient power from the grid to both power the load **and** charge the batteries. Urgent action is required otherwise the battery will discharge and the DC system will crash. Wither site load needs to be reduced, or AC reticulation must be upgraded to a higher power/current level.
AC Phase (1, 2 or 3) Unbalanced	If, for some reason, the phases are unable to be balanced, this alarm is raised. An example of this may be insufficient rectifier load to create a phase balanced system.	This is a warning only and not critical. No action required.

Alarm	Description	Action
Phase Balancing Inhibited	If, for some reason the EM4x is unable to perform Phase Balancing, this alarm is raised. When this alarm is active, the system will revert to the settings in the Inhibit/Rollback Configuration.	There a number of reasons why Phase Balancing may be inhibited. Refer to section **Inhibit/Rollback Configuration** on page 87 for details
WEB UI Alarm Configuration>Rectifier		
All Rectifiers Input Fail	AC input supply has failed at a system/bus level.	This is typically an external event (i.e., AC grid failure) to be monitored.
Rectifier Auxiliary Rail Fail	Rectifier secondary power circuit failure.	This is not user serviceable and the rectifier module should be replaced.
Rectifier Brownout	The rectifier AC input voltage has dropped low enough that the output has become insufficient for the load. The exact voltage this occurs at can vary depending on the size of the load.	No action required – the AC voltage level is outside the control of the Power System.
Rectifier Current Limit	A module current limit which the rectifiers is being held at is active and functioning.	A system notification, only.
Rectifier EEPROM Fail	The rectifier EEPROM has failed.	This is not a user serviceable part and the rectifier must be replaced.
Rectifier Fan Fail	The rectifier fan has failed/not rotating. The rectifier can be restarted to see if the issue persists.	If the fan is non-functional this is not a user serviceable part and the rectifier must be replaced.
Rectifier Firmware Upgrading	Notification of upgrade underway.	Information, only.
Rectifier Input Fail	AC supply to the specific rectifier has failed. One rectifier failing amongst multiple rectifiers connected to the same bus may imply an internal fault in the rectifier.	Understand reason for input fail, if external. Check if other alarms are raised in conjunction.
Rectifier Missing	A rectifier previously recognized in the system is missing from its shelf position or comms are lost to it. Rectifier Missing is default 1 module and Rectifier Urgent Missing indicates multiple modules missing. This threshold value uses the same field as Rectifier Urgent Fail found at Control>**Rectifier Urgent Fail Threshold**.	Note moving a rectifier from one location to another raises this alarm. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 rectifier in a large system of 10, for example. The alarm can be cleared by clicking on the Overview>**Clear Alarms** button. Note that a Rectifier Missing alarm will also occur if communication is lost between the EM4x and the rectifier – this could be due to interruption/miss-connection of the serial bus wire.

Alarm	Description	Action
Rectifier Urgent Missing	Multiple rectifiers previously recognized in the system are missing from their shelf position. Note moving a rectifier from one location to another raises this alarm. Rectifier Missing is default 1 module and Rectifier Urgent Missing indicates multiple modules missing. This threshold value uses the same field as Rectifier Urgent Fail found at Control>**Rectifier Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 rectifier in a large system of 10, for example.	If this has occurred in normal maintenance (as opposed to theft of a module for example) the alarm can be cleared by clicking on the Overview>**Clear Alarms** button. Note that a Rectifier Missing alarm will also occur if communication is lost between the EM4x and the rectifier – this could be due to interruption/miss-connection of the serial bus wire.
Rectifier Module Fail	A rectifier fault has caused the rectifier to stop operating. Rectifier Module Failed is default 1 module and the Rectifier Urgent Fail alarm indicates multiple modules failing. This threshold value is set at Control>**Rectifier Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 rectifier in a large system of 10, for example.	This is a non-user serviceable part and a faulty rectifier must be replaced. Note that Rectifier Module Fail also occurs when AC Input fails. This is because the microprocessor in the rectifier module cannot detect the difference between a failure of the module at its input, or the AC input failing.
Rectifier Urgent Fail	Multiple rectifiers have failed. Rectifier Module Failed is default 1 module while the Rectifier Urgent Fail alarm indicates multiple modules failing. This threshold value is set at Control>**Rectifier Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 rectifier in a large system of 10, for example.	Rectifiers are not user serviceable and must be replaced. Note that this alarm will also occur when AC grid fails This is because the microprocessor in the rectifier module cannot detect the difference between a failure of the module at its input, or the AC input failing.
Rectifier Over Temperature	The rectifier has shut down due to the rectifier's temperature exceeding its operational limits. Internal protection ensures the rectifier is not damaged during this state.	By default this is a non-latching state, as such once the fault condition has been resolved the rectifier will return to normal operation. If latching is enabled, the state needs to be manually cleared by clicking on the Power Modules>Power Modules>**Clear Shutdown Latch** button.
Rectifier Over Voltage	A notification that the rectifier has exceeded the voltage set at Alarm Configuration>Bus Alarms> **High Voltage Setpoint** and has shut itself down.	This is an extremely rare alarm, and could be due to the rectifier module itself losing control and trying to push the output voltage beyond limits, or (more likely) due to an external influence on the DC bus (e.g., surges, someone accidentally shorting another voltage source onto the bus). By default this is a non-latching state, as such once the fault condition has been resolved the rectifier will return to normal operation. If latching is enabled, the state needs to be manually cleared by clicking on the Power Modules>Power Modules>**Clear Shutdown Latch** button.

Alarm	Description	Action
Rectifier Postmate	The post-mate pin on the rectifier connector has failed to engage. (Pre- and post-mate pins are used to ensure the output capacitors in the rectifiers do not cause arcing of the connector pins as the rectifier is inserted into a live system (hot-plug).	This is usually due to a rectifier not being inserted fully into a system. Ensure the rectifier is pushed "hard" into the system. If the problem persists, check the pins on the backplane by inserting a different rectifier into that position. If the Postmate alarm "follows" the rectifier, it may need to be replaced.
Rectifier Power Save Active	A notification that that the rectifiers are in power save mode, with rectifiers alternatively shutting down to optimize efficiency.	See Control>Rectifier Power Save section for details of the power save mode settings.
Rectifier Shutdown	A specific rectifier has shut itself off due to an external command from the Power Save function, Input Logic, or directly by a user from the Power Modules>Power Modules>Shutdown command.	If this is set by Input Logic, then is should be viewed as a notification only. Otherwise this should be investigated in terms of other alarms raised, the parameters displayed on the Power Module page, or logs.
Rectifier Soft Starting	The rectifier is starting. During start-up it goes through a soft start mode in order to ramp up output current in a controlled manner, thus avoiding large step-load changes on the grid or gen-set.	This is a notification only and normal during a rectifier start-up sequence.
Rectifier Temperature Sensor Fail	A rectifier temperature sensor is non-functional.	The rectifier can be restarted to check if the issue persists. If the temperature sensor has failed this is not a user serviceable part and the rectifier must be replaced.
WEB UI Alarm Configuration>Single Phase Backoff		
Backing Off AC Power	AC current has exceeded the backoff threshold and the rectifiers are winding back.	This is the normal function of the backoff feature. The importance of the function triggering is system dependent.
Clamping AC	This alarm occurs when the AC breaker current limit is exceeded and a "Rapid Backoff" is required. If the balanced phase current is below the breaker rating, this alarm will turn off. However, if the balance point is beyond the breaker rating setpoint, the EM4x limits the AC input current to this level, and the balance of energy comes from the battery. This alarm stays on until the AC current falls below the breaker rating setpoint.	If this alarm persists, it means there is insufficient power from the grid to both power the load **and** charge the batteries. Urgent action is required otherwise the battery will discharge and the DC system will crash. Wither site load needs to be reduced, or AC reticulation must be upgraded to a higher power/current level.
Single Phase Backoff Inhibited	If, for some reason the EM4x is unable to perform Phase Balancing, this alarm is raised. When this alarm is active, the system will revert to the settings in the Inhibit/Rollback Configuration.	There a number of reasons why Phase Balancing may be inhibited. Refer to section **Inhibit/Rollback Configuration** for details

Alarm	Description	Action
WEB UI Alarm Configuration>Solar Converter		
Solar Current Backflow Protection	Each solar converter has its input connected to an independent set of solar panels. However, the outputs of the converters are all connected together, and to the battery. The converters are fully active switching devices (no diodes in the power train) and as such can pass current in both directions when they are active and "on" during the day (night-time/dark is a special case and the input voltage is so low that the modules inherently block back-flow). Backflow protection is enabled when the conditions are such that current could pass from the output back to the solar panels (the input),	Normally this is just a notification, no action required. Basically Backflow Protection occurs when the battery voltage (at the solar converters output) is above the solar converters demand voltage. Conditions that can cause this are differences in converter calibration, battery voltage being driven up by other devices connected to the bus, system demanding a lower battery voltage. With multiple converters if one converter is running and the other is in backfeed it is most likely due to slight difference in the calibration, i.e. the converter in backfeed protection reads the output voltage slightly high. In summary, Backflow Protection stops current flowing back into the solar panels when the DC bus voltage rises above the output voltage that the converter is set to.
Solar Current Limit	A module is outputting maximum current.	Normal operation - a system notification, only. If all modules are operating in current limit this indicate that the bus voltage is lower than the float setpoint. If the bus voltage keeps decreasing (i.e., the battery is discharging), this is indicative that the system is incorrectly sized and extra capacity may be required.
Solar Current Limit (Constant Voltage)	Solar Converter output current is being limited due to the output voltage reaching the float voltage setpoint (see Control>Rectifier>Float Voltage)	Notification only. Part of normal system operation - no action required. Note that the target output/float voltage from the solar converter is the "Float Voltage" as set in Control>Rectifier>Float Voltage. The Solar Converter Bias (normally 0.2V to 0.4V) is an offset applied to devices like rectifiers (i.e., the rectifier will be set to Float Voltage **minus** the Converter Bias) so that if there is solar energy available, this will always be used as it will always be the cheapest energy source.
Solar EEPROM Fail	The converter EEPROM has failed.	This is not a user serviceable part and the converter must be replaced.

Alarm	Description	Action
Solar Fan Fail	The converter fan has failed. The converter can be restarted to see if the issue persists.	If the fan is non-functional this is not a user serviceable part and the converter must be replaced.
Solar Input Earth Fault	The converter module has detected an earth fault in the solar panel array.	This indicates a fault in the solar panel array (not the Power System). A physical and electrical check of the solar panel array should be carried out.
Solar Input Limited	Solar Converter output current is being limited due to the input power/current (from the solar panels) being insufficient to support the prospective load.	Notification only. Part of normal system operation - no action required.
Solar Input Over Voltage	The input voltage is out of range for the module.	This is an indication that the solar panels have been miss-applied as the input voltage to the converter has been exceeded. Resolve by having fewer solar panels connected in series.
Solar Input Unavailable	There is no supply to the module.	Occurs at night-time when there is no solar panel voltage - as such is normal operation. However, if this occurs during daytime, check the solar panel cabling for circuit interruption.
Solar Internal AUX Fail	Converter secondary power circuit failure.	This is not user serviceable and the unit should be replaced.
Solar Module Fail	A module fault has caused the module to stop operating. Solar Module Failed is default 1 module and the Solar Urgent Fail alarm indicates multiple modules failing. This threshold value is set at Control>**Solar Module Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	This is a non-user serviceable part and a faulty module must be replaced.
Solar Module Missing	A module previously recognized in the system is missing from its shelf position or comms are lost to it. Missing is default 1 module and Urgent Missing indicates multiple modules missing. This threshold value uses the field **Solar Converter Urgent Fail Threshold** found at Control>Renewable Energy.	Note moving a module from one location to another raises this alarm. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example. The alarm can be cleared by clicking on the **Clear Alarms** button on the Overview page.

Alarm	Description	Action
Solar Module Upgrading	The module firmware is in the process of upgrading. Do NOT disconnect the converter.	Status notification, only.
Solar Module Urgent Missing	Multiple modules previously recognized in the system are missing from their shelf position or comms are lost to them. Missing is default 1 module and Urgent Missing indicates multiple modules missing. This threshold value uses the field **Solar Converter Urgent Fail Threshold** found at Control>Renewable Energy.	Note moving a module from one location to another raises this alarm. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example. The alarm can be cleared by clicking on the **Clear Alarms** button on the Overview page.
Solar Output Over Voltage	The DC output Over Voltage Shutdown voltage threshold has been exceeded and the Converter has shut itself down. See Control>**Converter Voltage Setpoint**	
Solar Over Temperature	The converter has shut down due to the converter's internal temperature exceeding its operational limits.	By default this is a non-latching state, as such once the fault condition has been resolved the converter will return to normal operation. If latching is enabled, the state needs to be manually cleared by clicking on the Power Modules>Power Modules>**Clear Shutdown Latch** button.
Solar Postmate	A module postmate connector fail.	This is usually due to a module not being inserted fully into a system. Ensure the module is pushed "hard" into the system. If the problem persists, check the pins on the backplane by inserting a different converter into that position. If the Postmate alarm "follows" the converter, it should be replaced.
Solar Shutdown	A specific converter has shut itself off due to an external command from Input Logic, or directly by a user from the Power Modules>Power Modules>Shutdown command.	If this is set by Input Logic, then is should be viewed as a notification only. Otherwise this should be investigated in terms of other alarms raised, the parameters displayed on the Power Module page, or logs.
Solar Soft Starting	The converter is starting from "cold" - i.e., power-on. During start-up it goes through a soft start mode in order to ramp up output current in a controlled manner.	This is a notification only and normal operation.

Alarm	Description	Action
Solar Temperature Sense Fail	A module temperature sensor is non-functional.	The module can be restarted to check if the issue persists. If the temperature sensor has failed this is not a user serviceable part and the converter must be replaced.
Solar Urgent Fail	A fault has caused multiple modules to stop operating. Solar Module Failed is default 1 module and the Solar Urgent Fail alarm indicates multiple modules failing. This threshold value is set at Control>**Solar Module Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	This is a non-user serviceable part and a faulty module must be replaced.
WEB UI Alarm Configuration>Wind Converter		
Wind Current Backflow Protection	Each wind converter has its input connected to an independent set of solar panels, however the outputs of the converters are all connected together, and to the battery. The converters are fully active switching devices (no diodes in the power train) and as such can pass current in both directions when they are active and "on" during the day (night-time/dark is a special case and the input voltage is so low that the modules inherently block back-flow). Backflow protection is enabled when the conditions are such that current could pass from the output back to the input.	Normally this is just a notification, no action required. Basically Backflow Protection occurs when the battery voltage (at the wind converters output) is above the wind converters demand voltage. Conditions that can cause this are differences in converter calibration, battery voltage being driven up by other devices connected to the bus, system demanding a lower battery voltage. This is very rare in wind converters.
Wind Current Limit	A module is outputting maximum current.	Normal operation - a system notification, only. If all modules are operating in current limit this indicate that the bus voltage is lower than the float setpoint. If the bus voltage keeps decreasing (i.e., the battery is discharging), this is indicative that the system is incorrectly sized and extra capacity may be required.

Alarm	Description	Action
Wind Current Limit (Constant Voltage)	If all modules are operating in current limit this indicates that the bus voltage is lower than the float setpoint.	If the bus voltage keeps decreasing (i.e., the battery is discharging), this is indicative that the system is incorrectly sized and extra capacity may be required.
Wind EEPROM Fail	The converter EEPROM has failed.	This is not a user serviceable part and the converter must be replaced.
Wind Input Earth Fault	The converter module has detected an earth fault in the wind generator.	This indicates a fault in the wind generator (not the Power System). A physical and electrical check of the wind generator should be carried out.
Wind Input Limited	Wind Converter output current is being limited due to the input power/current (from the wind generator) being insufficient to support the prospective load.	Notification only. Part of normal system operation - no action required.
Wind Input Over Voltage	The input voltage is out of range for the module.	This is an indication that the wind generator has been miss-applied as the input voltage to the converter has been exceeded. Resolve by checking what is the output voltage of the turbine or what has been connected in series.
Wind Input Unavailable	There is no supply to the module.	Occurs when there is no wind, when there is no turbine voltage - as such is normal operation. However, if this occurs during operation, check the cabling for circuit interruption.
Wind Internal AUX Fail	Converter secondary power circuit failure.	This is not user serviceable and the unit should be replaced.
Wind Module Fail	A module fault has caused the module to stop operating. Module Failed is default 1 module and the Urgent Fail alarm indicates multiple modules failing. This threshold value is set at Control> Solar Module Urgent Fail Threshold. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	This is a non-user serviceable part and a faulty module must be replaced.
Wind Module Fan Fail	The converter fan has failed. The converter can be restarted to see if the issue persists.	If the fan is non-functional this is not a user serviceable part and the converter must be replaced.

Alarm	Description	Action
Wind Module Missing	A module previously recognized in the system is missing from its shelf position or comms are lost to it. Missing is default 1 module and Urgent Missing indicates multiple modules missing. This threshold value uses the same field as **Solar Converter Urgent Fail Threshold** found at Control>Renewable Energy.	Note moving a module from one location to another raises this alarm. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example. The alarm can be cleared by clicking on the **Clear Alarms** button on the Overview page.
Wind Module Upgrading	The module firmware is in the process of upgrading. Do NOT disconnect the converter.	Status notification, only.
Wind Module Urgent Fail	A fault has caused multiple modules to stop operating. Solar Module Failed is default 1 module and the Solar Urgent Fail alarm indicates multiple modules failing. This threshold value is set at Control>**Solar Module Urgent Fail Threshold**. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example.	This is a non-user serviceable part and a faulty module must be replaced.
Wind Module Urgent Missing	Multiple modules previously recognized in the system are missing from their shelf position or comms are lost to them. Missing is default 1 module and Urgent Missing indicates multiple modules missing. This threshold value uses the same field as **Solar Converter Urgent Fail Threshold** found at Control>Renewable Energy.	Note moving a module from one location to another raises this alarm. The alarms are differentiated because it may be considered unnecessary for a site call out for just 1 module in a large system of 10, for example. The alarm can be cleared by clicking on the **Clear Alarms** button on the Overview page.
Wind Output Over Voltage	The DC output Over Voltage Shutdown voltage threshold has been exceeded and the Converter has shut itself down. See Control>**Converter Voltage Setpoint**	
Wind Over Temperature	The converter has shut down due to the converter's internal temperature exceeding its operational limits.	By default this is a non-latching state, as such once the fault condition has been resolved the converter will return to normal operation. If latching is enabled, the state needs to be manually cleared by clicking on the Power Modules>Power Modules>Clear Shutdown Latch button.

Alarm	Description	Action
Wind Postmate	A module postmate connector fail.	This is usually due to a module not being inserted fully into a system. Ensure the module is pushed "hard" into the system. If the problem persists, check the pins on the backplane by inserting a different converter into that position. If the Postmate alarm "follows" the converter, it should be replaced.
Wind Shutdown	A specific converter has shut itself off due to an external command from Input Logic, or directly by a user from the Power Modules>Power Modules>Shutdown command.	If this is set by Input Logic, then it should be viewed as a notification only. Otherwise this should be investigated in terms of other alarms raised, the parameters displayed on the Power Module page, or logs.
Wind Soft Starting	The converter is starting from "cold" - i.e., power-on. During start-up it goes through a soft start mode in order to ramp up output current in a controlled manner.	This is a notification only and normal operation.
Wind Temperature Sense Fail	A module temperature sensor is non-functional.	The module can be restarted to check if the issue persists. If the temperature sensor has failed this is not a user serviceable part and the converter must be replaced.

16.4.1 Energyhub & Energypak Alarms

Alarm	Description	Action
WEB UI Alarm Configuration>Charge		
Energypak Extended Capacity Active	The user controlled extended capacity function is active bringing the cell charge up to the level specified above the default maximum 4.05V/cell.	Information only, no action.
Energypak Self-Discharge Test Failed	The energypak has failed to complete a self-discharge test as set at Charge>Energypak Self-discharge Test	Information which should be reviewed as to the cause. The test may have been over-ridden because of some other event, or a potential system or energypak fault.
Energypak Self-Discharge Test In Progress	The energypak is undergoing a self-discharge test.	Information only, no action
Energypak Selftest Lockout Timer Active	The energypak cannot perform a self test at this time because it has been deliberately prevented from doing so. (An example lockout would be during commissioning when all batteries are being brought up to full charge.)	Information only, no action

Alarm	Description	Action
WEB UI Alarm Configuration>Battery		
Float Voltage Too High for Energypak	An indication that the float voltage has been attempted to be set too high for the system. The attempted setting is rejected and not able to save. The Float Voltage for an energyhub system cannot be greater than 56.7V (4.05V/cell).	Enter a correct figure at Control>**Float Voltage**
WEB UI Alarm Configuration>energypak		
Energypak Above Maximum Voltage	This alarm is set when the battery pack voltage exceeds 59V. If this alarm is set for more than 30 seconds, the battery will disconnect and reconnect when the bus voltage drops 0.5V below the battery voltage (conditions for a discharge)	See Energypak High Voltage Disconnect
Energypak Above Maximum Cell Voltage	This alarm is set when any one cell in an energypak exceeds 4.05V. If this alarm is set for more than 30 seconds, the battery will disconnect and reconnect when the bus voltage drops 0.5V below the battery voltage (conditions for a discharge)	See Energypak High Voltage Disconnect.
Energypak Above Maximum Temperature	This alarm is set when one of the 7 cell temperature measurements exceeds 60°C or the bridge (FET bridge) measurement exceeds 70°C	No action is taken. The battery will disconnect until the temperature measurement at fault is lower than the threshold.
Energypak Auxiliary Bus Fault	The 12V auxiliary bus internal to the battery module is not operating correctly, the battery is permanently disconnected.	Replace the energypak.
Energypak Below Minimum Battery Voltage	This alarm is set when the battery pack voltage is below 40.6V (also known as the LVD voltage). If this alarm is active for more than 20 seconds, the battery will disconnect and remain disconnected until the bus voltage is 1.0V above the battery (conditions for charge).	See Energypak Low Voltage Disconnect

Alarm	Description	Action
Energypak Below Minimum Cell Voltage	This alarm is set when any one cell in an energypak voltage is below 2.9V. If this alarm is active for more than 20 seconds, the battery will disconnect and remain disconnected until the bus voltage is 1.0V above the battery (conditions for charge).	See Energypak Low Voltage Disconnect
Energypak Below Minimum Temperature	This alarm is set when one of the 7 cell temperature measurements goes below –20 C°. The battery will disconnect until the temperature measurement is higher than the threshold.	Note that with continued temperature decrease the energypak will be permanently disconnected at -43°C.
Energypak Bridge Fault	The battery module's FET bridge is operating in an uncontrolled manner, it should be permanently disconnected. This includes a fuse blowing.	Replace the energypak.
Energypak Bridge Fault (while closed)	The battery module's bridge is closed, and a significant voltage is measured across it. The battery is permanently disconnected.	Replace the energypak.
Energypak Bridge Fault (while limiting)	The battery module's bridge is operating in buck charging mode and the current measured is not within expected limits. The battery is permanently disconnected.	Replace the energypak.
Energypak Bridge Fault (while open)	The battery module's bridge is open circuit, but current is detected. It should be permanently disconnected. The energypak has attempted to blow a fuse.	Replace the energypak.
Energypak Calibration Fault	The energypak has been unable to do its self-calibration.	Replace the energypak.
Energypak Cell Disconnect Fault	A cell voltage measurement indicates that it is not connected. The battery is permanently disconnected.	Replace the energypak.

Alarm	Description	Action
Energypak Cell Temperature Fault	This alarm is set when one of the cell temperature measurements increases by more than 2°C in charge or 3°C in discharge over a time period of one minute. The battery will disconnect and remain disconnected until it is removed from the system. The fault clears when removed from system.	Replace the energypak. This is considered a critical fault.
Energypak Cell Voltage Unbalance	This alarm is set when the highest cell voltage exceeds the lowest cell voltage by more than 0.2V. The cell balancing circuit operates when this alarm is raised.	An informative alarm which should be observed. The energypak should self-rectify this issue.
Energypak Critical Fault	This alarm requires no interaction. The battery will not disconnect.	Replace the energypak.
Energypak Current Limit Active	The battery is charging in current limiting mode. This is a low current charge mode of less than 150mA.	The cause should be understood. It is normal operation in most circumstances where one energypak at lower charge than others in the system is being slowly brought up to full charge to protect against inrush currents.
Energypak Deep Discharge Unrecoverable Fault	A cell voltage is below 2.5V. This is considered unrecoverable. The battery is permanently disconnected.	Replace the energypak. An example of this might be where an energypak has been left in storage for many months without a top up charge.
Energypak Disconnected	The battery module is disconnected from the bus (but is still communicating with the controller).	Any action required depends on the reason for the disconnection, usually indicated by other alarms being raised in conjunction. If this is the only alarm raised, observe over a day or so, if no recovery the energypak should be replaced.
Energypak EEPROM Fault	The EEPROM memory is not communicating. Calibration is not available, so the battery will not operate.	Replace the energypak.
Energypak Firmware Upgrade Available	During a firmware upgrade of the EM4x it has detected that there is a new version of the energypak firmware available.	It is recommended to upgrade the energypak firmware. Refer to your manual for instructions.
Energypak Firmware Upgrading	Firmware upgrade is in progress. Just wait!	No action required except to re-sign into the Web UI, the EM4x and Web UI reboot automatically.
Energypak Health Low	This alarm is set when the health of the battery is below 50%. No action is taken.	The performance of the batteries is impacted and the energypak should be replaced.

Alarm	Description	Action
Energypak Health Ultra Low	This alarm is set when the health of the battery module is below 25%. No action is taken.	The performance of the batteries is seriously impacted and the energypak should be replaced.
Energypak High Bus Voltage Warning	The bus voltage has exceeded 60V.	The bus voltage is above a voltage the energypaks can be safely charged to. Note other alarms that have been raised.
Energypak High Cell Voltage Warning	The highest cell voltage measurement has exceeded 4.1V.	No action is taken. A warning alarm as a precursor to Energypak High Voltage Disconnect.
Energypak High Temperature Warning	The highest cell temperature measurement has exceeded 40°C	This is an informative alarm with no action taken. However there are consequences of continued temperature rise. Charging of the energypak ceases at >45°C and the energypak disconnects at >60°C
Energypak High Voltage Disconnect	This alarm is set when the following conditions are met: a. Above maximum cell voltage for 30 seconds OR b. Above maximum battery voltage for 30 seconds And the battery module is charging for at least 3 seconds.	This is a fault requiring investigation, where in one potential instance the bus voltage has increased to a level that it is attempting to overcharge the battery and the battery has disconnected to protect itself.
Energypak Input Fail	Power supply to the energypak is not available.	The reason for this should be understood, if it is an energypak external event or not. If it is a hardware fault in the energypak the energypak should be replaced.
Energypak Low Bus Voltage Warning	The bus voltage has gone below 42V. No action is taken.	A warning alarm as a precursor to Energypak Low Voltage Disconnect.
Energypak Low Cell Voltage Warning	This alarm is set when the lowest cell voltage measurement goes below 3.1V.	An informative alarm. No action is taken. A precursor warning prior to the Energypak Low Voltage Disconnect alarm.
Energypak Low Temperature Warning	The lowest cell temperature measurement has gone below 10°C	This is an informative alarm with no action taken. However there are consequences of continued temperature decrease. Charging of the energypak ceases at <0°C and the energypak disconnects at <20°C
Energypak Low Voltage Disconnect	This alarm is set when the following conditions are met: c. Below minimum cell voltage for 20 seconds OR d. Below minimum battery voltage for 20 seconds And the battery module is discharging for at least 3 seconds.	See Battery>Battery Settings>Battery LVD Threshold for the parameter. In normal usage the energypak has discharged to the allowed level. The energypak should be recharged, the alarm clears automatically once the battery voltage starts to recharge.

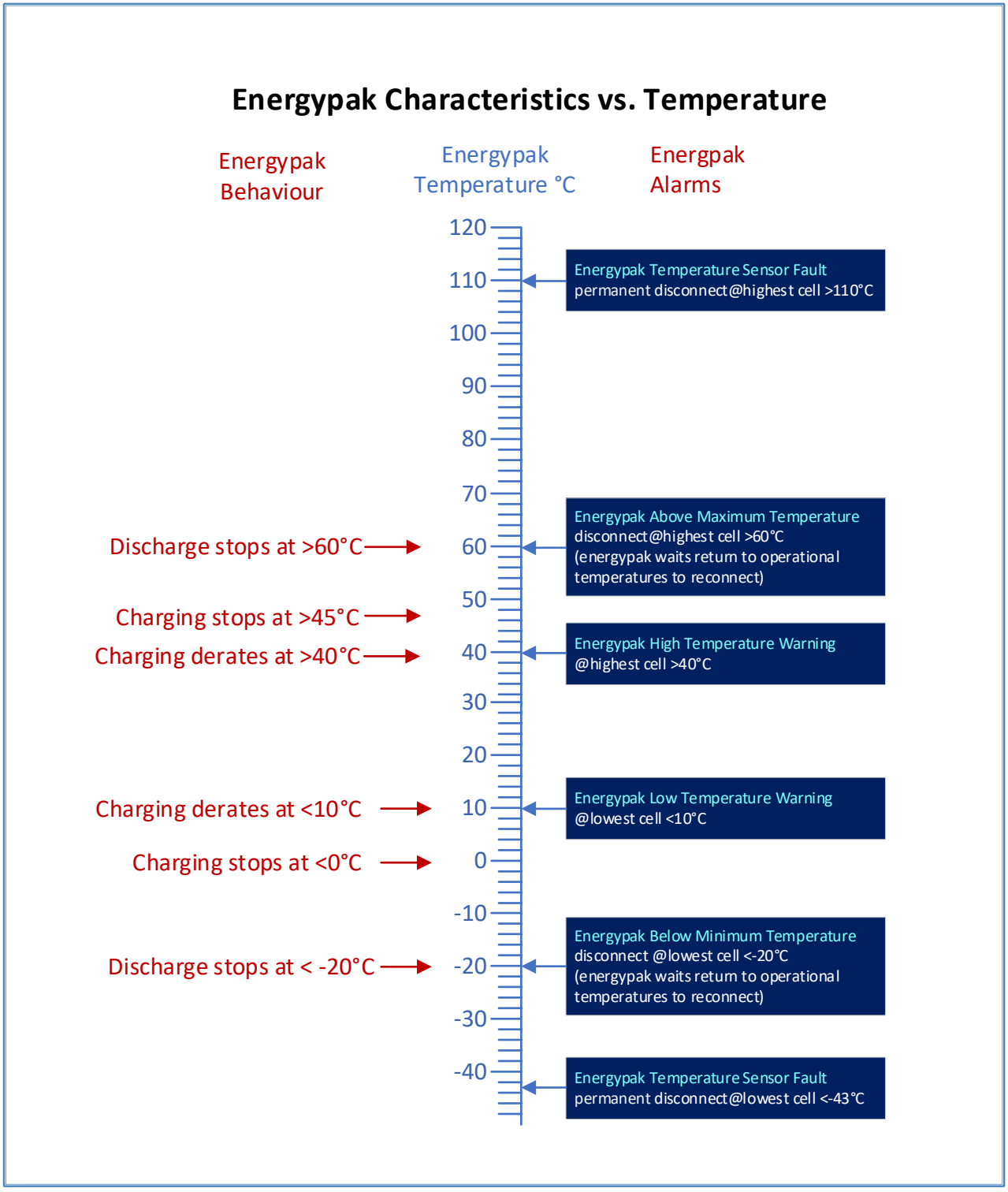
Alarm	Description	Action
Energypak Missing	A battery previously detected by the system is no longer communicating with the controller and assumed missing.	This alarm triggers in normal operation when an energypak is replaced or its position swapped in the system. The alarm can be cleared on the Overview page Clear Alarms button. This number is set at Battery>Battery Setting>Energypak Urgent Fail Threshold
Energypak Over Current Disconnect	This alarm will be set during discharge, when module current exceeds the limits enforced by the software breaker curve. The battery will disconnect until the bus voltage is 1.0V above the battery module. If this condition is not met, the battery will attempt to make low current connections every 30s as if it were being inserted into the system initially.	A typical issue here is that the load is too great for the energypak(s) to supply. Additional energypaks can be attempted to be inserted till they are able to supply the load in which case the alarm automatically clears. NOTE: energypaks in this case should be equally charged for optimum effective load supply otherwise the energypaks attempt to charge each other along with the load. This is a circumstance that in normal operation is to be avoided.
Energypak Over Current Warning	This alarm is set when the discharge current exceeds 6.9A.	A warning, precursor to the Energypak Over Current Disconnect should the discharge current continue to rise.
Energypak Self-Discharge Active	This alarm is set while the battery is performing a self-discharge test.	Information only, no action.
Energypak Shunt Fault	A large change in battery voltage is detected without a corresponding change in current. The battery is permanently disconnected.	Replace the energypak.
Energypak Temperature Sensor Fault	One of the temperature measurements is outside of the measurable range (-43 to +110°C). The battery is permanently disconnected.	Replace the energypak. DO NOT attempt to recharge or discharge or use the energypak in any manner. It is assumed in this instance that the energypak temperature has gone beyond these limits and is permanently irrecoverable.
Energypak Unknown Alarm	The battery module has an alarm which is unknown to the controller.	This should be observed. If constant the energypak should be replaced.
Energypak Unknown Board Version Fault	The firmware cannot determine which version of the PCB is fitted. The battery is disconnected permanently. Hardware fault.	Replace the energypak.
Energypak Unknown Fault	A critical fault that is not known to the controller occurred. The battery is permanently disconnected.	Replace the energypak.

Alarm	Description	Action
Energypak Unknown Product ID Fault	The firmware cannot determine which version of the PCB is fitted. The battery is disconnected permanently.	Replace the energypak.
Energypak Urgent Fail	A critical number of energypak modules have failed in a critical manner.	This alarm is raised when a number of energypaks have failed deemed critical to system functionality. This number is the same number set for the Energypak Urgent Missing which can be entered at Battery>Battery Setting>Energypak Urgent Fail Threshold.
Energypak Urgent Missing	A critical number of energypak modules are no longer communicating with the controller.	This alarm triggers when a number of energypaks previously recognized in the system are missing. In normal operation it occurs when energypaks are replaced or position swapped in the system. The alarm can be cleared on the Overview page Clear Alarms button. This number is set at Battery>Battery Setting>Energypak Urgent Fail Threshold

16.5 Energypak Temperature Behaviour

Figure 29 describes the energypak alarms associated with temperature levels and notes related key energypak characteristics.

Figure 29: Energypak vs. Temperature



17 SERVICE


All installation and maintenance must be carried out by suitably qualified personnel.


The energy manager contains static sensitive components that require careful handling and proper precautions to be taken.

If the controller unit should require service it should be removed from the system by an Approved Service Agent and returned to the manufacturer for servicing.

The controller should not be removed from the system by unauthorised personnel as this may lead to malfunctions of the DC system.

Appendix I ENATEL ENERGY STANDARD LIMITED WARRANTY POLICY

Enatel warrants that its products shall be free from defects of material or workmanship under use consistent with correct installation and commission, normal operation, product specifications, Enatel's written instructions, and regional standards compliance, for a period of one (1) year from the start date. The start date shall be defined as (a) the date the product is shipped from Enatel's factory; or (b) in the case of resale by an authorized Enatel reseller, whichever is the lesser of i) the date on the sales invoice or ii) ninety (90) days after original shipment by Enatel factory.

The warranty provides for repairing or replacing, at Enatel's sole discretion, those products deemed defective by Enatel after inspection of its products returned by the customer to the factory or other Enatel authorized location within the warranty period. Replaced product provided by Enatel under the terms of this warranty does not extend the original warranty, replacement product assumes the warranty of the original product. Repaired product or component thereof has a warranty period of ninety (90) days or the remainder of the unexpired term of the original product warranty, whichever is greater.

I.A Warranty Exclusions and Restrictions

Products or parts may be excluded from warranty coverage for reasons including, but not limited to: if the hardware or software has been altered or repaired by an unauthorized party; is defective due to misuse, negligence, accident, mechanical damage, improper installation or maintenance; inappropriate on-site conditions such as high humidity, dust, power surges, out-of-range temperatures, animal or insect damage, water or other liquid damage; where serial numbers or identification marks are removed or defaced in any way; Force Majeure event; has cosmetic shortcomings which do not affect normal operation; inappropriate electrical stress; for suspected fraud or abuse of Enatel's warranty policy; the account has breached or is in dispute of Enatel's commercial terms and conditions.

Note Enatel warranty does not cover data loss, regular back-ups to separate storage is required.

I.B Battery Warranty

Battery warranty is NOT covered under this warranty. Where Enatel supplies batteries a separate warranty statement shall govern the battery warranty, or where an Enatel battery warranty is not provided the authorized battery vendor's warranty shall be assigned to the batteries.

Note that batteries' operational limits are typically more constrained than Enatel manufactured equipment, need specific care during storage and maintenance, and requirements typically vary for each battery type and vendor. Enatel product warranty is voided should improper care of associated batteries be the cause of product defect.

Unless stated otherwise in the terms and conditions of sale warranty for peripherals, attachments or apparatus not manufactured by Enatel shall be excluded from this warranty.

I.C Initiating a Warranty Claim

To make a warranty claim please complete a Request for RMA Number form:

https://www.enatel.net/support/#rma.

Issuance of an RMA number means your RMA request has been approved and the product or part warranty claim may now be managed as instructed by Enatel.

Shipping Defective Product to Enatel: All shipments must be shipped prepaid and include proof of the date of your original purchase along with the RMA number of the approved RMA clearly indicated with the shipment – see the Request for RMA Number form for further details.

Note Enatel will pay the cost of shipping replacement or repaired units from warranty claims from Enatel back to the customer, only, unless otherwise approved by Enatel during the RMA Number application process.

I.D Disclaimer

Enatel's warranties and remedies set forth above are exclusive and in lieu of all other warranties, remedies and conditions, whether oral or written, express or implied. Enatel specifically disclaims any and all implied warranties, including but not limited to warranties of merchantability and fitness for a particular purpose. In no event shall Enatel be responsible for indirect or consequential damages or lost profits even in the case of negligence and if Enatel has been advised of the possibility of such damages. Enatel's sole obligation shall be the repair or replacement of a non-conforming product. In no case shall Enatel's liability under this warranty exceed the value of the unit provided. If the law prohibits Enatel from disclaiming implied warranties or warranties of merchantability, all such warranties are limited to the greatest extent permitted by law. Enatel reserves the right to change the information detailed within this statement without notice.

The benefits conferred by these warranties are in addition to other rights you may have depending on your country, state or province of residence. Furthermore, some countries, states and provinces do not allow the exclusion or limitation of incidental or consequential damages or exclusions or limitations on the duration of implied warranties, so the above limitations or exclusions may not apply to you. If any provision of these warranties is unlawful, void or unenforceable, that provision shall be deemed severable and shall not affect any remaining provisions. This warranty shall be governed by and interpreted in accordance with the laws of New Zealand.

I.E Remark

Enatel is a registered company name. New Zealand Company Number: 1202388

Enatel Energy® is a registered trademark of Enatel.

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