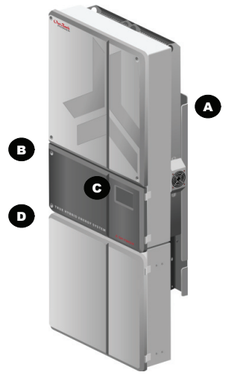
Programming Guide

SKYBOX True Hybrid Energy System

Contents

Features

A: Mounting panel
B: Inverter connection panel
C: Graphical User Interface (GUI)
D: Balance of Systems (BOS)



WARNING: Limitations on Use

This equipment is NOT intended for use with life support equipment or other medical equipment or devices.

WARNING: Reduced Protection

If this product is used in a manner not specified by SkyBox product literature, the product's internal safety protection may be impaired.

CAUTION: Equipment Damage

Only use components or accessories recommended or sold by OutBack Power Technologies or its authorized agents.

IMPORTANT

- This document is for use by qualified personnel familiar with photovoltaic (PV) systems and maximum power point tracking (MPPT) technology as well as basic inverter functionality. Users of this document should meet all local and governmental code requirements for licensing and training for the installation of electrical power systems with AC and DC voltage up to 600 volts. This product is only serviceable by qualified personnel.
- This document describes settings available under the ***Installer*** login profile. A password for this profile is required.

Interface Display

The user interface allows monitoring and programming of all items. It can be accessed remotely using a web browser once a local area network or internet connection is established.

The SkyBox interface screen is touch-sensitive. Items will respond or open when tapped with a finger or stylus. Mild pressure is required.

Arrows ←, chevrons ⌄, or pointers ▾ are frequently used for navigation. To navigate:

- Arrows ← usually proceed to the previous or next screen in a series. Continuing to press the left arrow will generally return to the Home screen.

Chevrons ⌄ proceed to the previous or next sub-screen in a series. Navigation within each **Tile** (see page 13) is usually performed with chevrons.

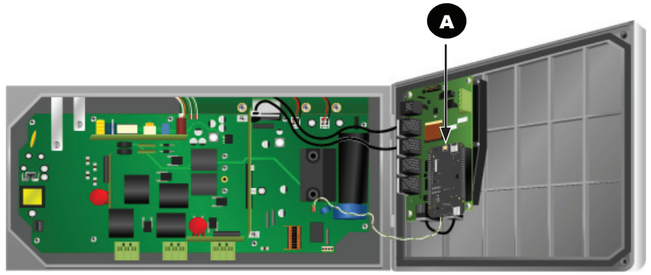
- Chevrons pointing up or down access additional screens for monitoring, programming, or settings.
- Chevrons pointing left or right access alternate views of the present screen from other dates. The left chevron brings up data from the previous day. The right chevron brings up the next day (if possible).

- Pointers ▾ access drop-down menus. A drop-down menu offers a list of pre-populated selectable items. Making a selection will automatically exit. Items without a pointer have a pop-up screen with a keypad for setting a number. Pressing the ***DONE*** command will automatically exit.

Setup Wizard

On initial power-up, a welcome message is shown. The right arrow → proceeds to the **Setup Wizard**. For this occasion the user is treated as logged into the ***Installer*** profile. (See page 17).

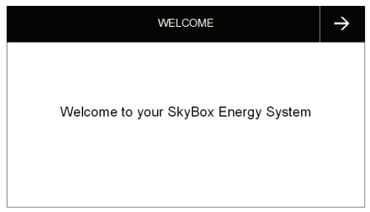
The Wizard begins with the applicable language, then offers the option to load previously saved information from a USB drive. The USB port is located here at **A**. See the *SkyBox Quick Start Guide* for more information on the use of this port.

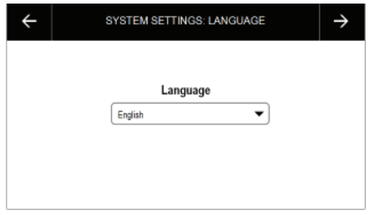


Subsequent Wizard items include language, region, and similar changes, then PV, battery, and AC settings. The list of bullets on the opposite page shows the progression of items. On the last screen, ***Save and Exit*** proceeds to the ***Home*** screen. After the first power-up, the ***Home*** screen appears after every power reset.

It is possible to re-run the Wizard. (See page 18.) When running it again, logging into the ***Installer*** profile (with password) is required to change settings. It is not possible to re-run the Wizard when logged in remotely.

NOTE: Some settings may not be compatible with each other. The Wizard will flag these combinations by outlining them in red until they are corrected.





NOTE: The Wizard is a streamlined version of the normal interface settings. All settings are also available under their respective headings without running the Wizard again.

900-0211-01-00 Rev A

Setup Wizard Items

- SYSTEM SETTINGS: LANGUAGE.

  NOTE: Only English is available at this time.

- WIZARD INSTALLATION
  - ***Quick setup allows you to load previously saved information from a USB drive and skip to the end of the Setup Wizard***
    - Insert a USB drive at this step to load saved information. Continue through the following items to check the settings.

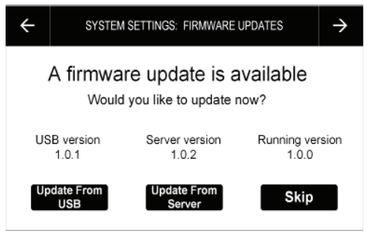
- SYSTEM SETTINGS: DISPLAY (see page 18)
  - ***System Name*** — can be manually populated.
  - ***Brightness*** — ***1*** to ***10***. Default: ***10***
  - ***Display timeout (minutes)*** — ***Never***, ***1***, ***2***, ***5***, ***10***, ***15***. Default: ***5***.
  - ***Login timeout (minutes)*** — same as above. Default: ***5***.

- SYSTEM SETTINGS: INTERNET CONNECTION
  - ***Connection mode*** — ***Wired*** or ***Disabled***. Default: ***Wired***.
  - ***DHCP enable*** — ***Yes*** or ***No***. Default: ***Yes***.
  - ***Ethernet connection*** — ***Wall*** or ***SkyBox***. Default: ***Wall***.
  - ***IP address*** — DHCP will auto-populate.
  - ***Subnet mask*** — DHCP will auto-populate.
  - ***Gateway*** — DHCP will auto-populate.
  - ***Primary DNS*** — DHCP will auto-populate.
  - ***Secondary DNS*** — DHCP will auto-populate.
  - ***Automatic port forwarding*** — ***Enable*** or ***Disable***. Default: ***Enable***.
  - ***UPnP Port number*** — DHCP will auto-populate.

- SYSTEM SETTINGS: FIRMWARE UPDATES

  NOTE: If a firmware update is available from an internet connection or a USB drive, a screen will appear to prompt a firmware update. This screen shows the firmware version currently running and the versions available from USB or the internet server. It will not appear if these conditions do not apply.

  When updating, select the highest version available.



- SYSTEM SETTINGS: REGIONAL SETUP

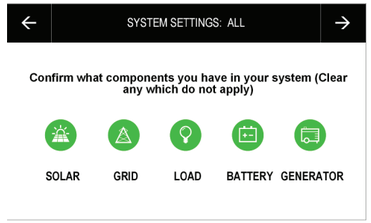
  NOTE: Most of these screen items lead to pop-up screens that allow setting changes.
  - ***Country*** — can be populated from a drop-down list.
  - ***Time zone*** — can be manually populated.
  - ***Date format*** — can be manually populated.
  - ***Date*** — required field.
  - ***Time format*** — can be manually populated.
  - ***Time*** — required field.
  - ***Temperature format*** — can be manually populated.

Setup Wizard (continued)

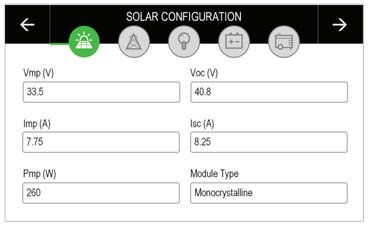
- SYSTEM COMPONENTS: ALL

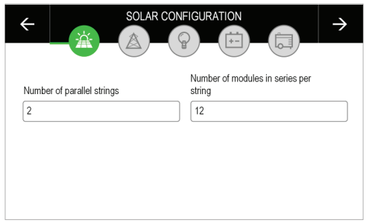
IMPORTANT:

- All five components on this screen are initially populated. Components not applicable to the system should be removed.
- If a component is not indicated here but is still present, the SkyBox will still accept it. For example, the SkyBox will not reject power from PV or generator even if this screen is not programmed for them.
- The ***Load*** component is not currently selectable, but shows onscreen as populated.
- The Wizard cannot proceed to the next screen unless at least two items are populated. NEED TO FIND OUT IF THIS INCLUDES LOAD, WHICH (AT LEASE VISIBLY) POPULATES AUTOMATICALLY

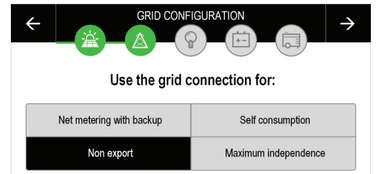


- SOLAR CONFIGURATION (see page 23)
  - ***PV array size (kW)*** — can be populated
  - V_{mp} ***(V)*** — ***24*** to ***100***.
    Default: ***33.5***
  - V_{oc} ***(V)*** — ***24*** to ***100***.
    Default: ***40.8***
  - I_{mp} ***(A)*** — ***0*** to ***30***.
    Default: ***7.75***
  - I_{sc} ***(A)*** — ***0*** to ***30***.
    Default: ***8.25***
  - P_{mp} ***(W)*** — ***0*** to ***500***.
    Default: ***260***
  - ***Module type*** — ***Monocrystalline***, ***Polycrystalline***, ***Thin film***.
    Default: ***Monocrystalline***
  - ***Number of parallel strings*** — ***1*** to ***10***.
    Default: ***2***
  - ***Number of modules in series per string*** — ***5*** to ***30***.
    Default: ***12***



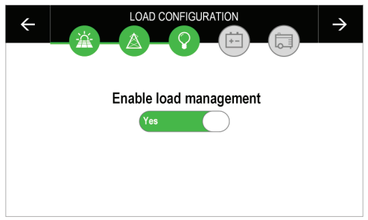


- GRID CONFIGURATION
  - **Use the grid connection for**:
    - ***Net metering with backup***. See page 27 and 28.
    - ***Self consumption***. See page 27 and 29.
      - If selected, another screen follows this one with GridZero™ settings.
    - ***Non export*** (the default selection) See page 27 and 29.
      - If selected, another screen follows this one with GridZero™ settings.
    - ***Maximum independence***. See page 27 and 28.
  - ***Cost of energy (kWh) varies throughout the day*** (see page 28)
    - If ***Yes*** is selected, an ***Enter time of use schedule*** screen follows this one.
    - If ***No*** is selected, a ***Cost of Energy (kWh) flat rate*** entry screen follows this one.
  - ***Demand charges apply to maximum kW peaks*** (see page 27)
    - If ***Yes*** is selected, a ***Max grid demand (kW)*** entry screen follows this one.
  - ***Enable external CTs*** (see page 16)
    - If ***Yes*** is selected, a ***CT settings*** screen follows this one.
  - ***Grid interconnection profile*** (see page 27)



- LOAD CONFIGURATION

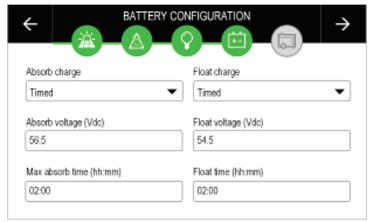
  This screen is not available at this time. Load configuration will be available in future revisions. The symbol illuminates automatically when BATTERY CONFIGURATION is enabled.

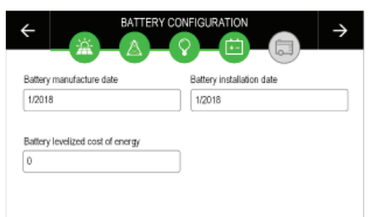


IMPORTANT:

Setup Wizard (continued)

- BATTERY CONFIGURATION (see page 39)
  - ***Battery series*** — This item presents a list of battery series. Select the one most applicable to this system. Default: ***None***
  - ***Battery model number*** — This varies according to the battery series selected above.
  - ***Total amp-hour capacity*** — ***0*** to ***20000***. Default: ***200***
  - Charging parameters (if ***Custom*** is selected above)
    - ***Absorb charge*** — ***Timed*** or ***Disabled***. Default: ***Timed***
    - ***Float charge*** — ***Timed***, ***Continuous***, or ***Disabled***. Default: ***Timed***
    - ***Absorb voltage (V)*** — ***36*** to ***68***. Default: ***56.5***
    - ***Float voltage (V)*** — ***36*** to ***68***. Default: ***54.5***
    - ***Max absorb time (hh:mm)*** — ***00:00*** to ***10:00***. Default: ***02:00***
    - ***Float time (hh:mm)*** — ***00:00*** to ***23:59***. Default: ***02:00***
    - ***Refloat voltage (V)*** — ***36*** to ***68***. Default: ***50***
    - ***Rebulk voltage (V)*** — ***36*** to ***68***. Default: ***48***
    - ***Equalize voltage (V)*** — ***36*** to ***68***. Default: ***58.8***
    - ***Equalize time min (hh:mm)*** — ***00:00*** to ***23:59***. Default: ***00:00***
    - ***Charge efficiency factor (%)*** — ***80*** to ***100***. Default: ***95***
    - ***Absorb end (Adc)*** — ***0*** to ***50***. Default: ***10***
    - ***Max charge (Adc)*** — Default: ***30*** (limits based on battery type)
    - ***Temperature compensation slope (–mV/°C/cell)*** Default: ***5***
    - ***Battery manufacture date (mm:yyyy)*** — Can be manually populated.
    - ***Battery installation date (mm:yyyy)*** — Can be manually populated.
    - ***Levelized cost of energy per kWh*** — Can be manually populated. See page 43 to determine this number.

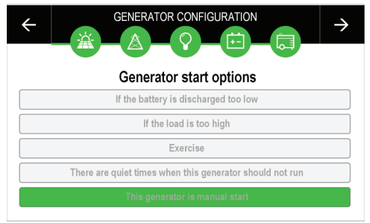




Setup Wizard (continued)

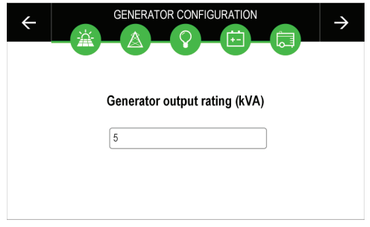
- GENERATOR CONFIGURATION
  - ***Generator start options*** (see page <?>)

    NOTES:
    - ***This generator is manual start*** is the only selection enabled by default. All other selections are initially disabled.
    - As long as ***This generator is manual start*** is enabled, other selections cannot be enabled. The other selections cannot be used until ***This generator is manual start*** is disabled.
    - At least one selection must be made before proceeding to the next screen.
    - When enabled, the items in each sub-bullet below will appear in order after this screen (not after each item).

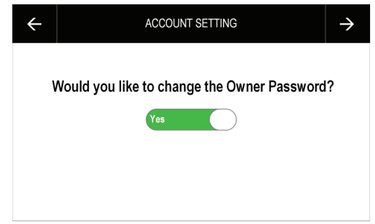


    - ***If the battery is discharged too low***
      - ***Start generator if SOC falls below (%)*** — ***0*** to ***80***. Default: ***50***
    - ***If the load is too high***
      - ***Select load level (kW)*** — ***0*** to ***50***. Default: ***5***
      - ***Load duration (seconds)*** — ***1*** to ***90***. Default: ***5***
    - ***Exercise***
      - ***Generator exercise start (hh:mm)*** — ***00:00*** to ***23:59***. Default: ***00:00***
      - ***Exercise duration (minutes) — 10***, ***15***, or ***20***. Default: ***10***
      - ***Exercise interval — Daily***, ***Weekly***, or ***Monthly***. Default: ***Monthly***
    - ***There are quiet times when this generator should not run***
      - ***Weekday quiet time begin (hh:mm)*** — ***00:00*** to ***23:59***. Default: ***00:00***
      - ***Weekday quiet time end (hh:mm)*** — ***00:00*** to ***23:59***. Default: ***00:00***
      - ***Weekend quiet time begin (hh:mm)*** — ***00:00*** to ***23:59***. Default: ***00:00***
      - ***Weekend quiet time end (hh:mm)*** — ***00:00*** to ***23:59***. Default: ***00:00***
    - ***This generator is manual start***

      If selected, the items above will not appear.
  - ***Generator output rating (kVA)*** — ***0*** to ***100***. Default: ***5***
  - ***Max Grid Demand (kVA)*** ***0*** to ***14.2***. Default: ***12***



- ACCOUNT SETTING (see page 17)
  - ***Would you like to change the Owner Password?***
    - If ***Yes*** is selected, another screen follows this one with entries for the current password and the new password.
    - The default Owner Password is **1234**.
  - ***Would you like to change the Installer Password?***
    - If ***Yes*** is selected, another screen follows this one with entries for the current password and the new password.
    - The default Install Password is **1234**.



IMPORTANT:

If the Installer password is left at the default setting, this will permit the end user to have configuration access. Installers who wish to restrict access must update this password.

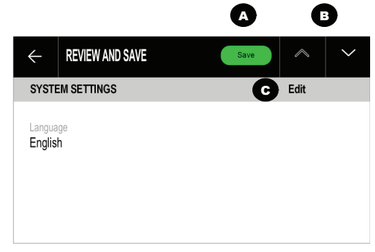
NOTE:

If ***Grid interconnection profile*** is set to anything other than ***IEEE 1547 2003***, the ***Installer Password*** must be updated before proceeding.

- INSTALLER INFO
  - ***Company name***
  - ***Name***
  - ***E-mail***
  - ***Telephone number***
  - ***Website***

- REVIEW AND SAVE

  This screen allows the installer to review each Wizard setting.
  - The up and down chevrons (**B**) can be used to review the previous settings, one section at a time.
  - If ***Edit*** (**C**) is pressed, the Wizard jumps to the Configuration screen that was shown with the up and down chevrons. Navigation proceeds as shown on the previous pages.
  - ***Save*** (**A**) presents additional options.
    - ***Save and exit*** saves the data, then exits the Wizard with the message ***Your changes are saved***. The display returns to the Home screen. If a USB drive is inserted when ***Save and exit*** is selected, the message ***Please confirm "you would like to save these settings to the USB drive also"***? will appear. If ***Yes*** is selected, the files are copied to the USB drive and the message ***Config files copied to USB drive*** appears. If ***No*** is selected, the display returns to the Home screen.
    - ***Discard and exit***: Any changes made in the Wizard are discarded. The display shows ***Changes discarded successfully*** and returns to the home screen.
    - ***Back*** returns the user to the review page and allows the user to stay in the Wizard and continue editing.



Home Screen

The Home screen is the entry point for all SkyBox monitoring.

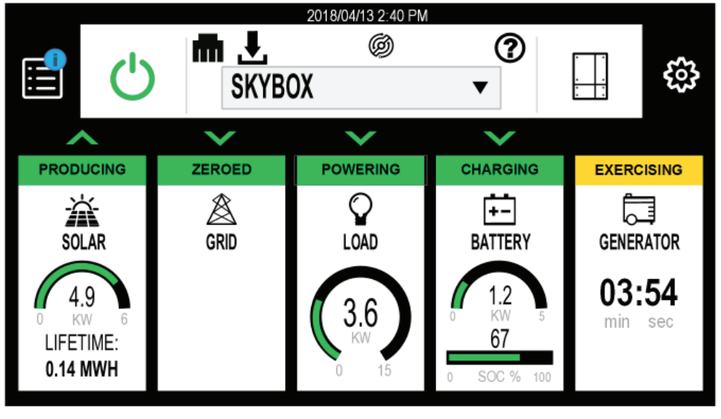
- The items along the top, the **Buttons**, allow access to status messages, notifications, and settings for one or all SkyBoxes.
  - The white box at the top represents the physical SkyBox(es) and contains direct SkyBox commands.
- The central items, the **Tiles**, show real-time data for different aspects of the system. Tapping a tile allows access to status messages, historical data, and settings. The tiles have several common features.
  - **Banner**. This appears at the top of each tile and includes a status message. The banner color also indicates general status.
  - **Chevron**. This appears above each tile. It is only present when the item in the tile is active. It may point either upward or downward. The chevron will point downward when power flows to that item (solar, battery, etc.). It will point upward when the item contributes power.

  Tile color codes :

  - Green — Item is in use and functioning normally
  - Yellow — Item is functioning normally in an alternate mode or state from that indicated by green
  - Black — Item is turned off and awaiting manual activation
  - Gray — Item is not available or not present
  - Red — Item is faulted and cannot be activated until the fault is corrected

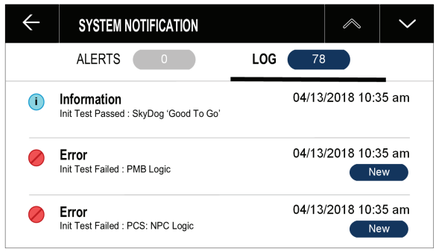
These color codes apply to both the banners, the chevrons, and the meter bars shown on many tiles.

The specific features of each tile are described in the **Tiles** section beginning on page 22.



900-0211-01-00 Rev A

System Notification Button (A)



Tapping this button opens the ***System Notification*** screen. It contains two tabs: **Alerts** and **Logs**, with a historical record of up to 50 events.

A Log is simply a record of a change in SkyBox status. An Alert is a condition that may occur during normal operation and may need monitoring. Alerts also include error messages that accompany shutdown faults. (See page 15 and the *SkyBox Overview Guide* for more information.)

Off/On Button (B)

This button controls all SkyBox functions. Tapping it will turn these functions on or off. This includes the inverting (load) function, connection to the utility grid or generator, PV harvest, and any selling or charging. The present state is indicated by the color.

- Green — ON. Tapping the button will change to OFF.
- Black — OFF. Tapping the button will change to ON.
- Yellow — Partial operation due to faults. Tapping the button opens the ***Inverter Fault Status*** page. See page 13. If the SkyBox is turned off from this state, the button turns red (shutdown with faults).
- Red — SkyBox has shut down with faults. Tapping the button brings up a command to clear all faults. See page 13.
- Gray — SkyBox has shut down and is unable to restart. The ***System Notification*** screen **A** may have more information.

See the **Troubleshooting** and **Rapid Shutdown** sections of the *SkyBox Overview Guide* for more information.

Network Button (C)

A black icon means communications are normal. Red indicates the RJ45 cable is present but no connection is established. Yellow indicates a partial connection. Tapping this button opens the **NETWORK** tab (see page 20).

Firmware Update Button (D)

If this button is present, a firmware update is available. The button will not be present if no update is available. Tapping this button opens the **FIRMWARE** tab (see page 21).

OPTICS RE Button (E)

Tapping this red button opens the ***OPTICS RE*** section of the **NETWORK** tab (see page 20).

Time and Date (F)

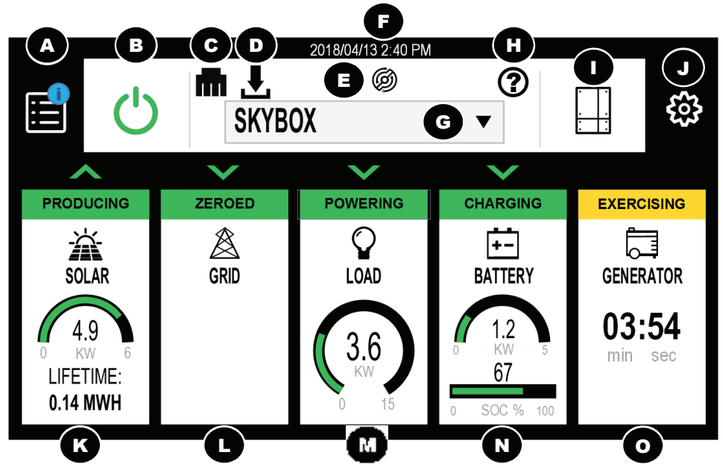
This is not a button, but a display. It uses the settings in the **REGIONAL** tab (see page 19).

SkyBox Select Button (G)

This drop represents the currently viewed SkyBox unit. See page 14.

Tapping this button, then tapping any other item on the screen, brings up a definition of that item. This mode is disabled by tapping the button again.

900-0211-01-00 Rev A



Information Button (H)

Tapping this button, then tapping any other item on the screen, brings up a definition of that item. This mode is disabled by tapping the button again.

SkyBox Button (I)

Tapping this button opens the SkyBox Status screen. See page 14.

Settings Button (J)

Tapping this button opens the ***Global Settings*** series of screens. Global settings affect the system as a whole as well as the GUI, network communications, and other large-scale settings. See page 17.

Solar Tile (K)

This tile and its screens summarize data (historical and real-time) regarding PV harvest. Information on lifetime production is available here. These screens also contain access to PV settings. See page 22.

Grid Tile (L)

This tile and its screens summarize data (historical and real-time) regarding power bought from, or sold to, the utility grid. Information on grid performance is located here. These screens also contain access to grid connection settings and required grid-interactive settings. See page 24.

Load Tile (M)

This tile and its screens summarize data (historical and real-time) regarding power being used to sustain loads. Information is located here on load performance for both the L1 and L2 lines. These screens also contain access to load management settings. See page 34 .

Battery Tile (N)

This tile and its screens summarize data (historical and real-time) regarding battery status and state of charge. Information can be tracked for multiple independent battery banks. These screens also contain access to charger settings and battery specifications. See page 36.

Generator Tile (O)

This tile and its screens summarize data (historical and real-time) regarding generator operation. The advanced generator start function (AGS) is managed here. The screens also contain access to generator settings and specifications. See page 46.

SKYBOX ▼

SkyBox Select Button

The ***SkyBox Select*** dropdown menu (**D** on page 13) allows general viewing of a specific SkyBox or viewing of all units.

When multiple units are stacked (networked) together in one system, the pointer ▼ presents a dropdown list of all units by name. When a selection is made, it sets the five Home Screen **Tiles** to display the solar, grid, and related properties associated with that particular SkyBox.

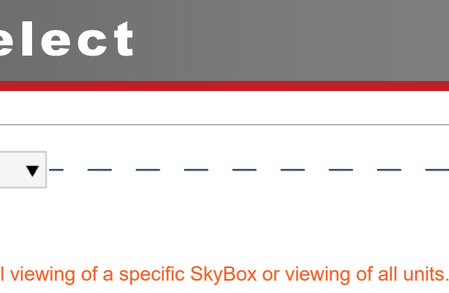
The ***System Name*** that was applied to each SkyBox in the Setup Wizard (see page 3) is used to identify them in the dropdown list. A ***System Name*** should be unique to each unit. These names can be changed under the **System** tab (see page 18).

SkyBox Button

SkyBox Status Screen

Tapping the **SkyBox** button (**E** on page 13) brings up the ***SkyBox Status*** screens. The first page has a history graph for the full SkyBox system (showing either positive or negative kilowatts) with daily behavior of the following items:

- Green SOLAR
- Red GRID
- Blue LOAD
- Yellow BATTERY
- Pink STATE OF CHARGE
- Purple GENERATOR



Solar, grid, load and generator output are measured in kilowatts. The batteries are measured in kilowatt-hours (the net daily production) and percentage (the present state of charge or SOC).

Each line on the graph is also represented as a real-time measurement at the bottom of the screen in the same color. Tapping each measurement hides that item in the graph, or restores it if it has been hidden.

System Info

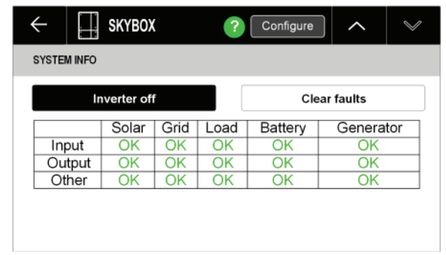
The chevrons bring up the ***SYSTEM INFO*** screen **B** (for the unit specified in the ***SkyBox Select*** dropdown) with:

- ***System name —*** Default is **SkyBox**. (See page 18.)
- ***Current Status***
  - ***Normal —*** unit operating normally.
  - ***Over temperature —*** unit has been derated due to high temperature.
  - ***Faulted —*** unit may be off (red symbol) or still running (yellow symbol) depending on fault.
  - ***Off —*** all SkyBox functions have been turned off with the **Off/On** button (see page 12) or the **Inverter off** button (see below).
- Unit model number
- Unit serial number

B

Inverter Fault Status

Pressing the chevrons again brings up the ***Inverter Fault Status*** screen **C**. This screen is also accessed by pressing the **Off/On** button when it is yellow. (See page 12.)



C

- **Inverter off** button

  This disables the inverting (load) function, connection to the utility grid or generator, PV harvest, and any selling or charging. When pressed, the **Off/On** button turns white (**OFF**). This does not clear a fault condition. If the button was previously in the yellow (partial operation) state, it will turn red (shutdown with faults).

- **Clear faults** button

  This attempts to reset all items indicated in the table. When pressed, the SkyBox will attempt to clear all faults and return to the appropriate operation. Faults may fail to clear if the fault condition is still present.

- **Faults table**

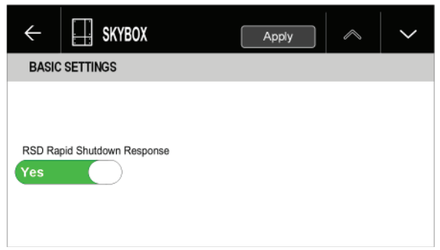
  This table shows coded values. Fault codes here indicate problems with either the input, output, or another aspect of the solar, grid, load, battery, or generator parts of the system. To identify a fault code, contact OutBack Power through one of the methods listed on the website, www.outbackpower.com.

See the next page for the **Configure** button **A**.

900-0211-01-00 Rev A

Basic Settings

The **Configure** button (**A** from the previous page) leads to the AC setup screen. An **Edit** button is available to change these settings. (See page 17). Once placed in Edit mode, the screen appears as shown in the image to the right.



The user can select the connections which will be keyed to a Rapid Shutdown signal, if present. The user can also select the functions of the SkyBox **Aux** terminals.

- ***Nominal AC output voltage (Vac)*** — Setting: ***100/200 Vac***. No other selections are available at this time.
- ***Nominal frequency*** — Range: ***60 Hz*** or ***50 Hz***. Default: ***60 Hz***
- ***RSD (rapid shutdown response)*** — Range: ***PV*** or ***PV and AC***. Default: ***PV***

  When Rapid Shutdown is used, this controls which parts of the SkyBox are shut down. The ***PV*** setting shuts down only the solar charging. The ***PV and AC*** setting shuts down all SkyBox input and output. After a Rapid Shutdown event, the SkyBox will be unable to be turned on until the condition is cleared.

  More information is available in the **Rapid Shutdown** section of the *SkyBox Overview Guide*.

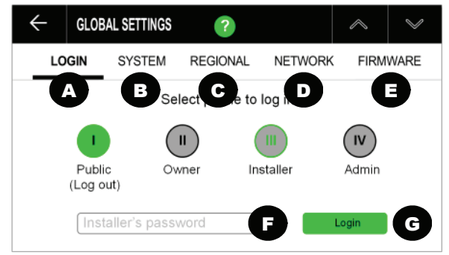
- ***12-volt AUX terminal*** — Range: ***Off***, ***AGS***, ***Rapid Shutdown***
  - ***Off***: The **Aux** contacts do not sent a signal.
  - ***AGS***: The contacts send a 12 Vdc signal to start a generator according to the ***Advanced Generator Start*** settings on page 52.
  - ***Rapid Shutdown***: The contacts deliver a 12 Vdc signal to communicate that a Rapid Shutdown has occurred. The OutBack Rapid Shutdown Initiator (RSI) has terminals to receive this signal.
- ***Dry contact AUX terminal*** — Range: ***Off***, ***AGS***, ***Rapid Shutdown***
  - ***Off***: The **Aux** contacts remain open.
  - ***AGS***: The contacts close to start a generator according to the ***Advanced Generator Start*** settings on page 52.
  - ***Rapid Shutdown***: The contacts close to communicate that a Rapid Shutdown has occurred. The OutBack Rapid Shutdown Initiator (RSI) has terminals to receive this signal.

Settings Button

Tapping this button (**F** from page 13) opens the Global Settings series of screens. Global settings affect the system as a whole as well as the GUI, network communications, and other large-scale settings.

NOTE: This button does not access settings for the charger, PV, etc. See the **Tiles** beginning on page 22.

This menu shows several tabs accessing different categories. Tapping the **Settings** button brings up the first tab, **LOGIN** .



LOGIN Tab (A)

This screen allows access to higher-level profiles for access to restricted settings or functions. A password is required for each profile. (See page 9 and page 18.) This book assumes the user is logged into ***Installer***. The items on the following pages assume this profile is in use. Without logging in, the available options are limited to the ***Public*** selection.

Public (I) (default):

- Can view status screens, configuration items, logs/alerts
- Has access to the inverting function and generator on/off
- Can clear faults

Installer (III):

- Can perform all actions shown in ***Public*** or ***Owner***
- Has access to Setup Wizard
- Has access to all Configuration items
- Can change ***Installer*** password

Owner (II)

- Can perform all actions shown in ***Public***
- Has access to all action buttons on status screens
- Can change ***Owner*** password
- Can install firmware updates

Admin (IV):

- For OutBack use only

Password

Selecting ***Owner*** (II) or ***Installer*** (III) causes that profile button to be outlined in green. A ***Password*** field **F** and a **Login** button **G** will appear. To enter the password, tap anywhere within **F**. This will bring up a simulated keyboard where the password can be typed. Once completed, tapping the **Done** key will return to the **Login** screen. Tap **G** to complete the process. **F** and **G** will disappear. The profile button will turn solid green to show successful login.

Selecting ***Public*** (I) will log the system out of any other profile.

Edit Button

Many screens, including **Configure** button screens, have an **Edit** button which puts the screen into a mode where settings can be changed. The user must log in to the ***Installer*** profile to change settings. If not already logged in, pressing the **Edit** button jumps to a version of the screen above to prompt the logging process.

Screen items are depicted differently than usual in Edit mode, with pop-up or drop-down menus as well as selectable ***On/Off*** or ***Yes/No*** items. Most screens in this book are shown in Edit mode.

900-0211-01-00 Rev A

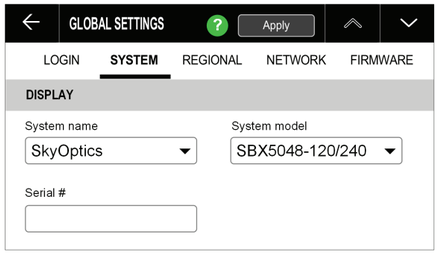
FOR NEXT FIRMWARE REVISION.

- ***120 degree phase operation*** — Range: ***Enable*** or ***Disable***. Default: ***Disable***

The down chevron ⌄ proceeds to the setup screen for AC current transducers. The user can select the CT type and rated current. The phase shift and turns ratio can also be specified.

SYSTEM Tab (B)

The **SYSTEM** tab opens several screens showing items of system settings and information. The first few screens are titled ***DISPLAY*** (shown in Edit mode).



- ***System name*** — can be entered. This is a required field. Other settings in this menu cannot be saved unless an entry is made here.
- ***System model*** — display only, not settable
- ***Serial #*** — display only, not settable
- ***Display timeout (minutes)*** — Range: ***Never***, ***1***, ***2***, ***5***, ***15***. Default: ***5***.
- ***Login timeout (minutes)*** — same as above. Default: ***5***.
- Display ***Brightness*** — Range: ***1*** to ***10***. Default: ***10.***

The down chevron ⌄ proceeds to the configuration settings screen ***BACKUP AND RESTORE***. This screen is only visible in Edit mode. Otherwise the down chevron ⌄ proceeds to ***SECURITY*** (see below).

- ***Load configuration from USB*** — brings up several prompts regarding overwriting the present set of files and inserting a USB drive.
- ***Save configuration to USB*** — brings up several prompts regarding overwriting the present set of files and inserting a USB drive.
- ***Reset to factory defaults*** — brings up a prompt to confirm the reset of all settings. Once this is confirmed and the reset takes place, another prompt will acknowledge that all items were reset.
- ***Re-run Wizard*** — immediately brings up the first screen of the Setup Wizard so that settings can be quickly updated. (See page 2.)

  NOTE: This option is not available when logging in remotely.

The down chevron ⌄ proceeds to the ***SECURITY*** screen.

- ***Change Owner Password*** — Clicking ***Change*** brings up several additional fields for the new and old passwords. The default ***Owner Password*** is **1234**.
- ***Change Installer Password*** — Clicking ***Change*** brings up several additional fields for the new and old passwords. The default ***Installer Password*** is **1234**.

IMPORTANT:

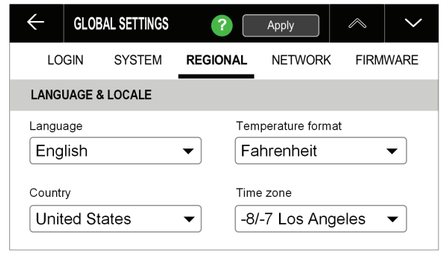
If the Installer password is left at the default setting, this will permit the end user to have configuration access. Installers who wish to restrict access must update this password.

The down chevron ⌄ proceeds to the ***REMOTE SECURITY*** screen for logging in remotely using a computer.

- ***Enable remote login*** — Range: ***Yes*** or ***No***. Default: ***No***.
- ***Change Remote Login Password*** — Clicking ***Change*** brings up several additional fields for the new and old passwords. This is only selectable if ***Enable remote login*** is set to ***Yes***.

REGIONAL Tab (C)

The **REGIONAL** tab opens several screens showing settings that are customizable to a geographic area. All items are settable. The first screen is ***LANGUAGE & LOCALE*** (shown in Edit mode).



NOTE: The ***Country*** and ***Time Zone*** fields have too many options to list here.

- ***Language*** — Range: ***English***. Other languages will be added in the future.
- ***Temperature format*** — Range: ***Celsius*** or ***Fahrenheit***. Default: ***Fahrenheit***.
- ***Country*** — Default: ***United States***.
- ***Time zone*** — Default: ***-8/-7 Los Angeles UTC***.

  NOTE: ***Time zone*** cannot be entered unless ***Country*** is selected.

The down chevron ⌄ proceeds to ***DATE & TIME***.

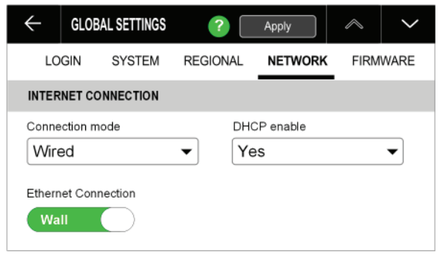
- ***Date format*** — Range: ***YYYY/MM/DD***, ***MM/DD/YYYY***, ***DD/MM/YYYY***. Default: ***YYYY/MM/DD***.
- ***Date*** — can be entered in the format selected above.
- ***Time format*** — Range: ***12HR*** or ***24HR***. Default: ***12HR***.
- ***Time*** — can be entered in the format selected above.

The down chevron ⌄ proceeds to ***INTERNET TIME***. This selection (defaulted to ***Yes***) allows the time to be set automatically.

900-0211-01-00 Rev A

NETWORK Tab (D)

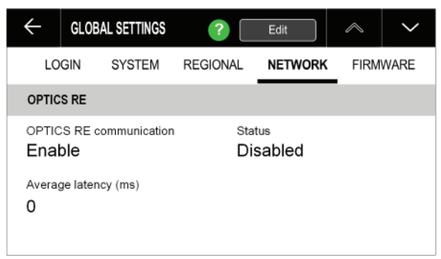
The **NETWORK** tab opens several network communication setting screens. Some items are settable, while others are automatically populated when an internet connection is made. The first few screens are all titled ***INTERNET CONNECTION*** (shown in Edit mode):



- ***Communication mode*** — Range: ***Disabled*** or ***Wired***. Default: ***Wired***
- ***DHCP enable*** — Range: ***Yes*** or ***No***. Default: ***Yes***
- ***Ethernet Connection*** — Range: ***Wall*** or ***SkyBox***. Default: ***Wall***
  - ***Wall*** is used when the SkyBox is connected to an external network or online.
  - ***SkyBox*** is used when multiple SkyBoxes are stacked in parallel. This setting indicates that the network port is being used to connect to another SkyBox.

The down chevron ⌄ proceeds to the second and third screens with these options. The first five items will be automatically populated if ***DHCP enable*** is set to ***Yes***. If it is set to ***No***, they can be manually populated.

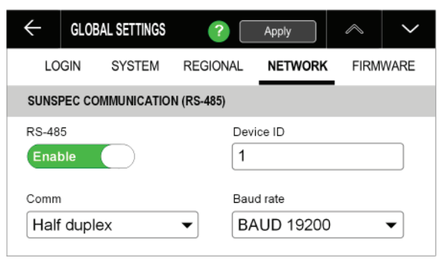
- ***IP address***
- ***Subnet mask***
- ***Gateway***
- ***Primary DNS***
- ***Secondary DNS***
- ***Automatic port forwarding UPnP*** — Range: ***Enable*** or ***Disable***. Default: ***Enable***
- ***UPnP port number*** — Range: ***1025*** to ***65535***. Default: ***3000***



The down chevron ⌄ proceeds to the ***OPTICS RE*** screen.

- ***OPTICS RE communication*** — Range: ***Enable*** or ***Disable***. Default: ***Enable***

The down chevron ⌄ proceeds to several screens for communication using the SunSpec protocol. All screens are titled ***SUNSPEC COMMUNICATION (RS-485)***.



- ***RS-485*** — Range: ***Enable*** or ***Disable***. Default: ***Disable***
- ***Device ID*** — Range: ***1*** to ***255***. Default: ***1***
- ***Comm — Half duplex***
- ***Baud rate —*** Range: ***BAUD 9600***, ***BAUD 19200***, or ***BAUD 38400***. Default: ***BAUD 9600***.

The down chevron ⌄ proceeds to the second SunSpec screen with these options.

- ***Parity bit*** — Range: ***None*** or ***Even***. Default: ***Even***
- ***Stop bits*** — Range: ***1*** or ***2***. Default: ***1***
- ***Data bits*** — ***8***

The down chevron ⌄ proceeds to the third SunSpec screen with these options.

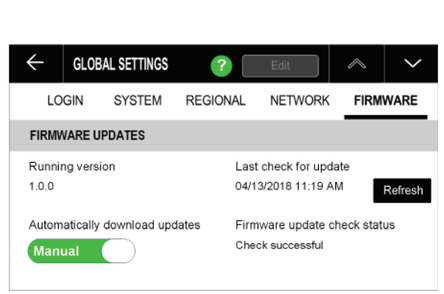
- ***TCP/IP***— Range: ***Enable*** or ***Disable***. Default: ***Disable***
- ***Port*** — Default: ***502***

FIRMWARE Tab (E)

The **FIRMWARE** tab opens several screens showing the current firmware revision. It allows updates to be downloaded from a server or a USB drive (see page 2).

NOTES:

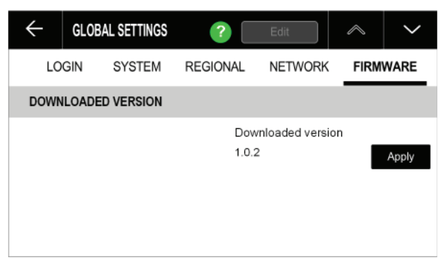
- These screens do not have an Edit mode. The **Edit** button is disabled.
- Grid power must be connected to perform an update.
- When using a USB drive, the file to be imported cannot be compressed or located in a subfolder. It must be in the root directory.



The first screen is ***FIRMWARE UPDATES***.

- ***Running version*** — display only, not settable
- ***Last check for update*** — displays the last time performed. Clicking **Refresh** prompts another update and resets this field.
- Automatically download updates — Range: ***Manual*** or ***Auto***. Default: ***Manual***.

The down chevron ⌄ proceeds to ***DOWNLOADED VERSION***. The following items will be shown below the title bar:



- ***Download version*** —
- ***Last known good version*** —
- If a USB drive is installed, ***Local drive detected*** will appear.

After pressing **Download**, the button changes to **Apply** and ***Downloaded version*** appears below the bar. If a USB drive was inserted, this screen will appear immediately instead of **Download**.

After pressing **Apply**, a confirmation screen will appear. Upon acceptance, the message ***Installing Firmware Update*** will appear (along with a reminder that the grid must remain connected). It will return to the Home screen when complete.

NOTE: While applying the new revision, the system will restart. Power to the loads will be interrupted.

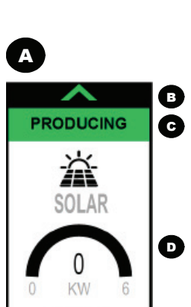
FOR NEXT FIRMWARE REVISION.

NOTE: Up to ten SkyBoxes may be stacked in parallel. The number of units

SOLAR Tile

The SkyBox harvests photovoltaic (PV) energy from a designated PV array using maximum power point tracking (MPPT) technology. This energy can be used by the batteries to run loads for battery charging, for grid-tied activity, or for other purposes.

- For loads, see page 34.
- For battery charging, see page 36.
- For grid-tied activity, see page 24.



The Home screen **SOLAR** tile **A** has several PV status indicators. The colors of each indicator use the same general key shown in the **Tile** section on page 9.

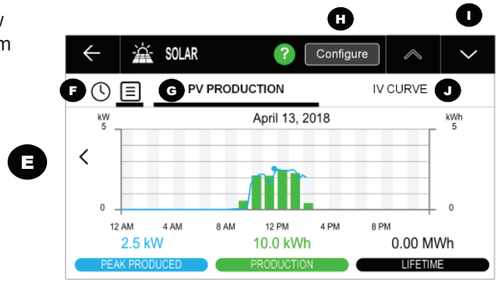
- The chevron **B** points to the SkyBox to show that PV energy is being harvested. This chevron is only present when the status of **C** is ***PRODUCING***.
- Message **C** displays the specific status of the SkyBox PV input (also noted by the color).
  - NONE (gray): The system was not configured with a PV array and one has not been detected.
  - SLEEPING (gray): The PV is not generating sufficient voltage to activate the input (the isolation relay).
  - TESTING (yellow): The SkyBox is performing a ground fault, arc fault, or impedance test prior to ***SWEEPING***.
  - SWEEPING (yellow): The SkyBox is performing an MPPT sweep prior to harvesting PV energy.
  - WAITING (green): PV energy is available but the SkyBox is unable to export it. The grid may be disconnected. The loads may be disconnected. The battery may be fully charged.
  - PRODUCING (green): PV energy is available and being used (see **D**). The chevron in **B** points upward.
  - FAULT (red): The array is in a fault condition, which must be cleared before proceeding.
- Item **D** is a circular meter which advances clockwise to show the PV input (***PRODUCING***) in kilowatts (kW). The maximum power that the SkyBox can harvest is 5 kW. The production is also displayed as a digit in the center.

Status

Tapping the **SOLAR** tile **A** opens **E**. In screen **E**, the **PV PRODUCTION** tab **G** is the default view. It shows:

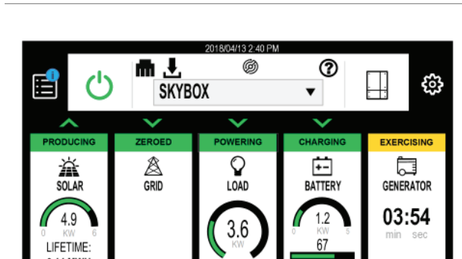
- Peak kilowatts (kW) output that day.
  - This is graphed with a blue line.
  - A blue dot marks the instantaneous peak.
- Kilowatt-hours (kWh) produced that day.
  - This is graphed with green bars.
- Lifetime megawatt-hours (MWh) produced.
- Displays for other days are available.

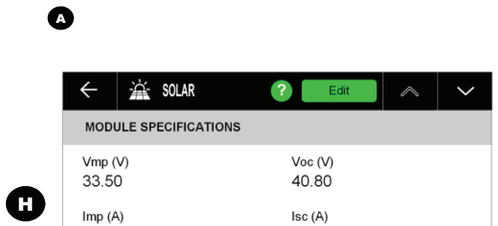
NOTE: Most of these items are graphed by time of day. The peak value for each is also shown as a number. Tapping a colored bar at the bottom of the screen will hide that number and graph, or restore it.



Historical Display

In screen **E**, tapping the clock symbol **F** changes the graph to a historical display (not depicted here) showing daily, weekly, monthly, or yearly production for a selected range of dates.





Configuration

The **Configure** button **H** opens several screens with PV module and array specifications.

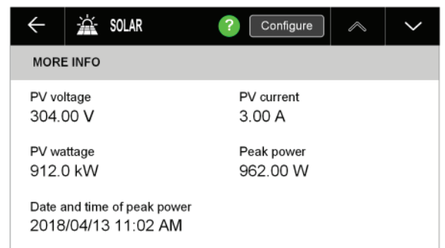
These values can be changed using the **Edit** button. They should be populated with values provided by the module manufacturer. They include

- ***V_{mp} (V)*** — Range: ***24*** to ***100***. Default: ***33.5***
- ***V_{oc} (V)*** — Range: ***25*** to ***100***. Default: ***40.8***
- ***I_{mp} (A)*** — Range: ***0*** to ***30***. Default: ***7.75***
- ***I_{sc} (A)*** — Range: ***0*** to ***30***. Default: ***8.25***
- ***P_{mp} (W)*** — Range: ***0*** to ***30***. Default: ***260***
- ***Module Type*** — Range: ***Monocrystalline***, ***Polycrystalline***, or ***Thin film***. Default: ***Monocrystalline***
- ***Number of parallel strings*** — Range: ***1*** to ***10***. Default: ***2***
- ***Number of modules in series per string*** — Range: ***5*** to ***30***. Default: ***12***
- ***Array size*** — Default: ***5***

In screen **E**, tapping the "down" chevron opens several ***MORE INFO*** screens (**I**) with:

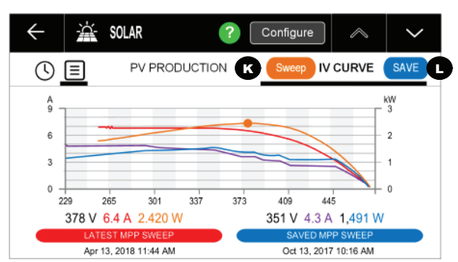
- The present level of PV voltage, current, and power harvested.
- The system's peak PV power and the time and date harvested.
- The system's highest V_{oc} and the time and date measured.

These are followed by an ***IRD***, ***GFDI***, and ***AFCI TEST*** screen. See the *Overview Guide* for more information on self-testing.



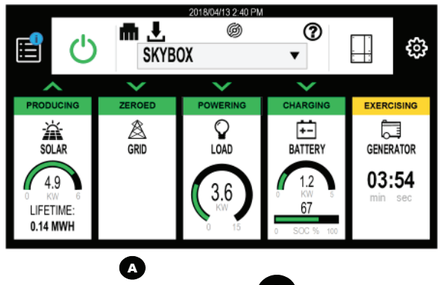
Tapping the **IV CURVE** tab **J** opens a view with current / voltage (I-V) curves for MPPT. It also displays measurements for V_{mp}, I_{mp}, and P_{mp}.

- The red and orange displays show the most recent MPPT sweep. Red indicates the current curve while orange indicates power. Voltage is displayed at the bottom of the graph. The orange dot shows the maximum power point. The purple and blue displays are a previous MPPT sweep that was saved for comparison.
- Tapping a colored bar at the bottom of the screen will hide that number and graph, or restore it.
- The **Sweep** button **K** forces the SkyBox to perform a new MPPT sweep after showing a confirmation screen. This replaces the most recent sweep on the screen.
- The **SAVE** button **L** saves the present sweep to memory after showing a confirmation screen. This replaces any sweep that was previously saved. Only one sweep can be saved at a time.



900-0211-01-00 Rev A

GRID Tile



The SkyBox connects to the utility grid to charge batteries and run loads using the transfer circuit. It can also sell to the grid, or interact with the grid in other ways if sell-back is not permitted.

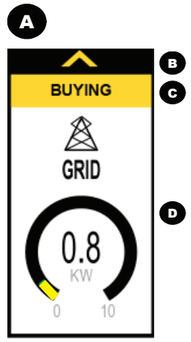
NOTE: The messages in this section assume that the utility grid, not another AC source, is connected to the appropriate input.

- For the transfer function, see page 24.
- For battery charging, see page 36.

The Home screen **GRID** tile **A** has several grid status indicators. The colors of each indicator use the same general key shown in the **Tile** section on page 9.

- The chevron **B** shows that the SkyBox is either buying or selling.
  - Chevron aimed upward: Buying more than 100 watts (see below).
  - Chevron aimed downward: Selling more than 100 watts (see below).

  NOTE: This chevron is only present when the status message **C** is ***Buying*** or ***Selling***.
- Message **C** displays the specific status of the SkyBox grid input (also noted by the color).
  - OFF GRID (gray): The grid is disconnected.
  - OUT OF SPEC (gray): The grid is outside the grid protection parameter boundaries.
  - WAITING (green): The grid is within the input range but the connection timer is still running. In the United States, grid-interactive installations usually require a duration of 5 minutes or more. The timer is depicted onscreen.
  - ZEROED (green): The SkyBox is minimizing grid input with the GridZero function. (See page 29.)
  - DROPPED (gray): The grid is available but is intentionally not being used. The user, or the programmed settings, have issued a command to disconnect the SkyBox.
  - CONNECTED (green): The SkyBox is connected to the grid. Total activity is less than 100 watts (bought or sold).
  - BUYING (yellow): More than 100 watts of power is being taken from the grid. The chevron in **B** points upward.
  - SELLING (green): More than 100 watts of power is being sold to the grid. The chevron in **B** points downward.
- Item **D** is a circular meter which advances clockwise to show the power measured by the **GRID** terminals (bought or sold) in kilowatts (kW). The meter is fully lit when the SkyBox reaches full capacity (10 kW when ***BUYING***, 5 kW when ***SELLING***). The production is also displayed as a digit in the center.



NOTE:

When current transducers are in use, the reading on the **GRID** tile automatically shows the CT measurement rather than the measurement made at the **GRID** terminals. See page 16.

900-0211-01-00 Rev A

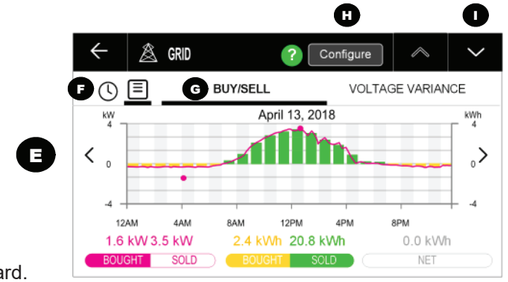
Status

Tapping the **GRID** tile **A** opens **E**.

In screen **E**, the **BUY/SELL** tab **G** is the default view. It shows:

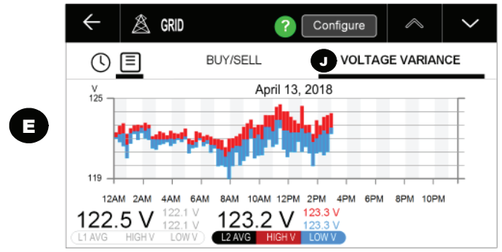
- Peak kilowatts (kW) either bought or sold that day.
  - This is graphed with a pink line.
  - Pink dots mark the peaks of buying and selling.
- Kilowatt-hours (kWh) accumulated (both bought and sold) that day.
  - Power bought is graphed by yellow bars that expand downward.
  - Power sold is graphed by green bars that expand upward.
- Net daily kWh accumulated. This is not graphed.

  NOTE: These items are graphed by time of day. The peak value for each is also shown as a number. Tapping a colored bar at the bottom of the screen will hide that number and graph, or restore it. When the **NET** display is tapped, it replaces the daily accumulated graph.
- Displays for other days are available.



The "down" chevron **I** opens a ***MORE INFO*** screen with additional information on grid interaction. See page 26.

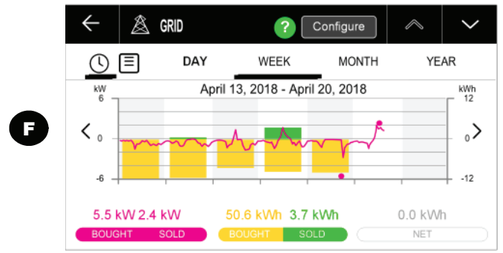
In screen **E**, tapping the **VOLTAGE VARIANCE** tab **J** opens a view with average high and low AC voltages on the utility grid L1 and L2 phases. These readings are only for the present day.



The **Configure** button **H** opens a series of of configuration screens for SkyBox grid acceptance. See page 27.

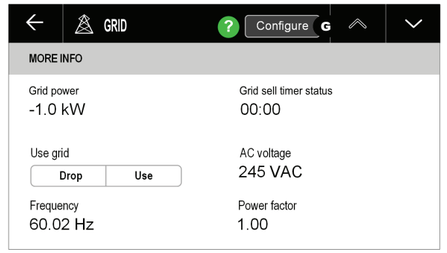
Historical Display

In screen **E**, tapping the clock symbol **F** changes the graph to a historical display showing daily, weekly, monthly, or yearly buying and selling for a selected date range.



More Info

From page 25, the "down" chevron **I** opens a ***MORE INFO*** screen with:



I

- ***Grid power***
  The present grid power handled by the SkyBox.
  Positive numbers indicate power sold to the grid.
  Negative numbers indicate power bought.
- ***Grid sell timer status***
  The present reading on the grid connection timer.
- ***Use grid***
  A command telling the SkyBox to either ***Drop*** or ***Use*** the grid.

  NOTES

  - ***Use*** instructs the SkyBox to follow its programmed usage instructions. It may still drop the grid based on various conditions. (See the following pages.)
  - ***Drop*** is a forced condition that is not normally overridden. The SkyBox will not reconnect to the grid unless the batteries reach ***Low Battery Cut-Out*** or ***High Battery Cut-Out***. (See page 40.) These are emergency states requiring grid power for the SkyBox to keep operating.
- ***AC voltage***
  The present grid voltage.
- ***Frequency***
  The present grid frequency.
- ***Power factor***
  The immediate power factor reading presented to the grid across all phases (0.8 to 1.0).

Transfer Relay

CAUTION:
Equipment Damage

Current draw in excess of the transfer relay rating can damage the relay. This is not covered by warranty. Use appropriate-sized protective devices.

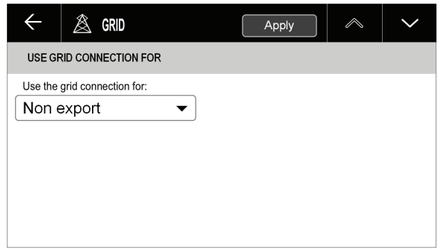
The SkyBox uses a mechanical transfer relay to alternate between the states of inverting and of accepting an AC source. The **GRID** and **GEN** terminals have separate, independent relays. Until the relay energizes, the **GRID** terminals are electrically isolated from the **LOAD**. When it closes, the **GRID** and **LOAD** terminals become electrically common. (The **GEN** terminals remain isolated.) When the relay changes states, the physical transfer delay is is fast as 20 milliseconds.

The relay contacts are limited to 60 Aac per phase or line. The continuous loads should never exceed this. When connected to an AC source, the SkyBox cannot limit the load current. The **GRID** or **LOAD** circuit breakers may trip.

See page 28 for a description of the conditions required for transfer.

Configuration

The **Configure** button **H** (also shown on page 25) opens a series of configuration screens for SkyBox acceptance of grid power. These values can be changed using the **Edit** button. Once placed in Edit mode, the screen appears as shown in the image to the right.



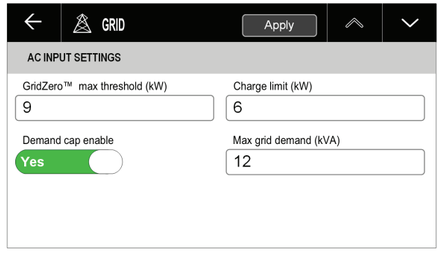
H

Grid Use

- ***Use the grid connection for —***
  - ***Net metering with backup***
  - ***Self consumption***
  - ***Non export***
  - ***Maximum independence***

  Default: ***Non export***
  The four major AC profiles. See page 30 to page 33.

AC Input Settings

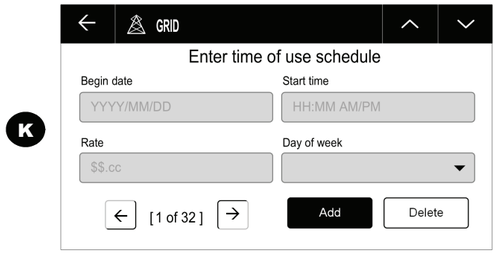


- ***GridZero™ max threshold (kW)*** — Range: ***1*** to ***50***. Default: ***4***
  The maximum level of AC inverting for GridZero operation. (See page 29.) Loads that exceed this threshold will be supported by the grid.
- ***Charge limit (kW)*** — Range: ***0*** to ***10***. Default: ***6***
  The maximum grid power used for charging the batteries.
  If set to zero, the SkyBox will never use the grid for charging.
  This is not the same as the ***Max charge (A)*** setting on page 41.
- ***Demand cap enable*** — ***Yes*** or ***No***. Default: ***No.***
  This enables the support function. The SkyBox uses battery energy to support loads that exceed the ***Max grid demand*** setting. See the **Setup Wizard** and ***Demand charges apply to maximum kW peaks*** on page 5.
- ***Max grid demand (kVA)*** — Range: ***0*** to ***14***. Default: ***12***
  The limit on the total draw on the grid (loads and battery charging). When this number is exceeded, the SkyBox will reduce charging to support the loads. If it is still exceeded, power will be removed from batteries and PV to support the loads.

900-0211-01-00 Rev A

Time of Use

Continuing to press the "down" chevron **I** brings up settings for the **Time of Use** function (**K**).



K

- ***Enable time of use rates*** — ***Yes*** or ***No***.
  Default: ***No***

  This enables the **Time of Use** function. When the cost of grid energy exceeds the cost of battery energy, the SkyBox uses the GridZero function to displace grid use with battery energy. See the **Setup Wizard** and ***Cost of Energy (kWh) varies throughout the day*** on page 5.
- ***Modify time of use***. This is only enabled if the previous item is set to ***Yes***. When enabled, the user can bring up ***Enter time of use schedule*** to set the appropriate times and rates.
- ***Cost of energy per kWh (flat rate)***. This is the rate in cents/kWh during the interval. Use the lowest baseline electric rate for power purchased from the utility. This rate is used whenever there is a gap in the **Time of Use** scheduled programming.

Grid Input

When the SkyBox **GRID** terminals are connected to a grid-quality AC source and the SkyBox is turned on, the SkyBox will synchronize itself with the grid source and connect to it for one of the ***Grid Use*** AC profiles. Its transfer relay will engage, linking the **GRID** terminals directly with the **LOAD**. (See page 26.)

The SkyBox must wait for the standard grid-interactive delay period (usually 5 minutes or more) before it can connect to grid power at the same time as PV or battery sources. If grid is introduced before PV or battery sources, the SkyBox will close its relay and transfer **GRID** to **LOAD** immediately. However, it will not connect to the other sources until the delay timer expires. If the PV or battery are already connected when the grid is introduced, the SkyBox will not close the transfer relay until the delay timer expires.

To be accepted, the utility grid must meet certain parameters, notably voltage and frequency. Agreements for utilty interconnection may require other specified settings.

- When these conditions are met, the SkyBox will close its transfer relay and accept the grid.
- If the conditions are not met, the SkyBox will not accept the grid.
- When a grid outage or shutoff occurs during normal operation, the SkyBox will open the transfer relay. This isolates itself and the protected loads from the grid so that it may serve the loads from the battery if one is present.

The SkyBox has a separate **GEN** connection (see page 46). These independent connections are used for wiring to multiple AC sources. However, the SkyBox can only use one AC source at a time. If both connections are powered, the SkyBox automatically accepts **GRID**. It cannot accept **GEN** as long as **GRID** is active.

Grid Protection

From pages 23 and 25, the **Configure** button **H** opens a series of configuration screens **L** for SkyBox grid acceptance. Continuing to press the "down" chevron brings up settings for the **Grid Protection** function. These values can be changed using the **Edit** button. They should be populated with values appropriate for the operating mode? AC profile? and any grid interconnection agreements.

L

The first screen is the grid interconnection profile. This is the code or utility company regulation which specifies the following preloaded settings.

- ***Grid interconnection profile***
  - ***IEEE 1547 2003***
  - ***HECO 1***
  - ***HECO 2***
  - ***CA RULE 21***
  - ***CA RULE 21 LS & T***

  Default: ***IEEE 1547 2003***

  This selection is the code or utility company regulation for a given installation. Settings have been preloaded according to the grid interconnection requirements.

IMPORTANT:

Settings which have been changed from the (preloaded) factory default values are marked onscreen with an asterisk.
Grid interconnection settings should not be changed without permission from the utility company or the appropriate authorities.

- ***Reset to defaults***
  The **Reset** button resets all grid interconnection parameters to the default values (of the ***Grid interconnection profile*** selected above). **NOTE**: This button will erase any settings which have been customized. All customized grid interconnection settings (noted onscreen with asterisks) should be recorded.
- ***Sell limit (kW)*** — Range: ***1*** to ***5***. Default: ***5***
  This limits the amount of power which can be sold to the grid.

NOTE:

Following this screen is a series of grid protection settings. These should not normally be adjusted and are not depicted in this manual.

900-0211-01-00 Rev A

AC Profiles (General)

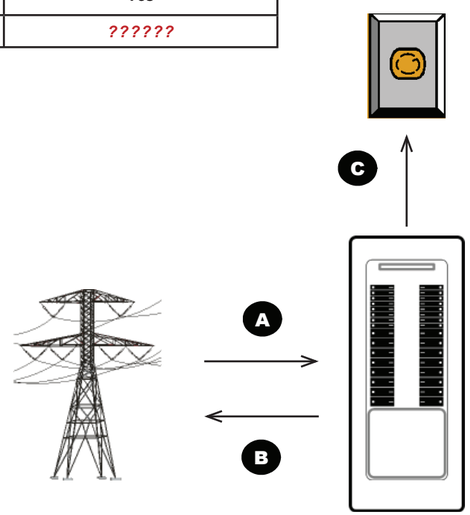
These selections assume the presence of a PV source, a battery bank, the utility grid, and a dedicated subpanel for critical loads connected to the SkyBox output terminals. Other applications are possible. The power flow to each of these elements is indicated by letters in the drawings below and on the next page.

In all AC profiles:

- When not using the grid, the SkyBox will create its own output waveform with energy from the battery bank and/or the PV array (**D** and **H**) to power loads (**I**).
- For all grid activities (buying or selling), the SkyBox uses the birectional terminals labeled **GRID**. (See the *SkyBox Quick Start Guide*.) Connection to the utility grid is controlled by the **Grid Protection** settings from page 29. An outage will cause the SkyBox to internally disconnect the **GRID** terminals and return to creating its own output. **E** and **F** are not permitted when disconnected. It will sweep periodically to detect when the grid returns to operation. (See **Transfer Relay** on page 26 and **Grid Input** on page 28.)
- Operation of local loads is permitted in addition to the critical load panel.

The four AC profiles and usages:

Parameters by AC Profile	Net Metering with Backup	Maximum Independence	Self-Consumption	Non-Export
Intent of AC profile	Support loads, sell to grid	Grid use is last resort only	Minimize grid use; utilize TOU metering	Support loads without selling
Default charge source	PV or grid	PV (only)	PV	PV
Battery usual state	Full SOC	Partial SOC	Partial SOC	Partial SOC
Charge limit (kW) (grid only)	0	0 (also disabled)	0	0
Demand Cap Enable (and ***Max Grid Demand***)	***Yes***	***No***	***Yes***	***Yes***
Enable time of use rates	***Yes***	***Yes***	***No***	***Yes***
Sell Limit (kW)	***5***	***??????***	***5***	***??????***



Net Metering with Backup

A net-metering agreement with the utility may be required to use this AC profile.

The SkyBox sends excess PV power to the loads (**G**). If additional PV power is available after that, the SkyBox sells it to the utility grid (**F** and **B**). The ***Sell limit (kW)*** setting (see page 29) affects this AC profile. Other loads on the main panel (**C)** may use the excess power as well.

The battery SoC is held at a high level (fully charged). This maximizes the days of autonomy during unforeseen grid outages. The SkyBox will maintain the battery SoC with PV power (**D**) if it is available. If not available, the SkyBox may charge the battery from the grid (**A** and **E**) regardless of the utility rate.

NOTES:

- ***Time of Use*** rates are enabled by default. (See page 28). When this function is enabled and the ***Cost of energy per kWh*** is greater than the battery ***Levelized cost of energy per kWh*** (see page 39), the SkyBox will only use PV power, not grid, to charge.
- The grid charging limit is set at zero by default. See page xx.

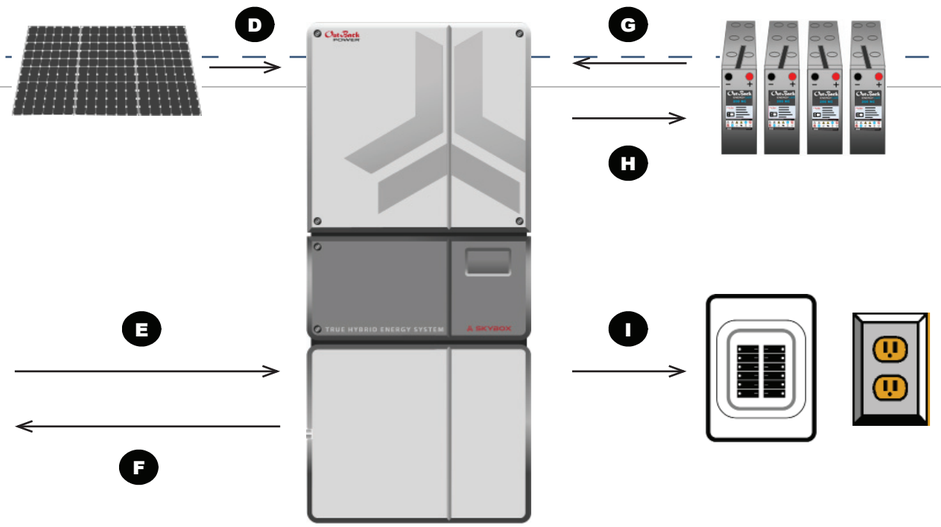
Maximum Independence

This AC profile does not permit the SkyBox to sell (export) power to the utility grid. Instead, the default operation is to be disconnected from the utility grid. If demand exceeds PV generation, the system will attempt to run on PV and battery-supplied power for as long as possible. When the batteries become depleted and reach the ***Minimum SOC (%)*** set point (see page 39), the system reconnects to the utility grid **E** to operate loads.

Recharging **H** is performed only with PV power. Grid power will be used to support the loads until the batteries reach 85% or more of maximum SOC. Upon recharging to the ***Maximum SOC (%)*** set point (see page 39), the SkyBox will disconnect from the grid. WHICH ONE????

NOTES:

- The PV array should be sized to meet the requirements for load and charging. It is possible, but not efficient, to operate with an undersized PV array. If the PV generation does not meet the load kWh or charging requirements, a different AC profile should be selected.
- Grid charging is not used in this AC profile. Charge Limit (kW) is disabled by default and cannot be enabled. See page xx.
- Need to identify if Sell Limit (kW) can be turned on manually even though it's defaulted to zero. Current evidence says yes.
-



AC Profiles (continued)

Self-Consumption

A net-metering agreement with the utility may be required to use this AC profile.

The goal of self-consumption is to displace as much of the utility usage as possible by serving critical loads with PV and battery power. (**D** and **G** are prioritized to supply **I**.) The SkyBox does not curtail PV production. This minimizes (or "zeroes") the grid use **A** and **E**, but excess generation is allowed to be sold to the utility **B** to avoid curtailing PV output. The ***Sell limit (kW)*** setting (see page 29) affects this AC profile. This AC profile allows charging from the grid, but this will reduce the effectiveness

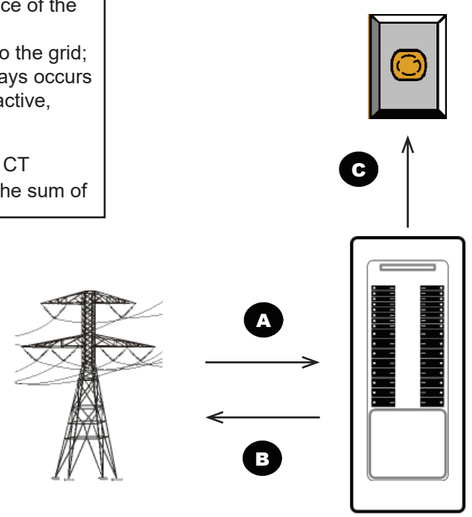
NOTES

- ***Time of Use*** rates are not used in this AC profile. That setting is disabled by default and cannot be enabled. See page xx.
- This AC profile allows charging from the grid, but this will reduce the effectiveness of **Self-Consumption**. The grid charging limit is set at zero by default. See page xx.

The SkyBox may also use one or more external current transducers (CT) to determine when PV production must be curtailed. The SkyBox can export power (**F**) to loads **C** on the main electrical service panel. Producing more power than used by these loads is prohibited.

A CT is placed on the main service input. Its readings take the place of the SkyBox onscreen readings at **E**/**F**.
The SkyBox is not allowed to produce enough power to sell back to the grid; the CT must always register a small amount of input so that **A** always occurs instead of **B**. (See the CT settings on page 12.) When the CT is active, the SkyBox will curtail PV production to prevent **B** from occurring.

When the CT is active, the reading on the **GRID** tile becomes the CT measurement (**A** or **B**). The reading on the **LOAD** tile becomes the sum of

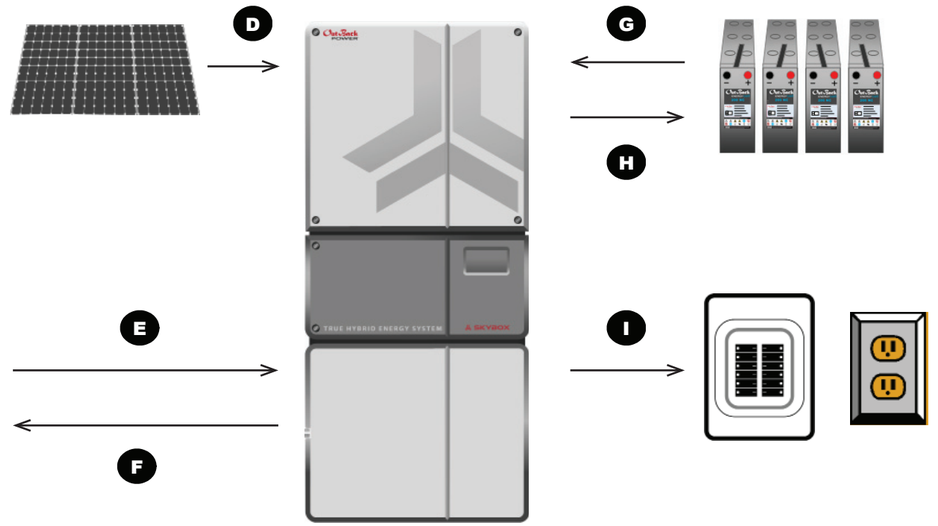


Non-Export

This AC profile does not permit the SkyBox to sell (export) power to the utility grid. Instead, grid usage is displaced by serving critical loads with PV and battery power. (**D** and **G** are prioritized to supply **I** and minimize grid use **A** and **E**.) The battery is charged with PV energy. If the loads are reduced and the battery is full,the SkyBox will curtail PV production **D** so that it it is always less than the load **I**.

NOTES

- In the above state, the SkyBox ensures a small amount of power is drawn from the grid at all times (**A**) to prevent **B** from occurring.
- If the SkyBox senses no load at **I**, the SkyBox will open the grid transfer relay at **F**, ensuring the renewable energy is not exported to the grid.
- ***Time of Use*** rates are enabled by default. See page xx.
- The grid charging limit is set at zero by default. See page xx.
- Need to identify if Sell Limit (kW) can be turned on manually even though it's defaulted to zero. Current evidence says yes.

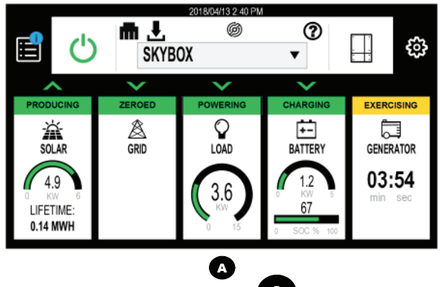


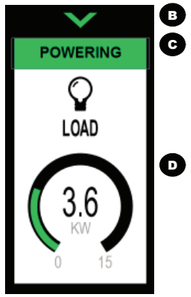
900-0211-01-00 Rev A

LOAD Tile

The SkyBox uses an inverting function to convert battery (DC) power to AC output. It can run loads in the absence of an AC source. If an AC source (utility grid or generator) is present, the SkyBox transfer relay will switch to run loads from the AC source.

The inverting function can also work with the utility grid. It can add PV and battery power to support loads (self-supply) if the grid connection is not large enough. It performs similar activity for the grid-interactive (sell-back) function.





- For the grid-interactive AC profiles, see page 30.
- For GridZero, see page 32.

The Home screen **LOAD** tile **A** has several load status indicators. The colors of each indicator use the same general key shown in the **Tile** section on page 9.

- The chevron **B** shows the status of SkyBox loads.
  - Chevron aimed downward: Sending power to loads (***POWERING***, ***SUPPORT***, or ***PASS THROUGH***).

  NOTE: This chevron is not present when no loads are present or configured.
- Message **C** displays the specific status of the SkyBox load functions (also noted by the color).
  - OFF (black): Loads are not being powered. The **Off/On** button (see page 12) is set to OFF.

  NOTE: The **Inverter Off/On** button is set to ON for all other status messages.
  - POWERING (green): Loads are being powered by the SkyBox.
  - SUPPORT (green): Loads up to the size of the ***Max Grid Demand (kW)*** setting are being powered by the AC source. (See page 27.) If additional power is needed, the SkyBox provides it from the PV and / or the batteries.
  - PASS THROUGH (yellow): Loads are being powered by the AC source.
- Item **D** is a circular meter which advances clockwise to show the power in kilowatts (kW) being handled by the **Load** terminals. The meter is fully lit when the SkyBox reaches full capacity (10 kW when ***POWERING***, ***PASS THROUGH***, or ***SUPPORT***). The power is also displayed as a digit in the center.

NOTE:

When current transducers are in use, the reading on the **LOAD** tile becomes the sum of the measurements made at the **Load** and **Grid** terminals. See page 16.

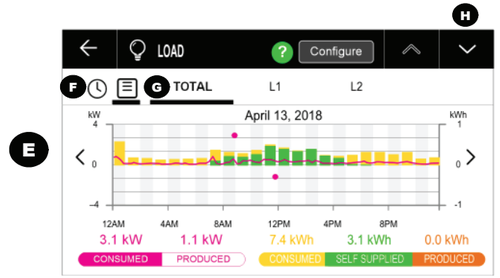
Status

Tapping the **LOAD** tile **A** opens **E**.

In screen **E**, the **TOTAL** tab **G** is the default view. It shows:

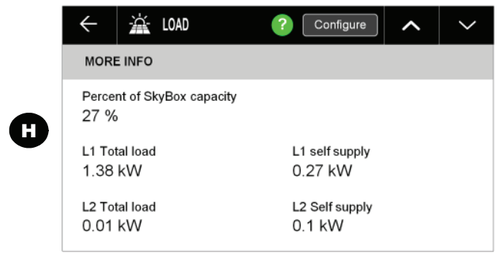
- Kilowatts (kW) consumed (by loads) that day.
  - This is graphed with a pink line.
  - Pink dots mark the peaks of consumption and production.
- Kilowatt-hours (kWh) consumed (by loads) or self-supplied that day.
  - Power consumed by loads is graphed by yellow bars that expand upward.
  - Power self-supplied to loads is graphed by green bars that expand upward. Where the green bars completely overlay the yellow, self-supplied power meets the full load demand.

  NOTE: These items are graphed by time of day. The peak value for each is also shown as a number. Tapping a colored bar at the bottom of the screen will hide that number and graph, or restore it.
- Displays for other days are available.

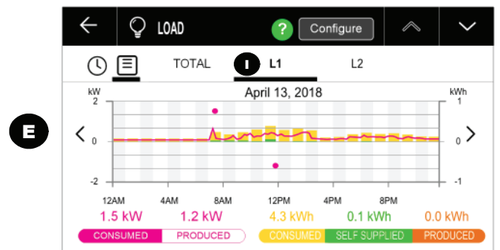


The "down" chevron **H** opens several ***MORE INFO*** screens with:

- ***Percent of SkyBox load capacity***
- ***L1*** and ***L2 Total load***
- ***L1*** and ***L2 Self supply*** (amount of load provided from battery and PV)
- ***Today's self supply (kWh)***
- ***Lifetime self supply (MWh)***

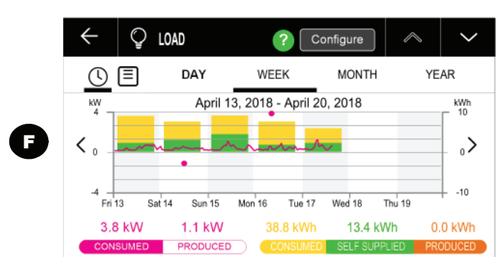


In screen **E**, tapping either the **L1** tab (**I**) or the **L2** tab opens individual screens with average loads on the L1 or L2 output lines for a selected date.



Historical Display

In screen **E**, tapping the clock symbol **F** changes the graph to a historical display showing daily, weekly, monthly, or yearly buying and selling for a selected date range.



900-0211-01-00 Rev A

Tiles: BATTERY

BATTERY Tile

The SkyBox can use a battery source to run loads as an inverter, zero the usage of grid, and other applications. It can recharge the batteries (The default setting is for a three-stage charging cycle, but custom settings are available.). It can also monitor usage and track the battery state of charge (SoC). If multiple charging sources are available, the SkyBox will use PV power before trying to charge from another source.

- For loads and the inverting function, see page 34.
- For GridZero, see page 32.

The Home screen **BATTERY** tile **A** has several status indicators. The colors of each indicator use the same general key shown in the **Tile** section on page 9.

NOTE: This chevron is not present when the state is ***Resting***.

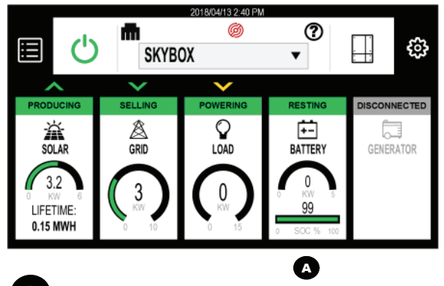
- The chevron **B** shows the direction of battery current.
  - Chevron aimed downward: ***Charging***.
  - Chevron aimed upward: ***Discharging***.
- Message **C** displays the specific battery activity and status (also noted by the color).
  - CHARGING (green): Power is being delivered to the battery from a charging source.
  - DISCHARGING (yellow): Power is being taken from the battery for one of several applications.
  - RESTING (green): Battery activity is less than 100 watts (charging or discharging).
- Item **D** is a circular meter that advances clockwise to show the power in kilowatts (kW) being handled by the batteries. The meter is fully lit when the SkyBox reaches full capacity (5 kW when either ***CHARGING*** or ***DISCHARGING***). The power is also displayed as a digit in the center.
- Item **E** is a meter bar that advances to the right to show the battery SoC in percentage. The SoC is also displayed as a digit above the bar.

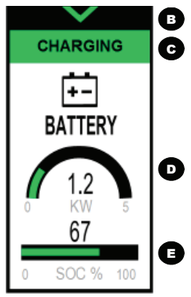
Status

Tapping the **BATTERY** tile **A** opens **F**. In screen **F**, the TOTAL tab **H** is the default view. It shows:

- Peak kilowatts (kW) used to charge the batteries that day. It also shows the peak kW discharged.
  - This is graphed with a pink line.
  - Pink dots mark the peak charge and discharge.
- Kilowatt-hours (kWh) used to charge the batteries that day. It also shows the daily discharged kWh.
  - Charging is graphed by green bars that expand upward. Discharging uses yellow bars that expand downward.
- A changeable screen item that shows a variety of other battery data for that day. This menu item is initially blank and labeled **MISC**. Tapping on this item will show the range of items, which include:
  - Battery SoC as a percentage
  - Battery voltage (**K**)
  - Battery temperature

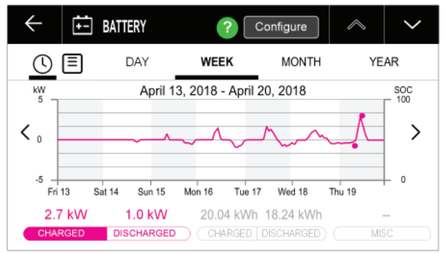
  NOTES:
  - ❖ These items are graphed by time of day and also shown as measurements. Tapping a colored bar at the bottom of the screen will hide that number and graph, or restore it.
  - ❖ Only two displays can be shown at a time. Tapping **MISC** will remove one of the others, usually the kWh display.
  - ❖ The vertical scales will change based on the display shown.
- Displays for other days are available.

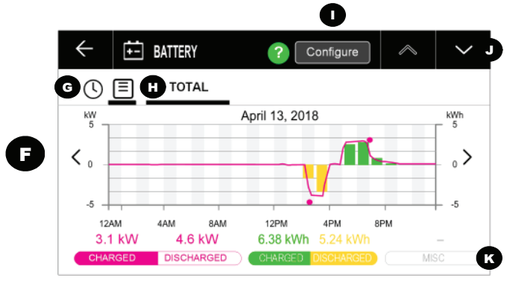


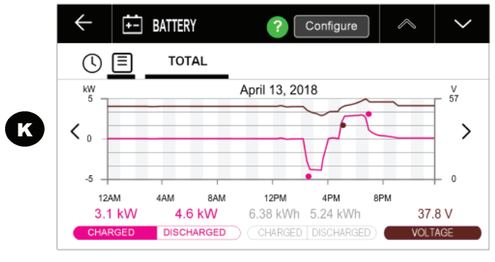


Historical Display

In screen **F**, tapping the clock symbol **G** changes the graph to a historical display **L** showing daily, weekly, monthly, or yearly charging and discharging for a selected date range.





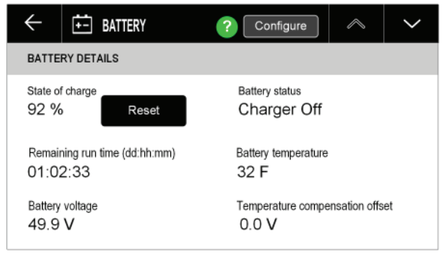


The **Configure** button **I** opens a series of of configuration screens for SkyBox battery charging. See page 39.

The "down" chevron **J** opens several ***BATTERY DETAILS*** screens. These include present data, commands that can be issued to the charging system, and historical performance data. See page 38.

Status (continued)

From page 37, the "down" chevron **J** opens several ***BATTERY DETAILS*** screens.



J

Present data:

- ***State of charge*** (resettable) — The same status as shown on the **BATTERY** tile.
- **Reset** button — This button resets the ***State of charge*** to 100% and automatically begins a new charge cycle.
- ***Battery status — Charger off***, ***Bulk***, ***Absorb***, ***Float***, ***Equalize***
- ***Remaining run time***

  NOTE: When using batteries, this item displays the remaining available run time (based on bank size and present loads). When charging or equalizing, it displays the remaining time for the present stage (the ***Absorb***, ***Float***, or ***Equalize*** timers). During the bulk stage, this item reads zero.
- ***Battery temperature***
- ***Battery voltage***
- ***Temperature compensation offset***
- ***Cumulative discharge (kWh)*** — (Resettable)
  The cumulative energy (in kWh) discharged since the batteries were last replaced. This is manually resettable to zero in the event of subsequent battery replacement or similar circumstances.

Charger commands:

- ***Initiate charge*** — ***Start*** or ***Cancel***
- ***Initiate equalization*** — ***Start*** or ***Cancel***

NOTE: Before starting, the system must determine if equalization is possible.

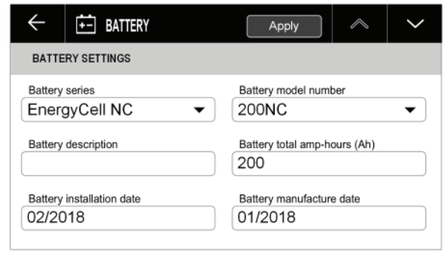
Historical Performance Data

NOTE: All items have **Reset** button commands to accommodate unusual circumstances requiring a number to be reset prematurely. Resetting requires login access.

- ***Lifetime MWh discharged***
  The total energy (in MWh) discharged over the batteries' lifetime.
- ***Lowest battery SOC %***
  The lowest state of charge reached by the batteries since the last reset.
- ***Days since charge parameters met***
  The number of days since the batteries last reached 100% SOC (the "fully charged" parameters).
- ***Lowest battery voltage***
  The lowest voltage reached by the batteries since the last reset.
- ***Highest battery voltage***
  The highest voltage reached by the batteries since the last reset.
-

Configuration

From page 37, the **Configure** button **I** opens a configuration screen for the SkyBox battery bank. These values can be changed using the **Edit** button. Once placed in Edit mode, the screen appears as shown in the image to the right.



The first few screens contain ***BATTERY SETTINGS***. See the text beginning on page 41 for descriptions of the charging function, state-of-charge measurements, and temperature compensation, as well as these set points.

- ***Battery series*** — ***None***, ***EnergyCell PL***, ***EnergyCell RE High Capacity***, ***EnergyCell PLC***, ***EnergyCell NC High Capacity***, ***EnergyCell OPzV, LG RESU, Custom***.
  Default: ***None***

  This is a list of battery series offered by OutBack. Selecting one of these types will preload the appropriate charger settings (as noted below) for that battery type.
- ***Battery model number*** — This screen lists all battery models belonging to the series selected above. Selecting a model will pre-load the appropriate values in the following screens. (If ***Custom*** is selected above, this screen will also show ***Custom***.)
- ***Battery description*** — can be manually populated when ***Battery series*** is set to ***Custom***.
- ***Battery total amp-hours*** — Range: ***0*** to ***20000***. Default: ***200***

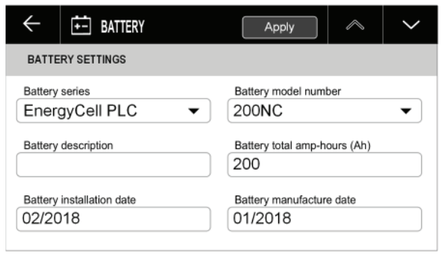
  NOTES:
  - Always enter the battery's capacity at the 20-hour rate (as specified by the manufacturer).
  - Battery capacity will dimish over time from the rated quantity. The SkyBox will perform automatic corrections to its measurements.
- ***Battery installation*** and ***manufacture date*** — mm/yyyy format
- ***Charge efficiency factor (%)*** — Range: ***80*** to ***100***. Default: ***95***
- ***Absorb end (A)*** — Range: ***0*** to ***50***. Default: ***10***
- ***Max charge current (A)*** — Default: ***30***
- ***Temperature compensation slope (-mV/°C/cell)*** — Default: ***5***
- ***Maximum SOC (%)*** — Range: ***0*** to ***100***. Default: ***100***
  This selection is used with AGS (see page 52). It is also used for all battery charging functions.
- ***Minimum SOC (%)*** — Range: ***0*** to ***100***. Default: ***50***
  This selection is used with all functions that discharge the batteries. It is considered the stopping point for discharging while grid-connected. Below this point is considered the reserve battery supply for backup during a grid outage. When this occurs, the batteries will be discharged to the ***Low battery cut-out voltage*** (see page 40).
- ***Levelized cost of energy per kWh*** — Default: ***0***
  Upon selecting this item, a tool will appear to calculate this value for a specific system. The figure calculated here is used in grid-interactive functions. This requires knowledge of the battery capacity in amp-hours, the battery cycle life, the charge and discharge efficiency, the typical depth of discharge, and any costs associated with installation.

900-0211-01-00 Rev A

Configuration (continued)

The next few screens contain ***BATTERY CHARGE*** and ***RECHARGE SETTINGS***. A description of the battery charging function and the charging set points begins on the right-hand side of this page. See page 42 for a description of equalization.

NOTE: The ranges and values shown here are those preselected for the EnergyCell PLC battery type. Settable items, ranges, and values may differ between battery types. Some battery types (such as lithium) may not have settable items.



- ***Absorb charge*** and ***Float charge*** — ***Timed***, ***Continuous*** (***Float*** only), or ***Disabled***. Default: ***Timed***
- ***Absorb voltage (V)*** — Range: ***36*** to ***58.6***. Default: ***56.5***
- ***Float voltage (V)*** — Range: ***42*** to ***60***. Default: ***54.5***
- ***Max absorb time*** and ***Float time (hh:mm)*** — Default: ***02:00***
- ***Rebulk voltage (V)*** — Range: ***36*** to ***54.5***. Default: ***48***

  NOTE: This item may not be set higher than the ***Refloat voltage***.
- ***Refloat voltage (V)*** — Range: ***42*** to ***60***. Default: ***50***
- ***Equalize voltage (V)*** — Range: ***42*** to ***60***. Default: ***58.8***
- ***Minimum equalize time (hh:mm)*** — Default: ***00:00***

The last screen contains ***BATTERY PROTECTION*** settings which affect the inverter operation.

- ***Low battery cut-out voltage LBCO (V)*** — Range: ***42*** to ***60***. Default: ***42***
- ***LBCO time delay (mm:ss)*** — Default: ***01:00***
- ***High battery cut-out voltage HBCO (V)*** — Range: ***42*** to ***60***. Default: ***60***
- ***HBCO time delay (mm:ss)*** — Default: ***00:30***

  The combination of these two items (low or high voltage for a certain length of time) causes the SkyBox to stop using the battery. This is accompanied by a fault message. (LBCO is meant to protect the batteries from severe overdischarge.) If other energy sources are available, the SkyBox will attempt to use them to continue operation.
- ***Low battery restart (V)*** — Range: ***??????*** Default: ***45.6***

  This is the recovery point for LBCO. When the batteries are charged to this voltage, the LBCO fault will clear and the SkyBox will use the batteries again.
- ***High battery restart (V)*** — Range: ***??????*** Default: ***60***

  This is the recovery point for HBCO. When the batteries decrease to this voltage, the HBCO fault will clear and the SkyBox will allow battery charging again.

Three-Stage Charging

The SkyBox can automatically charge the batteries using AC sources (utility grid or generator) or PV input. The charger settings are the same regardless of the source.

The default settings for SkyBox battery charging are for a "three-stage" process. These stages are titled **Bulk**, **Absorption**, and **Float**, after which the charger turns off. Some battery types may require considerable changes to the default settings, or may require a stage to be skipped. The settings can be extensively altered if necessary. For settings for a given battery type, see the battery manufacturer's requirements and the battery literature.

The stages of a standard three-stage charge are displayed under ***Battery status*** (see page 38):

- **Bulk** (constant-current). This is a constant-current stage that leaves the batteries at 75% to 90% SoC.
  - Status message: ***Bulk***
  - Exiting to **Absorption** stage: After reaching the ***Absorb voltage*** setting.
  - To skip **Bulk**: See "To skip ***Absorption***" below.
- **Absorption**. This is a constant-voltage stage that uses only enough current to maintain the ***Absorb voltage*** setting (usually requiring a tapering current). It "tops off" the batteries at effectively 100% SoC.
  - Status message: ***Absorb***. The timer countdown can be viewed under the ***Remaining run time*** menu item.
  - If the charging source is lost during this stage, the remaining time is retained. Upon resumption of charging, the charger will return to this stage after reaching the ***Absorb voltage*** and use the remaining time.

    NOTE: The absorption timer increments (gains time back) whenever the battery voltage drops below the ***Rebulk voltage*** setting, up to the limits of ***Max absorb time***.
  - Exiting to **Float** stage: After the ***Max absorb time (hh:mm)*** reaches zero or the ***Absorb end*** (trickle current) setting is reached. This may not always be the same length of time. The absorption timer may not have incremented the full amount. The trickle current setting will also override the timer.
  - To skip **Absorption**: Setting ***Absorb charge*** to ***Disabled***, or setting ***Max absorb time*** to zero, will skip both the ***Bulk*** and ***Absorption*** stages. The status will skip to ***Float***.
- **Float**. This stage uses only enough current to maintain the ***Float voltage*** setting. It maintains the batteries at 100% SoC. It is usually a constant-voltage stage when following **Absorption**. When re-entering this stage after reaching the ***Refloat voltage*** set point (see next page), it usually operates as a constant-current charger while restoring the ***Float voltage*** setting.
  - Status message: ***Float***. This is displayed regardless of whether the charger is in constant-current or constant-voltage operation. The float timer begins running as soon as the Absorption timer expires. The timer countdown can be viewed under the ***Remaining run time*** menu item.
  - If the charging source is lost during this stage, the remaining time is retained. Upon resumption of charging, the charger will return to this stage after reaching the ***Float voltage*** and use the remaining time.

  See the next page.

900-0211-01-00 Rev A

Three-Stage Charging (continued)

- Exiting the charge cycle: After the ***Float time (hh:mm)*** setting is reached.

  NOTE: The float timer resets to its maximum value whenever the battery voltage drops below the ***Refloat voltage*** setting, up to the limits of ***Max float time***.
- To skip **Float**: Setting ***Float charge*** to ***Disabled*** will skip this stage. Setting ***Float time*** to zero will do the same.
- Continuous **Float**: Setting ***Float charge*** to ***Continuous*** causes the SkyBox to maintain the **Float** stage for as long as sufficient power is available.

  NOTE: This setting is NOT recommended for lithium-chemistry batteries.

Following these three stages, the charger stops, with the following status:

- **Charger off**. The charger is no longer active. (The batteries may be immediately used by other functions. That status is displayed on the Home screen.) The charger will remain off until the battery voltage decreases to ***Refloat voltage***. The charger will then re-enter **Float**.

New Charging Cycle

When the batteries drop below the ***Rebulk voltage*** setting, this triggers a new three-stage cycle. (It also begins adding time to the absorption timer.) Normally this set point is only reached when the batteries are being discharged. When a charging source becomes available, the cycle will begin again with **Bulk**.

While connected to a charging source, the cycle will be restarted with **Bulk** if the batteries drop below the ***Minimum SOC %*** set point. A new cycle can also be manually started using the **Reset** button (see page 38). This also resets the state of charge reading to 100%.

NOTE: The SkyBox cannot sell power to the utility grid until the charging cycle is complete.

Equalization

Equalization is a controlled overcharge that is part of regular maintenance for flooded batteries. Equalization brings the batteries to a much higher voltage than usual and maintains this high voltage for a period of time. This has the result of removing inert lead sulfate compounds from the battery plates. It also reduces stratification by circulating the electrolyte.

Equalization follows the same pattern as standard three-stage charging as described on page 41. However, instead of the Absorption voltage and time set points, it is controlled by the ***Equalize voltage*** and ***Minimum equalize time (hh:mm)*** settings. (See page 40.) The timer countdown can be viewed under the ***Remaining run time*** menu item.

CAUTION: Battery Damage

- Do not equalize any battery types unless approved by the manufacturer. Some batteries may suffer severe damage from equalization.
- Contact the battery manufacturer for recommendations on equalization voltage, duration, schedule, and/or advisability. Other battery manufacturers may use a different definition of equalization than that shown above. Always follow manufacturer recommendations for equalization.

Temperature Compensation

Battery performance will change when the temperature varies above or below room temperature (77°F or 25°C). Temperature compensation is a process that adjusts battery charging to correct for these changes.

The SkyBox, when equipped with the Remote Temperature Sensor (RTS), will compensate for changes in temperature. To achieve a representative temperature, the RTS is attached to a single battery near the center of the bank. The SkyBox has a designated port for RTS installation.

If temperature compensation is not used:

When a battery is cooler than room temperature, its internal resistance changes. The battery voltage will rise more quickly and the charger will reach its voltage set points more easily. However, it will not deliver all the required current and the battery will tend to be undercharged. Conversely, when the battery is warmer than room temperature, the voltage will rise more slowly. The charger will not reach its set points as easily. The charger will continue to deliver energy until the set points are reached, but this will tend to be more than required. The battery will be overcharged and is likely to have a shorter life.

If temperature compensation is used:

The SkyBox will adjust the charging voltage settings inversely with changes in temperature. Below room temperature (77°C or 25°C), the settings are increased by a certain amount per degree (according to the **Slope** setting below). Above room temperature, the settings are decreased by the same amount.

Slope

The rate of adjustment, the "slope", is adjusted by the ***Temperature compensation slope (-mV/°C/cell)*** menu item. The default slope setting is ±5 mV/°C/cell.

This setting affects all DC voltage settings relating to the battery. These include the Absorption, Float, and Equalization set points. They also include ***Rebulk voltage***, ***Refloat voltage***, and others.

For settings for a given battery type, see the battery manufacturer's requirements and the battery literature.

900-0211-01-00 Rev A

State of Charge (SoC)

Battery capacity is measured in ampere-hours or amp-hours (Ah), a measurement of current over time. SoC is a percentage of the battery total, which is provided by the battery manufacturer and entered in ***Battery total amp-hours.*** The SkyBox senses the current flow either into or out of the batteries over time and calculates the Ah gain or loss. The resulting SoC is displayed on page 36.

Criteria

State of charge is not strictly a matter of counting amp-hours. The charger must reach the requisite criteria (voltage, current, time) before the batteries can be fully charged. For this reason, the charger settings on page 39 andpage 40 must be programmed accurately. Similarly, ***Battery total amp-hours*** must be correct for the SkyBox to make accurate measurements.

IMPORTANT:

Ensure that the battery settings and charging requirements are programmed correctly. If the battery manufacturer's requirements are not met, or are set incorrectly, the SoC meter may not be accurate. The batteries may not be full **even if the SoC meter reads 100%.**

Efficiency

The batteries cannot accept 100% of the charging energy due to internal losses. To account for this, the charging circuit discounts a percentage of the charge and does not apply it to the SoC. The amount can be set as the ***Charger efficiency factor (%)***. (See page 39.) The default setting is 95% but should be set as accurately as possible for the batteries. Charging efficiency decreases with battery age.

Reset

The charger may become unsynchronized with the SoC due to incomplete charge cycles, overcharging, and other factors. The SkyBox can automatically "zero" the state of charge to eliminate these errors by resetting it to 100%. This occurs after the following conditions are met.

- All charging criteria have been met

Discharging

Most batteries are rated for a certain number of charge/discharge cycles, usually based on the depth of discharge. Heavier discharge cycles tend to shorten the battery cycle life. Do not discharge the batteries below the manufacturer's recommended level. The ***State of charge*** and ***Lowest battery SOC %*** meters can monitor this condition. (See page 36 and page 38.)

The ***Cumulative discharge (kWh)*** and ***Lifetime MWh discharged*** can be used to track overall usage, particularly when compared against the ***Battery installation date*** and ***Battery manufacture date*** settings. (See page 39.)

Maximum Charge

The charge rate should not exceed a certain amount of current as specified by the battery manufacturer. The maximum current rate is usually a percentage of the total amp-hours. This item is entered as ***Max charge current (A)***. (See page 39.)

Charging at excessive rates of current will reduce the charging efficiency. The battery may permanently lose capacity over the long term. In severe cases, overcharging may create a safety hazard.

Other DC Devices

IMPORTANT:

Do not use DC devices other than the battery bank and PV array specified in the *SkyBox Quick Start Guide*. The SkyBox does not support alternate DC charging sources or DC loads that are not wired through the BOS (for example, an additional PV array wired directly to the batteries, or DC lighting). Any device of this kind cannot be measured with the SkyBox's internal monitoring. This will render the SkyBox battery monitoring inaccurate. Other side effects may be possible.

900-0211-01-00 Rev A

GENERATOR Tile

The SkyBox can control a generator to charge batteries and run loads. The generator can be started with a manual command or programmed to run automatically with the Advanced Generator Start (AGS) function. The generator can start or stop according to battery state, time of day, or several other external conditions.

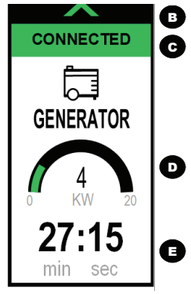
○ For battery charging, see page 41.

NOTES:

❖ The SkyBox cannot connect to both the generator and utility grid at the same time. It cannot sell generator power to the grid. If both are active at the same time, the SkyBox will always select the grid. If other programming has caused the SkyBox to disconnect from the grid, it may be allowed to connect to the generator.

❖ While solar power charges the batteries (see page 22), the generator cannot be used to charge, but can be used to run loads. The generator can charge batteries when the solar input is inactive.

The Home screen **GENERATOR** tile **A** has several status indicators. The colors of each indicator use the same general key shown in the **Tile** section on page 9.



○ The chevron **B** shows that the generator is delivering power.

- Chevron aimed upward: ***CONNECTED***.
- **NOTE**: This chevron is not present in states where the generator runs but no power is being used (***WARMING UP***, ***COOLING DOWN***, ***EXERCISING***, or others).
- The chevron does not point downward in any state.

○ Message **C** displays the specific generator activity and status (also noted by the color). See page 52 for a description of the AGS cycle and the states of generator operation.

- DISCONNECTED (gray): The generator is not operating or connected.
- STARTING (yellow): The SkyBox has sent a start command with its **Aux** terminals. The generator should start.
- WARMING UP (yellow): The generator has started and is going through the warmup period. See page 51.
- WAITING (green): The generator power is within limits, but it cannot be accepted because **Grid** is in use.
- CONNECTED (green): The transfer relay is closed. Generator power can be used for charging and loads.
- COOLING DOWN (yellow): The generator is preparing to stop and is going through the cooldown period. See page 51.
- EXERCISING (yellow): The generator has been started with the **Exercise** function (see page 54). The transfer relay is open and generator power cannot be used by the SkyBox.
- OUT OF SPEC (yellow): Generator power is not within acceptable limits.

○ Item **D** is a circular meter which advances clockwise to show generator power in kilowatts (kW) being used by charging, loads, or both. The meter is fully lit when the SkyBox reaches full capacity (10 kW when ***CONNECTED***). The power is also displayed as a digit in the center.

○ Item **E** is the amount of time elapsed since the generator was started. This timer counts up from zero when message **C** shows ***CONNECTED***. When the message is ***WARMING UP***, ***COOLING DOWN***, or ***EXERCISING***, the timer counts down from a defined time to zero.

When the generator is started from its own controls and the SkyBox is not in control, all items noted above still function. However, the only messages that can appear under **C** are ***WARMING UP***, ***WAITING***, ***CONNECTED***, or ***OUT OF SPEC***.

Status

Tapping the **GENERATOR** tile **A** opens **F**.

In screen **F**, the **GENERATOR** tab **H** is the default view. It shows:

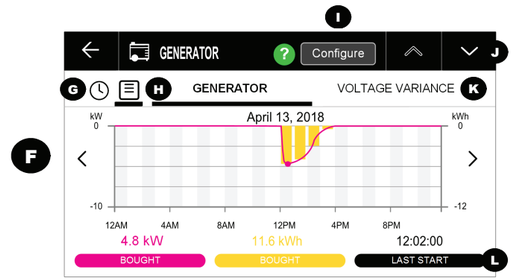
○ Kilowatts (kW) used from the generator that day.
- This is graphed with a pink line.
- Pink dots mark the peak charge and discharge.

○ Kilowatt-hours (kWh) used from the generator that day.
- This is graphed by yellow bars that expand downward.

NOTE: These items are graphed by time of day. The peak value for each is also shown as a number. Tapping a colored bar at the bottom of the screen will hide that number and graph, or restore it.

○ Displays for other days are available.

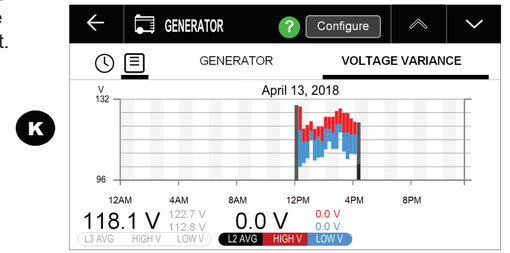
○ This screen also shows the date and time of the most recent generator start (**L**).



The **Configure** button **I** opens a series of of configuration screens for SkyBox generator operation. See page 48.

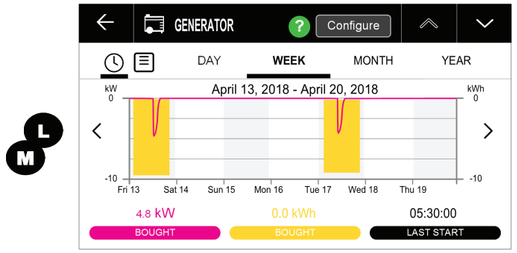
The "down" chevron **J** opens a ***MORE INFO*** screen with several generator status messages. See page 48.

In screen **E**, tapping the **VOLTAGE VARIANCE** tab **K** opens a view with average high and low AC voltages on the generator L1 and L2 phases. These readings are only for the present day.



Historical Display

In screen **F**, tapping the clock symbol **G** changes the graph to a historical display showing daily, weekly (**L**), monthly, or yearly charging and discharging for a selected date range.



Transfer Relay

CAUTION:
Equipment Damage

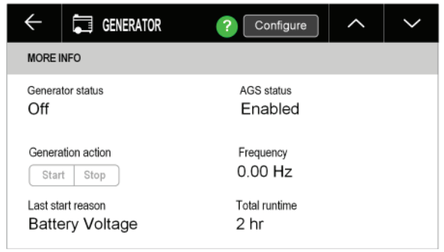
Current draw in excess of the transfer relay rating can damage the relay. This is not covered by warranty. Use appropriate-sized protective devices.

The SkyBox uses a mechanical transfer relay to alternate between the states of inverting and of accepting an AC source. The **Gen** and **Grid** terminals have separate, independent relays. Until the relay energizes, the **Gen** terminals are electrically isolated from the **Load**. When it closes, the **Gen** and **Load** terminals become electrically common. (The **Grid** terminals remain isolated.) When the relay changes states, the physical transfer delay is is fast as 20 milliseconds.

The contacts are limited to 60 Aac per phase or line. The continuous loads should never exceed this. When connected to an AC source, the SkyBox cannot limit the load current. The **Gen** or **Load** circuit breakers may trip.

See page 48 for a description of the conditions required for transfer.

More Info



- ***Generator status***: The status shown on the **GENERATOR** tile.
- ***AGS status —*** The general status of the AGS function. One of these messages will appear.
  - ***Disabled*** — One of the ***AUX terminal*** items (see page 16) has been set to ***Off*** (or to a setting other than ***AGS***.
  - ***Enabled*** — The ***AUX terminal*** item has been set to ***AGS***.
  - ***Exercise deferred*** — The **Exercise** function is active. The generator would normally be running, but has been manually stopped. The next exercise period will occur normally. (See **NOTES** below.)
  - ***Quiet time deferred*** — The **Quiet Time** function is active. (See page 54.) The generator would normally be prevented from running, but the generator had to be started due to critically low battery voltage. The next quiet time will occur normally.
- ***Generation action*** — Manual commands to **Start** or **Stop** the generator. See page 51.

  NOTES:
  - If AGS had already started the generator and this item is then set to **Stop**, ***Enable AGS*** (see page 50) will automatically switch to **No**.
  - An exception to the above item is that ***Enable AGS*** will not switch to **No** if **Stop** was selected to defer a single exercise period (see above). The next exercise period will occur normally.
- ***Frequency*** — The present output frequency of the generator.
- ***Last start reason*** — One of these messages will appear.
  - ***None*** — No record exists of generator operation.
  - ***Manual*** — The generator was started manually. This may mean the user selected ***Start*** under ***Generation Action***, or the AC input became active on its own (due to an external start).
  - ***Battery Voltage*** — The generator was started due to the settings for any of these items (low voltage, low state of charge, high load, or exercise). See page 52.
  - ***SOC*** —
  - ***Load*** —
  - ***Exercise*** —
- ***Total runtime*** — The amount of running time the generator has accumulated (for any reason) since the last reset.
- ***Reset generator runtime*** — This **Reset** button resets to zero the accumulation under ***Total runtime***.

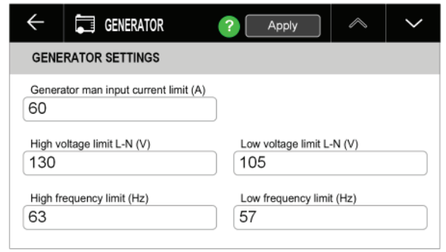
Generator Input

When the SkyBox **GEN** terminals are connected to a stable AC source (a generator), the **GRID** terminals are not in use and the SkyBox is turned on, the SkyBox will synchronize itself with the generator source and connect to it. After the ***Warm up time*** expires, its transfer relay will engage, linking the **GEN** terminals directly with the **LOAD**. (See page 47 for more information on the function of the transfer relay.)

- Upon connection, the generator power will be used to run any loads. It can charge batteries if PV is not in use. However, while solar power charges the batteries, the generator will only be used to run loads. It will not be used for charging.
- The SkyBox must be connected to at least 5 Aac of of loads before the charger will activate. If the loads drop below 4 Aac, the charger will turn off.
- The SkyBox does not have a **Support** function that will use battery or PV power to assist a generator.

Configuration

From page 47, the **Configure** button **H** opens a configuration screen for SkyBox generator operation.



These values can be changed using the **Edit** button. Once placed in Edit mode, the screen appears as shown in the image to the right.

The first few screens contain ***GENERATOR SETTINGS***. These inform the SkyBox of the generator's capabilities and control the overall interaction with the generator.

- ***Generator max input current limit (A)*** — Range: ***15*** to ***60***. Default: ***60***
- ***High voltage limit L-N (V)*** — Range: ***85*** to ***140***. Default: ***130***
- ***Low voltage limit L-N (V)*** — Range: ***85*** to ***140***. Default: ***105***
- ***High frequency limit (Hz)*** — Range: ***55*** to ***65***. Default: ***63***
- ***Low frequency limit (Hz)*** — Range: ***55*** to ***65***. Default: ***57***
- ***Generator output rating (kVA)*** — Range: ***0*** to ***100***. Default: ***5***
- ***Disconnect delay (s)*** — Range: ***0.07*** to ***2***. Default: ***1***
- ***Warm up time (mm:ss)*** — Default: ***00:00***
- ***Cool down time (mm:ss)*** — Default: ***05:00***

The next screens contain ***ADVANCED GENERATOR START SETTINGS***. See the next page for the AGS function.

To be accepted, the generator must meet certain parameters, notably voltage and frequency.

- When these conditions are met, the SkyBox will close its transfer relay and accept the generator. If the conditions are not met, the SkyBox will not close the relay or accept the generator.
- If the generator is shut down (or if the parameters are no longer met), the SkyBox will open the transfer relay. This isolates the protected loads from the generator and allows the SkyBox to serve the loads instead.
- The SkyBox will not work with a DC generator. The input from an AC generator must be connected to the **GEN** terminals and must not be connected to other locations on the SkyBox.

The SkyBox has a separate **GRID** connection (see page 24). These independent connections are used for wiring to multiple AC sources. However, the SkyBox can only use one AC source at a time. If both connections are powered, the SkyBox automatically accepts **GRID**. It cannot accept **GEN** as long as **GRID** is active.

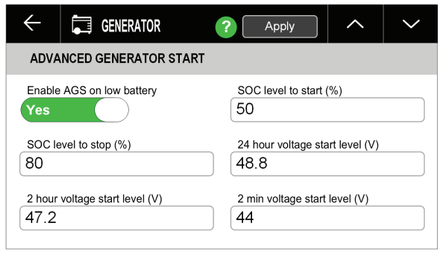
NOTE: If SkyBox programming has forced a disconnection from the grid (even if grid power is still present), the SkyBox can accept generator power instead.

Configuration (AGS)

From page 47, the **Configure** button **H** opens a configuration screen for SkyBox generator operation.

These values can be changed using the **Edit** button.

The screens shown here contain ***ADVANCED GENERATOR START SETTINGS***. These set the limits for automatic starting and stopping of the generator.



NOTES:

- ❖ The items on this screen are inactive (as is the AGS function) until one of the ***AUX Terminal*** items on page 16 is set to ***AGS***. The items on each screen below are inactive until **Yes** is selected on that screen.
- ❖ If AGS had already started the generator and the user then sets ***Generation Action*** to force the generator to **Stop** (see page 48), the ***AUX Terminal item*** will automatically switch to ***Off***.

- ○ ***Enable AGS on low battery*** — Activates both the SOC start and voltage start functions. Range: **Yes** or **No**. Default: **No**.
  - ***SOC level to start (%)*** — Range: ***0*** to ***80***. Default: ***50***
  - ***SOC level to stop (%)*** — Range: ***0*** to ***100***. Default: ***80***
  - ***24 Hour Voltage start level (Vdc)*** — Range: ***42*** to ***60***. Default: ***48.8***
  - ***2 Hour Voltage start level (Vdc)*** — Range: ***42*** to ***60***. Default: ***47.2***
  - ***2 Min Voltage start level (Vdc)*** — Range: ***42*** to ***60***. Default: ***44***
- ○ ***Enable AGS start on load*** — Range: **Yes** or **No**. Default: **No**.
  - ***Load start (kW)*** — Range: ***0*** to ***50***. Default: ***5***
  - ***Load start delay (minutes)*** — Range: ***1*** to ***90***. Default: ***5***
  - ***Load stop (kW)*** — Range: ***0*** to ***50***. Default: ***5***
  - ***Load start delay (minutes)*** — Range: ***1*** to ***90***. Default: ***1***
- ○ ***Enable AGS quiet time*** — Range: **Yes** or **No**. Default: **No**.
  - ***Weekday quiet time begin (hh:mm)*** — Default: ***00:00***
  - ***Weekday quiet time end (hh:mm)*** — Default: ***00:00***
  - ***Weekend quiet time begin (hh:mm)*** — Default: ***00:00***
  - ***Weekend quiet time end (hh:mm)*** — Default: ***00:00***
- ○ ***Enable AGS Exercise*** — Range: **Yes** or **No**. Default: **No**.
  - ***Exercise interval*** — Range: ***Daily***, ***Weekly***, or ***Monthly***. Default: ***Monthly***
  - ***Exercise day of month*** (if ***Monthly*** is selected) — Range: ***1*** to ***31***. Default: ***1***
  - ***Exercise day of week*** (if ***Weekly*** is selected) — Range: ***SUNDAY*** to ***SATURDAY***. Default: ***SUNDAY***
  - ***Generator exercise start (hh:mm)*** — Default: ***12:00***
  - ***Exercise duration (minutes)*** — Range: ***10***, ***15***, or ***20***. Default: ***15***

Generator Control

When the SkyBox is wired to the generator's start circuit, the item ***Generation Action*** (see page 48) will manually **Start** or **Stop** a generator. This will also occur if any of the ***ADVANCED GENERATOR START SETTINGS*** are met. A "start command" in the SkyBox refers to either situation.

The SkyBox **Aux** connections send generator commands. Either a 12-volt output or “dry” contacts with no voltage can be used. (See the *SkyBox Quick Start Guide* for connections.)

It is more common for the start circuit on a two-wire-start generator to use dry contacts. If a 12-volt signal is needed, this output can be used to drive the OBR-16-DIN (or a similar relay) which is equipped with dry-contact connections.

CAUTION: Equipment Damage

These functions, particularly AGS, can damage the generator or the batteries if either are not properly maintained. Be sure to follow all maintenance requirements for all the components in the system to prevent unnecessary and expensive damage.

NOTE:

When **Start** is pressed, the generator will continue to run until commanded to **Stop**. It will not stop automatically unless AGS is in use.

If using a generator with a three-wire-start circuit, a three-wire to two-wire conversion kit may be needed to use OutBack **Aux** connections. Atkinson Electronics (***http://atkinsonelectronics.com***) is one company that makes these kits. The Atkinson GSM-Mini is intended to work with OutBack products.

Starting, Running, and Stopping

When the **Aux** connection sends a start command, the SkyBox displays ***STARTING***. After the **Gen** terminals receive voltage from the running generator, the display changes to ***WARMING UP***. During this countdown, the generator is allowed to run with no load. When the ***Warm up time*** setting expires, the SkyBox will close its transfer relay and display ***CONNECTED***.

- ○ If the start command was due to an exercise period, it will not close the relay and will display ***EXERCISING*** instead.
- ○ If the **Grid** terminals are in use, it will not close the relay and will display ***WAITING***.
- ○ If the power becomes unacceptable at any point (including while warming up), the SkyBox will open its transfer relay and display ***OUT OF SPEC***. It will not shut off the generator in the expectation that the power will return to normal.
- ○ If no power is received after five minutes of attempting the start sequence, the ***Inverter Fault Status*** screen will display a fault. This fault must be cleared before the SkyBox can attempt to start the generator again. (See page 15.) The ***System Notification*** screen will also display an alert.

When the run period is over (whether due to automatic criteria or a manual command), the SkyBox opens its relay and displays ***COOLING DOWN***. During this countdown, the generator is allowed to run with no load. When the ***Cool down time*** setting expires, the **Aux** connection sends a stop command.

If the generator was started from its own controls, the behavior described above remains the same except that the **Exercise** and cool-down functions will not operate.

900-0211-01-00 Rev A

Advanced Generator Start (AGS)

AGS allows SkyBox to start and stop the generator automatically. The advanced functions allow generator control based on battery state, time of day, or load size. It can be exercised during inactive periods, or prevented from starting late at night or during other "quiet times".

AGS starts the generator when any of its Start conditions are met and stops the generator when any of its Stop conditions are met. A **Quiet Time** schedule overrides most Start conditions to keep the generator from running at inappropriate hours. See page 55 for a list of conditions that will stop the generator.

SOC Start

When the battery discharges to the ***SOC level to start (%)*** set point, the generator starts and the SkyBox uses generator power to charge the batteries. When the battery is charged to the ***SOC level to stop (%)*** set point, the generator stops. (See page 36 to monitor the present state of charge percentage.)

The **SOC Start** settings will only operate (and can only be set) when the ***Enable AGS on low battery*** function is enabled.

Voltage Start

When the batteries discharge to any of several selected low-voltage points for a designated period of time, the generator starts and the batteries are charged. The designated time periods are 24 hours, 2 hours, and 2 minutes. When the SkyBox completes a three-stage battery charge (see page 41), the generator stops. The generator will also stop if it reaches the ***Maximum SOC (%)*** set point (see page 39) before reaching the end of the three-stage cycle.

- If the battery voltage drops below any of these set points, the designated timer starts counting down.
- If the voltage increases above the set point, the timer resets to maximum.
- The timers also reset to maximum when AGS stops the generator or upon an AGS fault.
- When any timer reaches zero (0), a start command is sent to the generator.
- These timers cannot be viewed.

The three time designations are meant to show increasing levels of urgency (due to increased battery discharge). The voltages should be set accordingly.

- ***24-hour voltage start level*** is intended to start the generator after a mild battery discharge.
- ***2-hour voltage start level*** is intended to start the generator after a major battery discharge.
- ***2-minute voltage start level*** is intended to start the generator after a critical battery discharge. This is considered an emergency start and should be set accordingly. It is the only AGS setting that will override **Quiet Time**.

The **Voltage Start** settings will only operate (and can only be set) when the ***Enable AGS on low battery*** function is enabled.

Load Start

Whenever the SkyBox load exceeds a selected (kilowatt) set point for a selected period of time, the generator starts. When the load decreases below a different set point for a selected period, the generator stops.

- When the SkyBox **LOAD** terminals register an amount greater than ***Load start (kW)*** for the ***Load start delay (minutes)*** time, the generator starts. Following this condition:
- When the SkyBox **LOAD** terminals register an amount less than ***Load stop (kW)*** for the ***Load stop delay (minutes)*** time, the generator stops.

NOTES:

- This function is meant to protect against rapid and unnecessary battery discharge. It does not protect against overload if the load is simply too large. Large, instantaneous loads can still overload the SkyBox if the generator does not start in time. The loads should be sized appropriately.
- When this function runs the generator, the inverter will charge the batteries. However, it is not programmed to perform a complete charge cycle. The charge might not be complete if the SkyBox reaches the ***Load Stop*** point and shuts down.

The **Load Start** settings will only operate (and can only be set) when this function is enabled.

900-0211-01-00 Rev A

Quiet Time

During evening hours or other times when generator noise is not desired, the generator can be prevented from starting automatically.

- The 24-hour and 2-hour start settings will not start the generator during these times. Similarly, the **SOC Start**, **Load Start**, and **Exercise** functions will not start the generator.
- The generator can be started normally with the **Start** button.
- The generator can be started normally using its own controls.
- One quiet time can be set for weekdays. A different time can be set for weekends.

NOTE:

The 2-minute start setting **will** start the generator regardless of quiet time. This is considered an emergency start due to low battery voltage. It overrides quiet time to perform required battery charging.

The **Quiet Time** settings will only operate (and can only be set) when this function is enabled.

Exercise

During long periods of disuse, the generator can be started automatically and test-run for a short time.

- During exercise, the SkyBox does not close its transfer relay to connect to the generator. It does not charge batteries or use generator power in any other way. The SkyBox displays the message ***Exercising***.
- The SkyBox can exercise the generator while utilizing grid power.
- The exercise time can be set at daily, weekly, or monthly intervals. Several different durations can be selected.

NOTE:

Quiet Time overrides the **Exercise** function. If the two settings partly overlap, **Exercise** will only occur during the portion not covered by **Quiet Time**. If the **Exercise** period is completely within **Quiet Time**, **Exercise** will not function.

Start/Stop Table

This table summarizes the various start and stop conditions that apply to both AGS and manual control.

START REASONS	Full Charge Cycle	STOP REASONS								
		Inverter in Float or Silent	Stop SOC %	Max SOC %	Below Load kW	Quiet Time	Exercise Time Expires	Stop Button	Generator Controls	Run During Quiet Time?
2 Min Batt V	Yes	Stop		Stop				Stop	Stop	Yes
2 Hour Batt V	Yes	Stop		Stop		Stop		Stop	Stop	No
24 Hour Batt V	Yes	Stop		Stop		Stop		Stop	Stop	No
Start SOC %			Stop			Stop		Stop	Stop	No
Load kW					Stop	Stop		Stop	Stop	No
Exercise						Stop	Stop	Stop	Stop	No
Start button	Yes							Stop	Stop	Yes
Generator controls	Yes							Stop	Stop	Yes

900-0211-01-00 Rev A

Contact Information

About OutBack Power Technologies

OutBack Power Technologies is a leader in advanced energy conversion technology. OutBack products include true sine wave inverter/chargers, maximum power point tracking charge controllers, and system communication components, as well as circuit breakers, batteries, accessories, and assembled systems.

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