

# EnergyCell PLC Series

## Owner's Manual



## 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.

## Applicability

These instructions apply to OutBack EnergyCell PLC series batteries only.

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# Important Safety Instructions

## READ AND SAVE THESE INSTRUCTIONS!

This manual contains important safety instructions for the EnergyCell battery. These instructions are in addition to the safety instructions published for use with all OutBack products. Read all instructions and cautionary markings on the EnergyCell battery and on any accessories or additional equipment included in the installation. Failure to follow these instructions could result in severe shock or possible electrocution. Use extreme caution at all times to prevent accidents.



### **WARNING: Personal Injury**

- ❖ Some batteries can weigh in excess of 100 lb (45 kg). Use safe lifting techniques when lifting this equipment as prescribed by the Occupational Safety and Health Association (OSHA) or other local codes. Lifting machinery may be recommended as necessary.
- ❖ Wear appropriate protective equipment when working with batteries, including eye or face protection, acid-resistant gloves, an apron, and other items.
- ❖ Wash hands after any contact with the lead terminals or battery electrolyte.



### **WARNING: Explosion, Electrocution, or Fire Hazard**

- ❖ Ensure clearance requirements are strictly enforced around the batteries.
- ❖ Ensure the area around the batteries is well ventilated and clean of debris.
- ❖ Never smoke, or allow a spark or flame near, the batteries.
- ❖ Always use insulated tools. Avoid dropping tools onto batteries or other electrical parts.
- ❖ Keep plenty of fresh water and soap nearby in case battery acid contacts skin, clothing, or eyes.
- ❖ Wear complete eye and clothing protection when working with batteries. Avoid touching bare skin or eyes while working near batteries.
- ❖ If battery acid contacts skin or clothing, wash immediately with soap and water. If acid enters the eye, immediately flood it with running cold water for at least 20 minutes and get medical attention as soon as possible.
- ❖ Never charge a frozen battery.
- ❖ Insulate batteries as appropriate against freezing temperatures. A discharged battery will freeze more easily than a charged one.
- ❖ If a battery must be removed, always remove the grounded terminal from the battery first. Make sure all devices are de-energized or disconnected to avoid causing a spark.
- ❖ Do not perform any servicing other than that specified in the installation instructions unless qualified to do so and have been instructed to do so by OutBack Technical Support personnel.

## Additional Resources

These references may be used when installing this equipment. Depending on the nature of the installation, it may be highly recommended to consult these resources.

Institute of Electrical and Electronics Engineers (IEEE) guidelines: IEEE 450, IEEE 484, IEEE 1184, IEEE 1187, IEEE 1188, IEEE 1189, IEEE 1491, IEEE 1578, IEEE 1635, and IEEE 1657 (various guidelines for design, installation, maintenance, monitoring, and safety of battery systems)



# Introduction

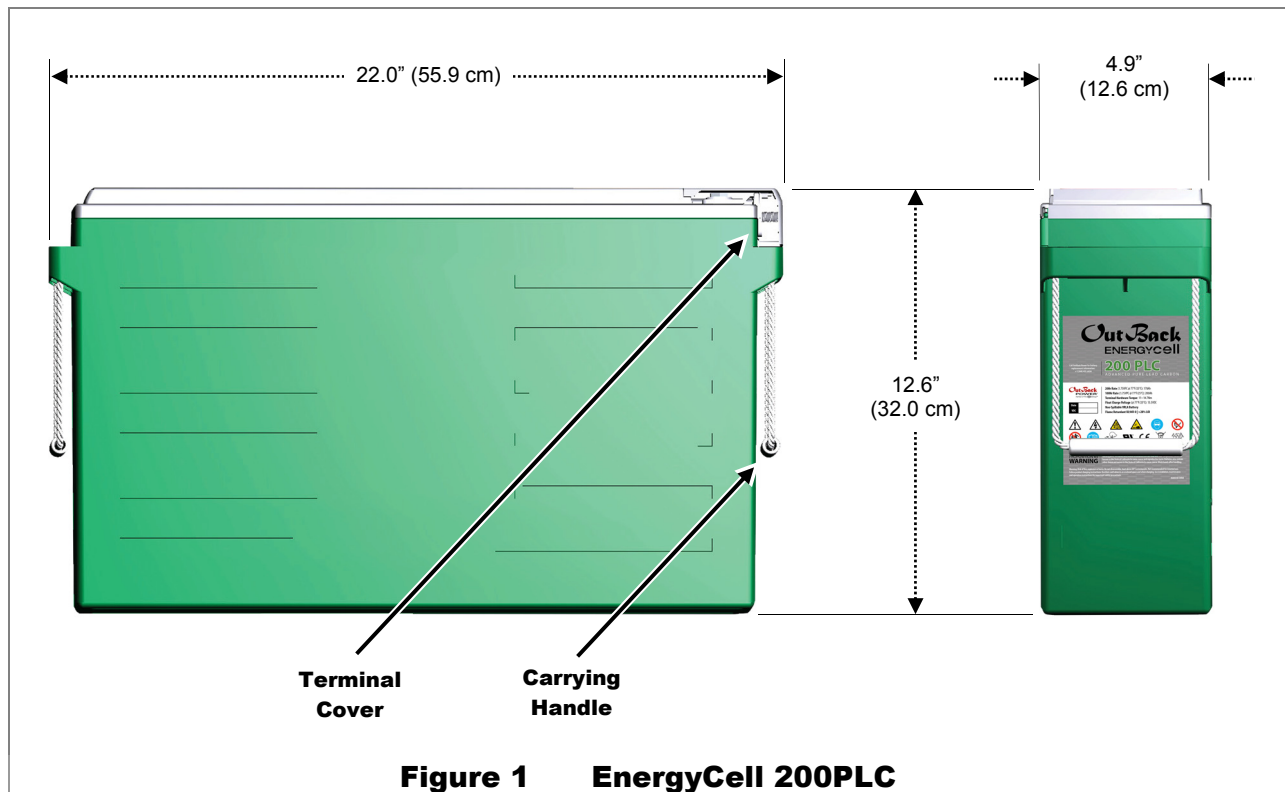
## Audience

This manual is intended for use by anyone required to install and operate this battery. Be sure to review this manual carefully to identify any potential safety risks before proceeding. The owner must be familiar with all the features and functions of this battery before proceeding. Failure to install or use this battery as instructed in this manual can result in damage to the battery that may not be covered under the limited warranty.

## EnergyCell PLC

The EnergyCell PLC (pure-lead carbon) uses pure lead plate construction combined with carbon additives to obtain maximum cycle life, float life, shelf life (18 months at 25°C), and PSoC operation. The PLC is ideally suited for the three primary applications where OutBack inverters are used: Off-Grid, Grid-Tied Battery Backup, and Grid-Tied Self Consumption.

- o Low self-discharge
- o Oxygen recombination efficiency:  $\geq 97\%$
- o 3D plate structure, optimal plate design provides better performance for high power output than other EnergyCell models
- o VRLA maintenance free battery type
- o UL94-V0 flame-retardant jar container



## Materials Required

### Tools (use insulated tools only)

- o Digital voltmeter
- o Socket wrench
- o Torque wrench calibrated in inch-pounds
- o Box end wrench
- o Battery lifting equipment (handles) and fork lift to lift pallets of batteries
- o Rubber gloves
- o Full face shield
- o Plastic apron
- o Portable eyewash
- o Spill kit
- o Fire extinguisher (class C)

### Accessories

- o Interconnect bar (included)
- o Terminal cover (included)
- o Hardware (included)
- o Interconnect cables as needed



#### **CAUTION: Fire Hazard**

Install properly sized battery cabling and interconnect cables. The cable ampacity must meet the needs of the system, including temperature, deratings, and any other code concerns.

## Storage and Environment Requirements

### Temperatures

- o To achieve maximum life of EnergyCell batteries, it is recommended not to operate them in average ambient temperatures outside the range of 68°F to 86°F (20°C to 30°C). High operating temperatures will shorten a battery's life (see page 7).
- o Do not allow batteries to freeze, as this will damage them and could result in leakage.
- o Do not expose batteries to temperature variations of more than 5°F (3°C). This leads to voltage imbalance between multiple batteries (or between battery cells if there is a temperature differential).
- o Batteries should be stored in a cool, dry location. The best storage temperature is 77°F (25°C), but a range of -4°F to 104°F (-20°C to 40°C) is acceptable.

## Self-Discharge

All EnergyCell batteries will discharge over time once charged, even in storage. Higher storage temperatures increase the rate of self-discharge. Fully charged, the natural (“rest”) voltage of all EnergyCell batteries is approximately 13.0 Vdc. A battery should have a freshening charge (see page 12) if its rest voltage is below 13.0 Vdc per battery (2.16 Vdc per cell). A battery should not be used if its rest voltage is 12.0 Vdc or lower upon delivery. Contact the vendor upon receiving a battery in this state.

## Storing EnergyCell PLC Batteries

The EnergyCell PLC batteries must be given a freshening charge every 18 months when stored at 77°F (25°C). If stored in higher temperatures, the charge should be more often.

## Capacity

Battery capacity is given in ampere-hours or amp-hours (Ah). This is a current draw which is multiplied by the duration of current flow. A draw of X amperes for Y hours equals an accumulation of XY amp-hours.

Because the battery’s chemical reaction constantly releases energy, its amp-hour capacity is affected less by lighter loads. The battery has greater capacity under lighter loads.

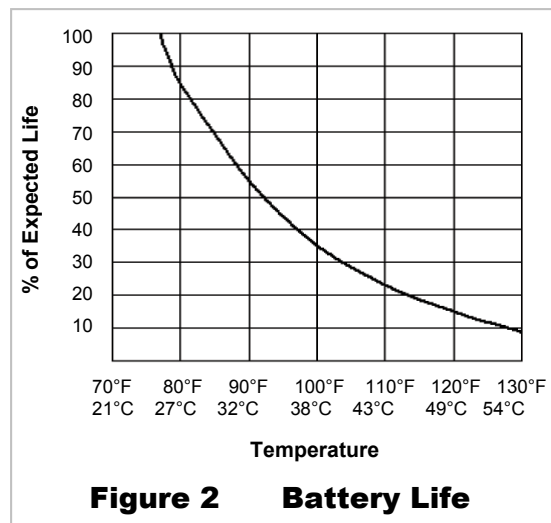
For example, if the EnergyCell PLC is discharged at the 48-hour rate to a voltage of 1.75 Vpc (a load expected to effectively drain 100% of its capacity in 48 hours), it will be measured to have 191 amp-hours. However, at the 4-hour rate, a heavier load, only 140 amp-hours will be measured. For all tested discharge rates and amp-hours, see Table 3 on page 19.

The EnergyCell 200 PLC is named after its capacity at the 100-hour rate when discharged to 1.75 Vpc.

## State of Charge

The EnergyCell SoC can be determined by two methods. One is to measure its voltage. This is accurate only if the batteries are left at rest (no charging or loads) for 24 hours at room temperature (77°F or 25°C). **If these conditions are not met, then voltage checks may not yield usable results.** If they are met, then on average, a battery at 13.0 Vdc will be at 100% SoC. A rest voltage of 12.2 Vdc represents roughly 50% SoC.

The more accurate method is to use a battery monitor such as the OutBack FLEXnet DC. Using a sensor known as a shunt, the monitor observes the current through the battery. It keeps a total of amp-hours lost or gained by the battery and can give accurate SoC readings.



**Figure 2 Battery Life**

## Installation and Operation

The EnergyCell can be discharged and recharged (cycled) regularly to a level as low as 50% depth of discharge (DoD). This is common in a cycling application such as an off-grid system. However, for optimal life, the best practice is to avoid ever discharging below 50%. Lower DoD levels can shorten the battery life.

If operated in a range with consistent charge and discharge to no more than 50% DoD, the EnergyCell PLC will typically have a life of 3,000 cycles. With consistently lighter discharge (10 to 30% DoD with proper recharge), the battery may have significantly more cycles.

For the anticipated cycle life, see the OutBack data sheet for the EnergyCell 200 PLC. (The cycle life can be affected by temperature. Figure 2 on the previous page shows the effect of ambient temperature on typical battery life.)

## System Layout

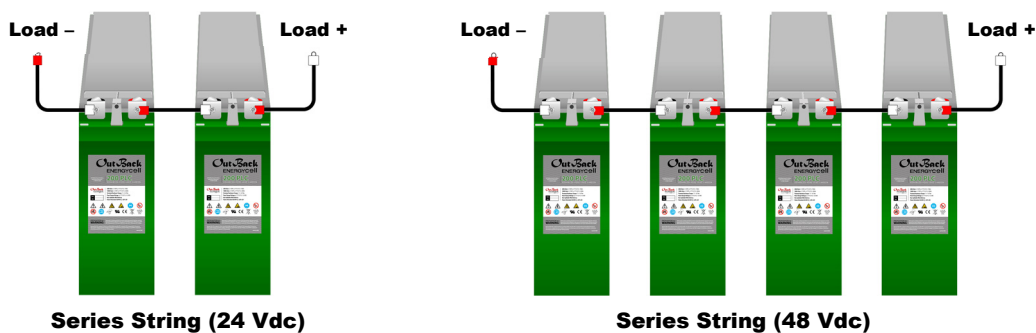


### CAUTION: Fire Hazard

Failure to ventilate the battery compartment can result in the buildup of hydrogen gas, which is explosive.

- o The battery enclosure or room must be well-ventilated. This ventilation protects against accidental gas buildup. All EnergyCell batteries are valve-regulated and do not normally emit noticeable amounts of gas. However, in the event of accidental leakage, the enclosure must not allow the leaked gas to become concentrated.
- o The battery enclosure or room must have adequate lighting. This is necessary to read terminal polarity, identify cable color, and view the physical state of the battery as required.
- o The battery should be installed with a minimum 36" (91.4 cm) clearance in front. This allows access for testing, maintenance, and any other reasons.
- o Multiple batteries should have a minimum of 1/2" (12.7 mm) clearance on either side.

## Battery Configurations



Batteries are placed in series (negative to positive) for additive voltages. Batteries in series are known as a "string". A string of two EnergyCell batteries has a nominal voltage of 24 Vdc and can be used for 24-volt loads. A string of four has a nominal voltage of 48 Vdc. Other voltages are possible. However, batteries in series do not have additive amp-hours. A single string of any voltage (as shown above) has the same amp-hours as a single battery.

When replacing batteries, a new battery should not be placed in series with old batteries. This will cause severe stress and shorten the life of all batteries. All batteries in a string should be replaced at the same time.

**Figure 3 Series String Configurations**



Batteries are placed in parallel (positive to positive, negative to negative) for additive amp-hour capacity. Three batteries in parallel have three times the amp-hours of a single battery. However, batteries in parallel do not have additive voltages. A single set of batteries in parallel (as shown in this figure) have the same voltage as a single battery.

**NOTE:** Use caution when designing or building systems with more than three EnergyCell batteries or strings in parallel. The extra conductors and connections used in larger paralleled systems can lead to unexpected resistances and imbalances between batteries. Without proper precautions, these factors will reduce the system efficiency and shorten the life of all batteries. For systems beyond three strings, contact an OutBack representative.

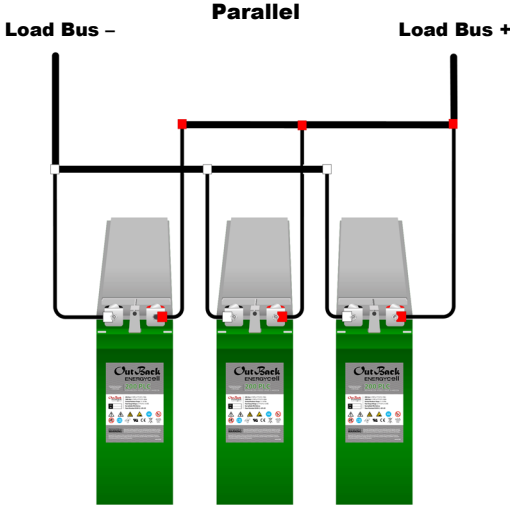


Figure 4 Parallel String Configuration

Batteries are placed in both series and parallel for both additive voltage and amp-hour capacity. Series strings placed in parallel have the same nominal voltage as each string. They have the same amp-hour capacity of each string added together. Two parallel strings of two EnergyCell batteries in series have a nominal voltage of 24 Vdc, twice the nominal voltage. They also have double the amp-hour capacity of a single battery. Two parallel strings of four batteries in series have a nominal voltage of 48 Vdc at double the amp-hour capacity of a single battery.

In a series-parallel bank, it is not recommended to connect the load to the positive and negative terminals of a single string. Due to cable resistance, this will tend to put more wear on that string. Instead, it is recommended to use “reverse-return” or “cross-corner” wiring, where the positive cable is connected to the first string and the negative is connected to the last. This will allow current to flow evenly among all strings.

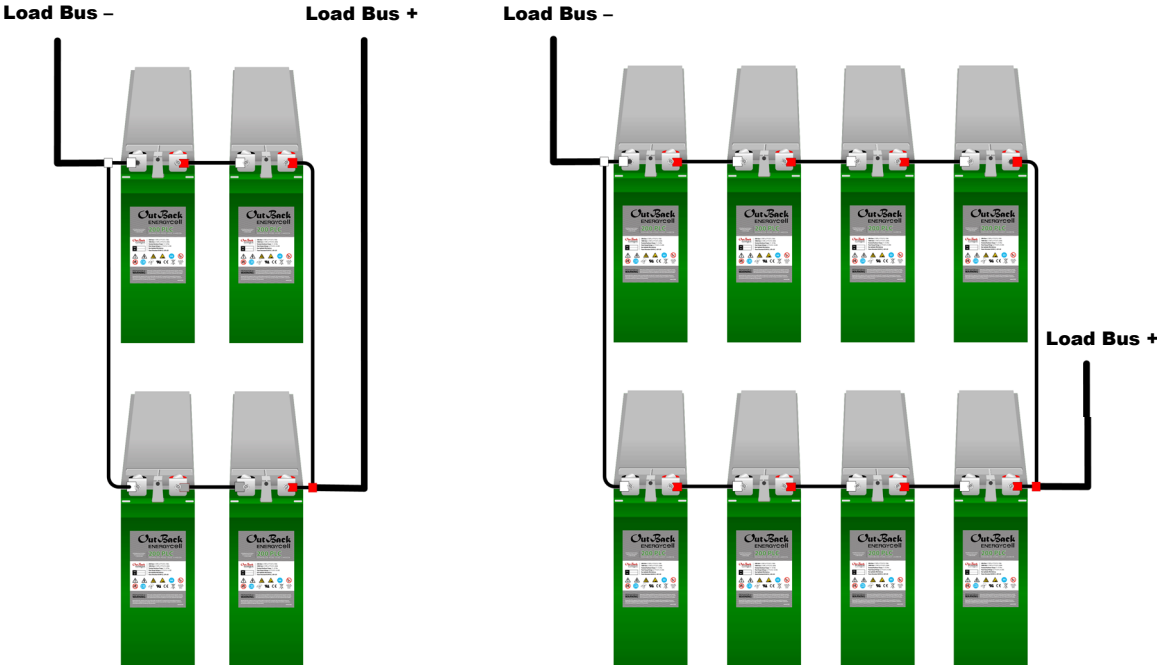





Figure 5 Series/Parallel String Configurations

# Installation and Operation

## DC Wiring

	<b>CAUTION: Equipment Damage</b> Never reverse the polarity of the battery cables. Always ensure correct polarity.
	<b>CAUTION: Fire Hazard</b> Always install a circuit breaker or overcurrent device on the DC positive conductor for each device connected to the batteries.
	<b>CAUTION: Fire Hazard</b> Never install extra washers or hardware between the mounting surface and the battery cable lug or interconnect. The decreased surface area can build up heat.

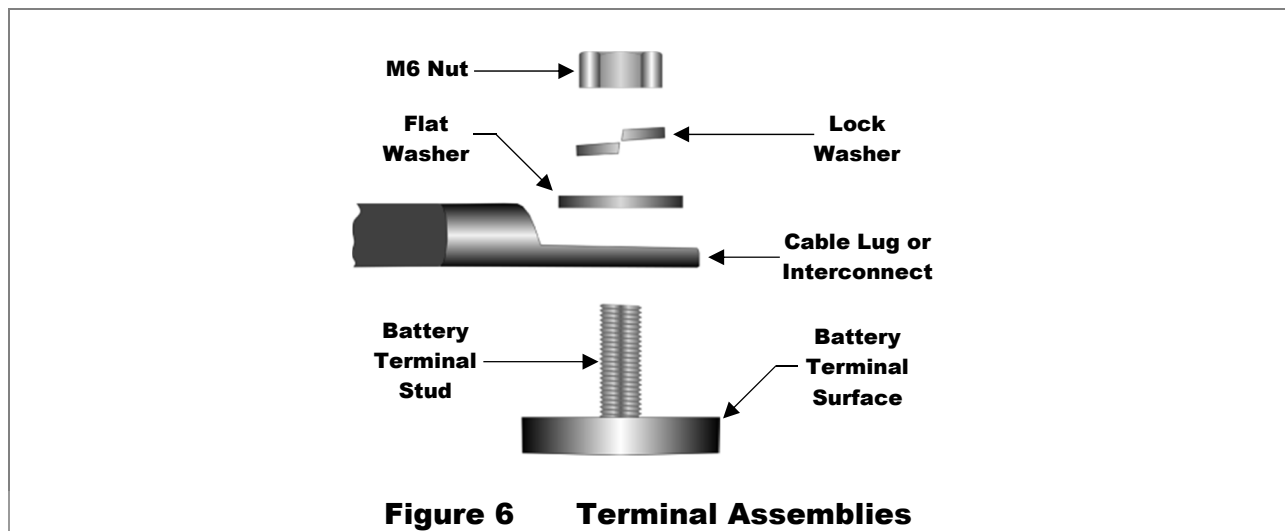
## Terminal Hardware

EnergyCell PLC battery terminals consist of a threaded stud which receives a nut. Terminal hardware is assembled as shown in Figure 6.

**NOTE:** Install the cable lugs (or interconnects) and all other hardware in the order illustrated. The lug or interconnect should be the first item installed. It should make solid contact with the mounting surface. Do not install hardware in a different order than shown.

**NOTE:** To avoid corrosion, use plated lugs on cable terminations. When multiple cables are terminated, use plated terminal bus bars.

Tighten the terminals to a torque value of 97.4 to 130.1 in-lb (11 to 14.7 Nm).



## Cleaning Battery Terminals

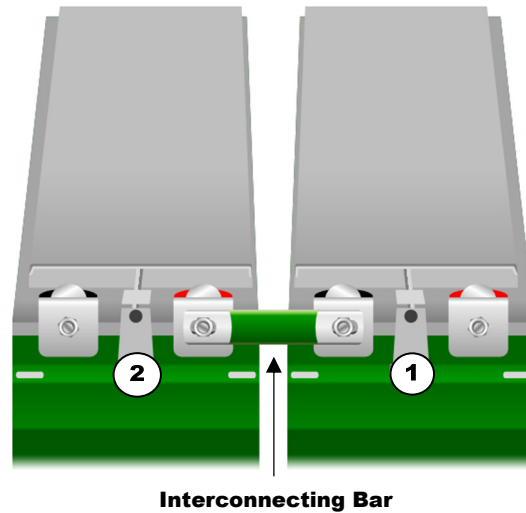
To minimize contact resistance, it is important that the lead terminals of the batteries be cleaned of any oxidation that may have occurred during transportation and storage. It is most convenient to clean them prior to placing them on the rack.

Lightly brush the terminal contact surface areas with a brass bristle brush or the equivalent. Next apply a light coating of special antioxidant grease such as NO-OX-ID or NCP-2 to the surfaces. This will protect the lead terminal from further oxidation.

## To make the DC connections:

Make certain to clean all terminals and contact surfaces according to the steps on page 10.

1. If installing batteries in a rack or cabinet, always begin with the lowest shelf for stability. Place all batteries with terminals facing to the most accessible side of the rack. If terminal protectors are present, remove and save them.
2. In common configurations, the battery on one end will be the positive (+) output for that string. This battery should be designated [1]. Proceeding to the other end, adjacent batteries in that string should be designated [2], [3], and so on.
3. If more than one string is present, designate the first string as A, the second as B, and so on. This should be done regardless of whether the strings are on the same shelf or higher shelves. Number the batteries in subsequent strings just as in step 2.
4. Install series connections. If an interconnecting bar was supplied, it should connect from the negative (left) side of battery [1] to the positive (right) side of battery [2] as shown above (see arrow). Top-terminal batteries require short interconnecting cables to be provided. Tighten interconnect hardware “hand tight” only.
5. Repeat the process as appropriate for batteries [2], [3], and any others in the string. Connect the proper number of batteries in series for the nominal voltage of the load.
6. If multiple series strings will be used, repeat this process for strings B, C, and so on.
7. Install parallel connections. Parallel connections are made from the positive terminal of one battery or string to the positive of the next; negative connections are made similarly. (See Figure 4 on page 9.) External cables or bus bars must be provided. Interconnecting bars cannot make parallel connections.
8. Use a digital voltmeter (DVM) to confirm the nominal system voltage and polarity. Confirm that no batteries or strings are installed in reverse polarity.
9. Install cables or bus bars for DC loads. Size all conductors as appropriate for the total loads. See the manual for the battery rack or cabinet if necessary.
10. Before making the final battery connection, ensure the main DC disconnect is turned off. If this is not possible, then do not make the final connection within the battery enclosure. Instead, make it at the load or elsewhere in the cable system so that any resulting spark does not occur in the battery enclosure.
11. Once hardware is installed and batteries are properly aligned, torque all connections to the appropriate value for the battery model. (See the requirements on page 19.) Lightly coat the surfaces with battery terminal grease. Reinstall the terminal covers if present.



**Figure 7 Connecting Batteries**



### IMPORTANT:

Before using the battery bank, commission the batteries as described on the next page.

## Commissioning

The commissioning charge applies when the batteries have been in transit or in storage for 24 months or more. (This applies at a storage temperature of 25°C or 77°F. The interval is shorter at higher temperatures.) It is also needed when the battery system is intended for use at the minimum float charging voltage or when the number of cells in series is greater than 24. Under any of these conditions, it is recommended the battery system be given a freshening charge at 2.35 volts average per cell for 24 hours. This will assure higher initial performance and will reduce the time period required for the cells to achieve proper voltage balance between the individual units.

### To apply a freshening charge:

1. Confirm the freshening (equalization) voltage from the charger/rectifier is set to a value equal to the Absorb Charging Voltage shown below.
2. Close the circuit from the charger to the battery and confirm that the battery accepts current.
3. Monitor the battery periodically and note that the operation is proceeding normally. Make certain that the current acceptance is declining and that the batteries are not overheating (within  $\pm 5^{\circ}\text{F}$  or  $\pm 2.8^{\circ}\text{C}$  of each other and the ambient temperature). Make certain that the individual battery voltages on equalization charge are  $14.1 \pm 0.50$  Vdc.
4. Terminate the freshening charge in the case of any extraordinary situation or after 24 hours.

## Initial Float Charging

Following the freshening charge the battery system should be placed on float charge at a value equal to the Float Charging Voltage shown in the following section. See page 13 for a description of float charging.

Prior to placing on float charge, assure the charger is set to the proper output voltage. After the battery system has been on float for approximately 24 hours, the float current acceptance should be greater than zero, but no more than approximately 0.005 Adc per rated ampere-hour capacity of the battery string.

## Charging

EnergyCell PLC batteries are usually charged using a “three-stage” charging cycle: bulk stage, absorption stage, and float stage. Most OutBack chargers follow this algorithm. However, not all chargers are designed or programmed the same way. The settings should be checked and changed to match the recommendations below if necessary.

## Charging Voltages

- o **Absorb Charging Voltage:** 14.1 Vdc
- o **Equalize Charging Voltage:** 14.1 Vdc (same as Absorb voltage but used under different conditions)
- o **Float Charging Voltage:** 13.5 Vdc

## Bulk Stage

The bulk stage is a constant-current stage. The charge current is maintained at a constant high level. The battery voltage will rise as long as the current flows. This battery has a recommended maximum current limit of 50 Adc which should not be exceeded. At excessive

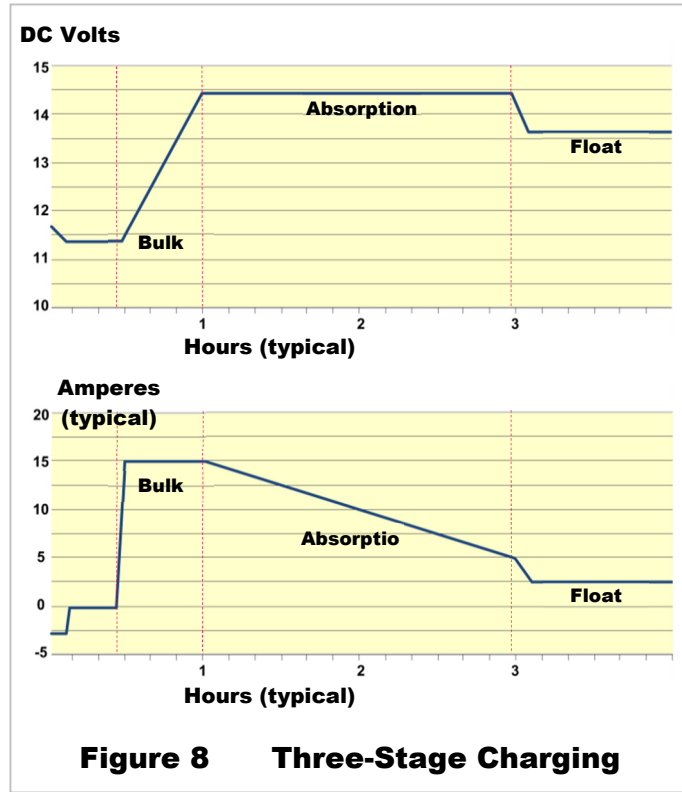
current rates, the battery's conversion efficiency becomes less and it may not become completely charged. The battery may permanently lose capacity over the long term.

The purpose of the bulk stage is to raise the battery voltage to a relatively high level (usually referred to as either bulk voltage or absorption voltage). This number is shown as the Absorb Charging Voltage on page 12. If batteries are in series, this number is multiplied by the number of batteries in the string. This stage typically restores the battery to 85% to 90% SoC, if the charge rate does not exceed the 50 Adc maximum.

## Absorption Stage

Absorption is a constant-voltage stage. It is established upon reaching the Absorb voltage setting. The charger limits the current flow to only what is necessary to maintain this voltage. A high current is required to raise the voltage to the absorption level, but less is required to maintain it there. As long as the absorption level is maintained, the requirement tends to decrease, causing a tapering current. The amount of absorption current will vary with conditions, but will typically decrease to a very low number. This "tops off the tank", leaving the battery at 100% SoC.

The battery is considered to be full when the following conditions are met: The charge current must taper down to a level between 1% and 2% of the total battery amp-hours (while maintaining the absorption voltage). The charger can then exit absorption to the next stage.



Not all chargers measure this in amperes. Many chargers hold the absorption for a timed period (often two hours), assuming that the current will taper down by then. However, if the charge ends before the current tapers to the desired level, the battery may not reach 100% SoC. Repeated failure to charge the batteries to 100% will result in decreased battery life. If possible, use a DC ammeter to observe and time the current as it tapers down. The absorption timer can then be set accordingly.

## Float Stage

The float stage is a maintenance stage which ensures the battery remains fully charged. Left with no maintenance, the battery will tend to slowly lose its charge. The float stage provides current to counter this self-discharge. As with the absorption stage, float is a constant-voltage stage which supplies only enough current to maintain the designated voltage.

The voltage requirements for float stage are much lower than for bulk and absorption. This number is shown as the Float Charging Voltage on page 12. The float stage should provide enough current to maintain the appropriate voltage. If batteries are in series, this number should be multiplied by the number of batteries in the string.

### Freshening Charge

A maintenance or “freshening” charge should be given to batteries that have been in storage. The freshening charge must be appropriate to the battery model. All charging should be temperature-compensated (see below). With a three-stage charger, the voltages for each stage are set as noted on page 12.

### Notes on EnergyCell PLC Charging

The current requirements for the absorption and float stages are usually minimal; however, this will vary with conditions, with battery age, and with battery bank size. (Larger banks tend to have higher exit current values for the absorption stage, but they also have higher float current.) Any loads operated by the battery while charging will also impact the requirements for the charger, as the charger must sustain everything.

Not all chargers exit directly to the float stage. Many will enter a quiescent or “silent” period during which the charger is inactive. These chargers will turn on and off to provide periodic maintenance at the float level, rather than continuous maintenance.

### Constant-Float Charging

“Constant-float” charging may be used with the EnergyCell PLC in backup power applications where the battery bank is rarely discharged. When a discharge occurs, it is critical to recharge the bank as soon as possible afterward. When charged with a constant-float charger, the charger should be set to maintain the batteries at 13.5 Vdc per battery in a string (2.25 Vpc) at room temperature. The batteries are considered to be fully charged when the cell voltage is maintained at this level and the charge current has dropped to a low level over a long period of time. In constant-float charging, it is critical to compensate the settings for temperature.

## Temperature Compensation

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

When a battery is cooler than room temperature, its internal resistance goes up, the voltage changes more quickly, and the charger reaches 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, its internal resistance goes down, the voltage changes more slowly, and the charger does not reach its voltages as easily. It will continue to deliver energy until the set points are reached, but this tends to be far more than required. The battery will be overcharged. (See **Improper Use**.)

To compensate for these changes, a charger used with the EnergyCell battery must have its voltages raised by a specified amount for every degree below room temperature. They must be similarly lowered for every degree above room temperature. This factor is multiplied if additional batteries are in series. Failure to compensate for significant temperature changes will result in undercharging or overcharging which will shorten battery life.

### EnergyCell PLC Required Compensation



The factor is 5 mV per cell (0.03 Vdc or 30 mV per battery) per degree C above or below room temperature (77°F or 25°C) when the battery is regularly cycled. The factor is 3 mV per cell (0.018 Vdc or 18 mV per battery) per degree C in constant-float applications.

## Remote Temperature Sensor

OutBack inverter/chargers and charge controllers are equipped with the Remote Temperature Sensor (RTS) which attaches to the battery and automatically adjusts the charger settings. When the RTS is used, it should be placed on the battery sidewall, as close to the center of the battery (or to the center of the bank) as possible.

The charger determines the RTS compensation factor. Most OutBack chargers are preset to a compensation of 5 mV per cell. If an RTS is not present, if a different charger is in use, or if a different compensation factor is required, it may be necessary to adjust the charger settings manually. The RTS should be checked periodically. Failure to compensate correctly may result in wrong voltages.

## Improper Use

	<p><b>CAUTION: Equipment Damage</b></p> <p>Read all items below. Maintenance should be performed as noted on page 18. Failure to follow these instructions can result in battery damage which is not covered under the EnergyCell warranty.</p>
	<p><b>CAUTION: Equipment Damage</b></p> <p>Do not exceed the specified absorption voltage when charging any EnergyCell battery. Excessive voltage could result in battery damage which is not covered under the EnergyCell warranty.</p>

For any EnergyCell battery, if the charger settings are too high, this will cause premature aging of the battery, including loss of electrolyte due to gassing. The result will be permanent loss of some battery capacity and decreased battery life. This is also true for battery charging that is not compensated for high temperatures.

“Thermal runaway” can result from high ambient temperatures, charging at higher voltages over extended time, incorrect temperature compensation, or shorted cells. When the buildup of internal heat exceeds the rate of cooling, the battery’s chemical reaction accelerates. The reaction releases even more heat, which in turn continues to speed up the reaction. Thermal runaway causes severe heat, gassing, lost electrolyte, and cell damage. It usually requires battery replacement. The process can be halted by turning off the charger. However, if cell damage has occurred, shorted cells may continue to generate heat and gas for some time.

If an EnergyCell battery is not charged completely (or if the settings are too low), it will not reach 100% SoC. Its total capacity will not be available during the next discharge cycle. This capacity will become progressively less and less over subsequent cycles. Long-term undercharging will result in decreased battery life. This is also true for battery charging that is not compensated for low temperatures.







# Troubleshooting and Maintenance

**Table 1 Troubleshooting**

Category	Symptom	Possible Cause	Remedy
Performance	Reduced operating time	Normal life cycle	Replace battery bank when (or before) capacity drops to unacceptable levels.
		Defective cells	Test and replace battery as necessary.
	Excessive voltage drop upon applying load	Excessively cold battery	Carefully warm up the battery.
		Undersized cabling	Increase cable ampacity to match loads.
		Loose or dirty cable connections	Check and clean all connections. Physical damage on terminals may require the battery to be replaced. Replace hardware as necessary.
		Undersized battery bank	Add additional batteries to match loads.
		Defective cells	Test and replace battery as necessary.
External Inspection	Swollen or deformed battery casing; "rotten-egg" or sulfurous odor; battery is hot	Thermal runaway <b>NOTE:</b> A modest amount of swelling (or concavity) on the battery case is normal.	<b>NOTE:</b> Thermal runaway is a hazardous condition. Treat the battery with caution. Allow the battery to cool before approaching. Disconnect and replace battery as necessary. Address the conditions that may have led to thermal runaway (see page 15).
	Damaged battery casing	Physical abuse	Replace battery as necessary.
	Heat damage or melted grease at terminals	Loose or dirty cable connections	Check and clean all connections. Physical damage on terminals may require the battery to be replaced. Replace hardware as necessary.
Voltage testing	Fully-charged battery displays low voltage	High temperature	Carefully cool the battery. An overheated battery may contribute to thermal runaway.
	Fully-charged battery displays high voltage	Low temperature	Carefully warm up the battery.
	Individual battery charging voltage will not exceed 13.3 Vdc; high float current; failure to support load	Shorted cell	Test and replace battery as necessary. A shorted cell may contribute to thermal runaway.
	Individual battery float voltage exceeds 14.5 Vdc; failure to support load	Open cell	Test and replace battery as necessary.
Current testing	Charging current to series string is zero; failure to support load	Open connection or open battery cell in string	Check and clean all connections. If battery appears to have an open cell, test and replace as needed. Replace hardware as necessary.
	Charging current to series string remains high over time	Batteries require additional time to charge	Normal behavior; no action necessary.
	Charging current to series string remains high with no corresponding rise in voltage	Shorted cell	Test and replace battery as necessary. A shorted cell may contribute to thermal runaway.

### Periodic Evaluation

Upon replacement of a battery, all interconnect hardware should be replaced at the same time.

To keep track of performance and identify batteries that may be approaching the end of their life, perform the following tests during on a quarterly basis following commissioning (see page 12). Tests must be made with a high-quality digital meter. Voltages must be measured directly on battery terminals, not on other conductors. All connections must be cleaned, re-tightened, and re-torqued before testing. If a battery fails any test, it may be defective. If this occurs under the conditions of the warranty, the battery will be replaced according to the warranty terms.

Bring the batteries to a full state of charge before performing the following test.

### Monthly Battery Inspection

- o General appearance and cleanliness of battery, battery rack and battery area.
  - Inspect for contamination by dust.
  - Inspect for loose or corroded connections.
  - If necessary, isolate the string/battery and clean with a damp soft cloth. Do not use solvents or scouring powders to clean the batteries.
- o Cracks in cell containers or leakage of electrolyte.
- o Any evidence of corrosion at cell terminals, connectors or racks.
- o Ambient temperature and condition of ventilation equipment.
- o Current and voltage during charge cycle. Measure individual battery voltages at the battery terminal. The measurements should be within 5% of the average.
- o Voltage at end of charge cycle. Measure individual battery voltages at the battery terminal. The measurements should be within 5% of the average.
- o End of discharge voltage measured at the battery. Measure individual battery voltages at the battery terminal. The measurements should be within 5% of the average.
- o Record findings clearly. List the dates for all entries.

### Quarterly Battery Inspection

This should include the monthly observations, plus:

- o End of charge voltage of every cell and battery terminal voltage measured at battery.
- o End of discharge voltage of every cell and battery terminal voltage measured at battery.
- o Electrolyte temperature in representative cell(s), typically one cell/tier distributed throughout battery.
- o Record findings clearly. List the dates for all entries.

### Annual battery inspection

This should include the monthly and quarterly observations, plus:

- o Inter-cell / inter-unit connection integrity.
- o Retighten terminals to specified torque values. See page 19 for specifications.
- o Record findings clearly. List the dates for all entries.



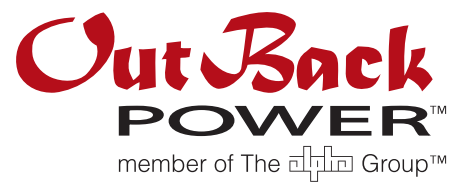
# Specifications

**Table 2 Specifications**

	<b>EnergyCell 200PLC</b>
<b>Cells Per Unit</b>	6
<b>Voltage Per Unit</b>	12V
<b>Optimal Operating Temperature</b>	68°F to 86°F (20°C to 30°C)
<b>Operating Temperature Range (Storage)</b>	-4° to 104° F (-20° to 40° C)
<b>Operating Temperature Range (Discharging)</b>	-40° to 149° F (-40° to 65° C)
<b>Operating Temperature Range (Charging)</b>	-5° to 140° F (-15° to 60° C)
<b>Float Charge Voltage</b>	13.5 Vdc
<b>Absorb or Equalize Charge Voltage</b>	14.1 Vdc
<b>Maximum Charge Current</b>	50 Adc
<b>Charging Temperature Compensation Factor</b>	±5 mV / °C / cell
<b>Relative Humidity</b>	0% to ~95%, non-condensing
<b>Terminal</b>	T11
<b>Terminal Torque<sup>2</sup></b>	97.4 to 130.1 in-lb (11 to 14.7 Nm)
<b>Weight</b>	~130 lb (~59 kg)
<b>Dimension L x W x H</b>	22.0 × 4.92 × 12.6" (559 × 125 × 320 mm)
<b>Warranty</b>	6 years (global), full replacement

**Table 3 Ampere-Hour Capacity to 1.75 Volts Per Cell at 25°C**

<b>Discharge in Hours:</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>8</b>	<b>12</b>	<b>20</b>	<b>24</b>	<b>48</b>	<b>100</b>
<b>EnergyCell 200PLC</b>	104	120	132	140	145	160	168	178	182	191	200



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