IMPORTANT DECISION FACTORS WHEN PURCHASING A DEEP-CYCLE BATTERY FOR RENEWABLE ENERGY APPLICATIONS

Deep-cycle lead-acid batteries are widely used in renewable energy and grid-backup applications as well as other applications including fork lift trucks, sweepers/scrubbers, golf cars, personnel carriers, recreational vehicles, marine motors and electric vehicles. Deep-cycle lead acid batteries are ideally suited for these applications because of their long, reliable life, low cost of ownership and nearly 100% recyclability. No other battery system has this combination of benefits. Many companies sell deep-cycle lead-acid batteries so it is important to understand that significant differences exist between the deep-cycle batteries on the market that affect overall performance and battery life. To make an educated buying decision you should consider a number of factors that have an influence on how well and for how long the battery will perform. In this technical brief we will review some of these factors.

FACTORS THAT AFFECT COST OF OWNERSHIP

When buying a deep-cycle battery there are several factors you should take into account that will help you determine the total cost of ownership over the life of the battery.

- **Price:** A battery with a low price is always attractive but if this is obtained at the expense of quality and battery life, the cost over time will be high because of frequent battery replacements. This makes it important to consider issues other than price in making the decision.

- **Capacity**: A battery's capacity is very important since this is the measure of the amount of energy stored in the battery. The capacity is measured in ampere hours (Ah) and the amount of stored energy is the capacity multiplied by the voltage.

Ampere hours x Volts = Watt hours.
Watt hours/1000 = Kilowatt hours

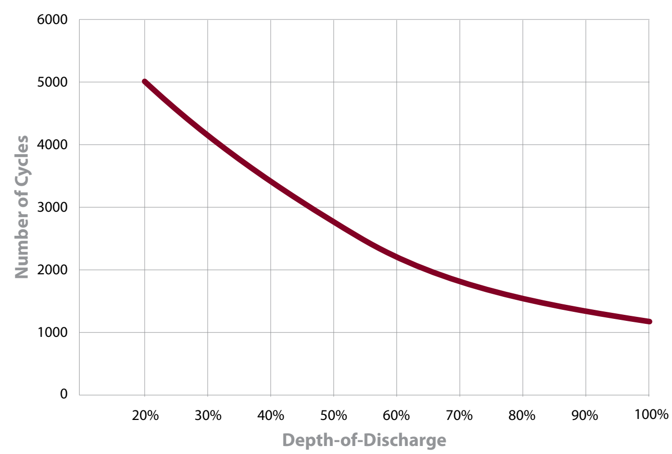
For example, a 100 Ah, 12V battery will contain 1200 watt hours or 1.2 kilowatt hours of energy, while a 200Ah, 12V battery will contain twice as much energy; 2,400 watt hours, or 2.5 kilowatt hours or energy. It is important that the battery is properly rated for the application because a battery with insufficient energy content will not provide long enough run time and will have a short life. An oversized battery also is a poor choice because it will cost more for no added value.

- **Voltage:** Individual batteries are combined together is series and parallel wiring configurations to create battery banks with the total Ah capacity and voltage required for the application. The battery bank voltage is important to consider in order to make sure it matches the system requirements. In a renewable energy system, the battery bank voltage is often determined by the inverter specifications if you are installing a DC to AC system, or by the voltage of the loads if it is a DC only system.

- **Brand:** Choosing a battery from a company with a reputable brand is important. Since many companies sell deep-cycle batteries, choosing a company with a focus on deep-cycle technology and with a history of manufacturing deep-cycle batteries means you will benefit from the company's experience in the industry.

- **Cycle Life:** The most important characteristic to consider when purchasing a deep-cycle battery for a renewable energy application is cycle life. This is usually measured as the number of discharge/charge cycles the battery can provide before its capacity drops to a specified percentage of its rated capacity (i.e. 50%). Batteries from different manufacturers may have the same capacity and energy content and be similar in weight, but design, materials, process, experience and quality control have a big influence on how long the battery will cycle. When comparing two batteries of equal Ah capacity and cost, a battery capable of 1,000 cycles is effectively half the total life cost of one that is only capable of 500 cycles.

EXAMPLE OF INDUSTRIAL LINE CYCLE LIFE GRAPH

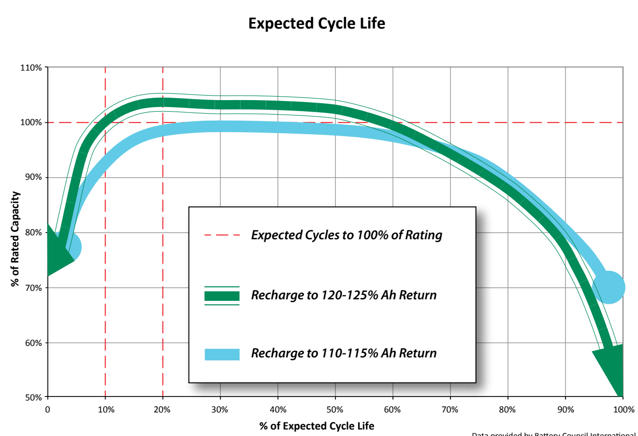


THE CHARACTERISTICS OF A GOOD CYCLING BATTERY

Batteries usually wear out because of degradation of the positive plates during use. The principal wear out mechanisms are softening and shedding of active material and corrosion of the grids that hold the active material. Negative plate failures are rare because their grids do not corrode nor does their active material soften and shed. The positive grids of a cycling flooded lead-acid battery are produced from a lead alloy that generally contains antimony in the concentration range of 4.0% to 6.0%. These grids have been proven to have a long life in heavy duty cycling applications. To assure long life of the positive active material, a high-density paste formula is used that produces a very durable active material. This is important because it produces plates that are resistant to the volume changes that take place during cycling. When the positive active material is discharged, the volume increases due to the higher volume of lead sulfate compared to lead dioxide. It shrinks by the same amount when the battery is charged. This frequent expansion and contraction degrades the active material structure over time causing it to lose cohesion. A low-density active material will break down during cycling whereas a high-density active material maintains its structure much better.

THE WARM-UP CHARACTERISTIC OF A GOOD BATTERY

In order to get the longest cycle life from the battery it is advisable not to convert all of the lead chemicals in the active material to lead dioxide and lead during the final charging step in the manufacturing process. This process is known as formation in the industry. The formed plates should contain about 85% of lead dioxide and lead and 15% lead sulfate. The reason for this is twofold: it reduces mechanical stress on the active materials caused by volume changes as described earlier, and it also provides a buffer of lead sulfate against the damaging effects of overcharging. This residual lead sulfate is gradually converted to lead dioxide during cycling which prevents active material degradation and grid corrosion. This is why the best deep-cycle batteries have a characteristic warm-up period early in their life. It can take as many 100+ cycles to fully charge this lead sulfate buffer before the battery develops its full capacity. The Battery Council International (BCI) has recognized this in their specification BCIS-05 for deep-cycle batteries as shown in the figure below.



BATTERY RATINGS

The nameplate rating on a battery is the fully developed capacity. Therefore, testing a battery immediately after it is purchased will be misleading since it may take up to 100+ cycles for a battery to reach its full capacity. You should beware of a battery that has its full capacity at the time of purchase or one that reaches its full capacity after a few cycles. The batteries with 100+ cycle warm-up will always outlast a battery with a high initial capacity.

The best way to ensure that you are getting what you pay for is to buy from a reputable manufacturer. Choose a company that has experience in manufacturing deep-cycle batteries and a reputation for integrity, quality and durability.

It is not uncommon to find inferior batteries on the market that are overrated. This is not only a dishonest practice but one which will lead to early battery failure. If you purchase a battery that is overrated, the capacity needed to power the load may not be available when it is needed and the battery may discharge to a greater level than anticipated when it is used. This causes active material degradation resulting in softening and shedding. In some cases the discharge will result in reversal of cells in the battery causing irreversible damage. The specific gravity of the electrolyte also will drop to a dangerously low value which will result in lead sulfate dissolving from the plates. This is subsequently deposited in the separators when the battery is charged and the specific gravity increases again. These crystalline pathways through the separators can short circuit the battery resulting in premature failure.

The only way to know if a battery is overrated is to carry out a capacity test. The BCI specifications BCIS-05 and BCIS-06 provide detailed information on how to determine the capacity of a deep-cycle battery. They recommend cycling the battery until its fully-developed capacity is reached before the rating is determined. The International Electrotechnical Commission (IEC) also has issued Standard 61427 specifically for deep-cycle type photovoltaic batteries.

It is not always practical for a user to do cycle life testing but a reputable manufacturer will have this data and will be prepared to show it to the customer. In addition, there are a number of independent test laboratories that carry out these tests at a reasonable cost.

In summary, the most important single factor to consider when purchasing a lead-acid battery for a renewable energy application is cycle life. This will allow you to determine the true value of the battery over its life by understanding the total cost of ownership.

We hope that this brief bulletin has given you useful information on the most important things to consider when selecting a deep-cycle battery.