Trojan BATTERY COMPANY

BATTERY MAINTENANCE FOR OFF-GRID PV SYSTEMS

MAXIMIZE YOUR RETURN ON INVESTMENT BY PROPERLY CARING FOR YOUR BATTERY BANK

Rapid growth in photovoltaic (PV) markets worldwide has stimulated increasing focus on batteries as a key component in power delivery solutions. Selecting the right type of battery can have a significant impact on the performance, durability and total cost of a system. The battery bank in an off-grid PV system often represents a considerable percentage of the overall equipment cost, so careful attention to proper selection and maintenance of batteries is important in order to maximize the return on your investment.

Batteries store direct current (DC) electrical energy produced by renewable sources, such as solar, wind and hydro, in chemical form. Because renewable energy charging sources are often intermittent in their nature, batteries provide energy storage in order to provide a relatively constant supply of power to electrical loads, regardless of whether the sun is shining, the wind is blowing or the river is flowing.

Batteries used in off-grid PV systems, no matter what the application, should be designed for "deep cycle" use, meaning their design and construction are optimized for the deep discharge and recharge cycles characteristic of renewable energy systems. Deep cycle batteries typically used in renewable energy systems fall into two primary groups: flooded lead acid (FLA) and sealed-valve regulated lead acid (VRLA). FLA battery technology provides the best cycling performance of all deep cycle battery technologies. It is the ideal option for most renewable energy applications where lowest life-cycle cost is a key system design objective. However, to achieve their maximum potential life, FLA batteries require regular care and maintenance.

Although maintenance is critical to the long-term life of a battery bank, it is not a substitute for poor system design or sub-standard installation. No amount of regular maintenance can compensate for the effects of an improperly sized or an incorrectly installed battery bank. Poor design or incorrect installation can be expensive, often resulting in additional battery bank purchases. Experienced renewable energy system designers and installers serve a critical role in helping to avoid the common design problems that impact overall battery life.

Once a system has been designed and installed properly, daily charging of the battery bank is perhaps the most important factor influencing the longevity of an FLA battery bank. Both under- and over-charging batteries can reduce the life of the battery. It is important to optimize systems to meet the load requirements of the application, while taking into account the specific nature of the charging sources available.

Batteries are simply an energy storage device, so it's critically important that a three-stage charge control mechanism is provided that can be optimized for the most efficient charging of the battery bank, regardless of the charging source. For systems that are charged exclusively with photovoltaic power, a charge regulator provides the means to control battery charging parameters. PV hybrid systems, which use generator backup, will often use a combined inverter/charger to provide supplemental charging to the battery bank. The charge settings of these devices need to be set according to the battery manufacturer's recommendations to ensure efficient charging.

Energy Storage Solutions
for Renewable Energy and Backup Power

The three stages of charging typically associated with daily charging cycles in an FLA battery bank are bulk, absorption and float charging. Bulk charging refers to a higher rate of initial charging that brings a battery to an 80 percent to 90 percent full state of charge and regulates at a pre-determined voltage set-point. Absorption charging is the stage immediately following bulk charging. The current is reduced to prevent over charging while maintaining the battery at a specific voltage set-point for a period of time, allowing it to complete the last 10 percent to 20 percent of the charge cycle. Float charging is the final stage of three-stage charging. The charge current and voltage are reduced to maintain a full battery, providing just enough charging to compensate for self discharge. Since temperature variations affect batteries, using a charging system with the ability to measure battery temperature will ensure that batteries will receive a proper charge. Always consult the battery manufacturer for recommended bulk, absorption, float and temperature compensation set-points to be sure the settings will provide for optimum charging efficiency. Some devices are programmable while others may have pre-programmed options. In either case, incorrect settings can potentially reduce the life of a battery over time.

As FLA batteries charge, hydrogen gas is produced and vented in the process. This off-gassing of hydrogen reduces the electrolyte level in the FLA battery and so periodic "watering" of the batteries with distilled water is required to ensure maximum life. Distilled water should only be added to fully charged batteries that are in float charge mode. While there may be some variation from manufacturer to manufacturer, electrolyte levels should never be allowed to go so low as to expose the battery plates to air. Trojan recommends watering its FLA batteries until the final level of the electrolyte is one-eighth inch below the vent well. While many installers recommend watering batteries on a monthly basis, the frequency will really depend upon how the batteries are used and the operating temperatures of the battery bank. With that in mind, new installations should be monitored more closely, perhaps weekly,

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to establish the watering frequency required. As FLA batteries age, their gassing rate will increase, requiring more water on a regular basis. Always wear protective clothing, gloves and goggles when working with batteries. The electrolyte in an FLA battery is a solution of acid and water, so take extra precaution to avoid contact with skin and clothing.

No matter how frequently a battery bank is watered, do it according to a regular schedule and take advantage of the opportunity to do a routine check of terminal connections. A poor electrical connection anywhere in the system, whether caused by a loose connection or corrosion, can lead to poor performance. Use tools with insulated handles when tightening connections, as batteries can easily short circuit by connecting the positive to negative terminal. To fully understand the potential risks associated with working around batteries, consult a local professional for assistance.

It's a good idea to evaluate the state of charge (SOC) of an FLA battery bank as a regular part of the maintenance procedures. Determining the SOC of an FLA battery bank can be accomplished by taking the open-circuit voltage reading of the battery bank with a voltmeter or by taking specific gravity (SG) readings of individual cells within a battery with a hydrometer. SG is widely believed to be the most accurate indicator of state of charge. Keep in mind that both voltage and SG readings will be more accurate if taken under a no-load condition, with all charging sources and loads disconnected from the battery. Keep a battery maintenance log to record both voltage and SG readings over time. Not only does this help when trouble shooting a potential problem in the future, but it also helps to establish a regular maintenance plan that otherwise might not be given the priority it deserves.

When using either voltage or SG readings as a means for understanding SOC, always consult the battery manufacturer's technical specifications for reference. Do not assume that all FLA batteries have the same voltage or SG readings to indicate a specific SOC percentage. For example, Trojan Battery Company's RE Series line of FLA batteries, which have been optimized for maximum life cycle in renewable energy applications, employ an electrolyte with a lower SG than most FLA batteries. The RE series FLA batteries are considered at 100 percent SOC with an SG reading of 1.265 while Trojan's standard deep cycle products are considered at 100 percent SOC with an SG reading of 1.277. Because there are variations among battery manufacturers and even among batteries from a single manufacturer, rely on manufacturer's data whenever possible when determining SOC.

Equalizing is a process by which FLA batteries are over-charged at a higher voltage for a period of time. Batteries are equalized in order to prevent electrolyte stratification. The process also reduces sulfation and cell inconsistencies, which develop over time and reduce overall system efficiency. As with watering, batteries should be in float charge mode prior to equalizing. The equalization process produces more hydrogen gas than normal charging, so steps should be taken to provide maximum ventilation of the battery bank. There are varying schools of thought on how frequently FLA batteries need to be equalized, and many controllers can be programmed to perform this function automatically. However, SG readings should be used to determine whether equalization is really required as well as whether the equalization process has been fully completed. Step-by-step procedures will vary depending upon the system's configuration, the charging source and the extent to which the battery is discharged and has been maintained up until the point of equalization. Trojan recommends equalizing batteries when specific gravity falls below 1.235 across all cells or when there is a wide range in specific gravities, 0.030 or greater, between cells. Again, referring to specific manufacturer recommendations and keeping good notes are key to long-term success when equalizing FLA batteries.

Many common, yet seemingly minor, mistakes made when designing renewable energy systems contribute to poor performance and shortened life of the battery bank. Most often, these mistakes result in a battery bank that appears to function well initially. Yet, if it never reaches a full state of charge on a regular basis, long-term damage will result. A battery bank that spends long periods of time under conditions of partial state of charge is potentially more likely to have a shortened life and premature failure. No two renewable energy systems are alike, given the wide range of potential loads, environmental conditions and sizing methodologies that might impact the system design approach. Likewise, FLA battery life depends on a number of factors, many of which seem difficult to predict or control. However, taking steps to commit to a care and maintenance plan for batteries in a properly designed and installed off-grid PV system will protect the initial investment and keep the total cost of ownership to a minimum.

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Trojan Battery Company: Founded in 1925, Trojan Battery Company is one the world's leading manufacturing deep cycle batteries and four ISO 2000:2001quality management certified plants within North America, Trojan Battery Company supports its renewable energy clients through a worldwide network of master distributors in over 50 countries. With the largest R & D facility in the USA dedicated to performance testing of deep cycle batteries, Trojan battery continually monitors product performance under true life cycle conditions. This dedication to continual product improvement allows us to set the standard for quality and longevity in deep cycle batteries used in off-grid renewable energy systems.