ISSN 2250-3153

Utilisation of Battery Bank in case of Solar PV System and Classification of Various Storage Batteries

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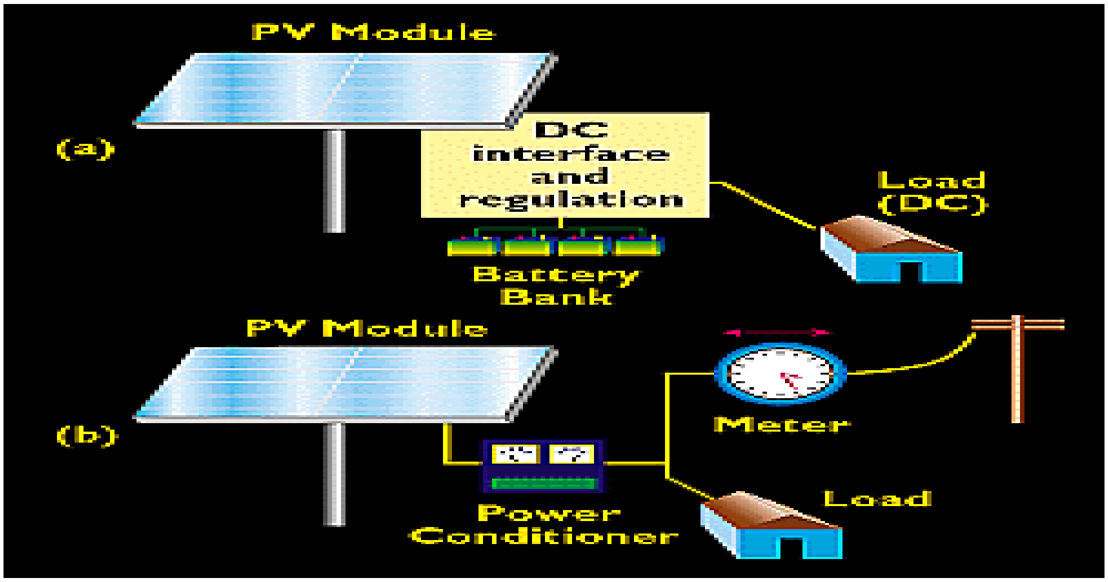
***Abstract*-** A battery storage system provides an independent source of power. This is essential for off-grid living where battery storage holds all energy produced by your solar, wind or hydro system. Note also that grid-connected solar power doesn't automatically provide you with an independent power supply - if the grid goes down then you lose supply completely. However, it is possible to add a battery storage option so that you have an uninterrupted power supply. A typical battery backup option would use a 400Ah 24V battery bank, which will provide approximately 6kWh of backup power, enough to run fridge/freezer/lights and TV for a day (longer, if it's sunny). This adds approximately $10,000 to cost of standard grid-connected system. These gel batteries require no maintenance as long as a backup generator is connected to keep battery levels high when solar or wind is not maintaining this supply. The Selectronics SP Pro inverter is recommended, as it will manage this system well. One can rest easily, just checking battery 'state of charge' only occasionally. This paper explains how a battery bank is utilized in case of Solar Pv system and also gives an idea about various types of batteries and their comparisons.

Index Terms- Insolation, CCA, VRLA, Cranking, Selectronics

I. Introduction

The principal problem to overcome with any PV system is that the sun does not shine on every part of the planet with equal intensity. This uneven availability of solar energy is greatly exacerbated in the Polar Regions. Daily and annual fluctuations in solar insolation necessitate storing excess energy for later use. Batteries are the technological solution most commonly employed for this purpose, but other energy storage mediums do exist. Fossil fuels and combustion generators can be used to provide on-demand power. Dynamic flywheels have been successfully utilized in several larger systems to kinetically store energy. On-site production and storage of hydrogen as an alternative fuel source holds great promise but is not quite ready for prime time as of this writing. All of these means are dealt with in greater detail elsewhere in this web site. For now, batteries provide the most cost-effective solution for energy storage for small- to medium-sized autonomous power systems. A battery stores electrical energy in the form of chemical energy. For a PV-battery system to function effectively, the electrochemical processes must work in both directions—in other words, the system must be rechargeable.

A PV system that is independent of the grid typically consists of a battery bank and charge controller. This type of system, a) in the following graphic, can be used to provide direct-current (DC) power, or with an inverter, can be used to supply power for alternating current (AC) loads. A PV system tied to the utility grid, typically consists of one or more PV modules connected to an inverter (or power conditioner) that changes the system's DC output to AC, which is compatible with the utility grid. You may include batteries in the system to provide reliable back-up power in case your utility experiences power outage



The figure: above illustrates typical arrangements for (a) a direct current off-grid, and (b) an alternating current grid-connected, residential PV system.

.**1. Functions performed by batteries in a Stand Alone PV System**.

Batteries perform three main functions in a stand-alone PV system:

1. Autonomy–by meeting the load requirements at all times, including at night, during overcast periods, or during the winter when PV input is low or absent.
2. Surge-current capability –by supplying, when necessary, currents higher than the PV array can deliver, especially to start motors or other inductive equipment.
3. Voltage control–thereby preventing large voltage fluctuations that may damage the load .

Figure shows Battery Bank

II. Need for a Battery Bank

Battery failure has often been the cause of suboptimal power system performance. Without a doubt, this is not the area to cut expenses. The battery bank for any power system must be of the highest quality available, of the correct type for the application, and of sufficient capacity to ensure that the depth of discharge does not exceed design parameters. The size of a battery bank for even relatively low-power applications can be surprisingly large, particularly if year-round autonomy is a design requirement. Cold temperatures reduce capacity but tend to extend battery life. System sizing worksheets (see the end of this document) are essential for ensuring adequate battery capacity for a given project. The most common type of battery found in PV systems is the lead acid battery. Although the discussion will focus on this blanket technology, other rechargeable battery types do exist, including nickel-cadmium (NiCad), nickel metal hydride (NiMH), nickel-iron (NiFe), lithium ion, and lithium polymer batteries. Of these, the NiMH and lithium polymer batteries show significant promise for broader application in autonomous power systems. These battery types demonstrate up to a four-fold greater energy density and enhanced performance across a wider temperature range, which might ultimately favor this emerging technology. NiCad batteries have been used in a few polar applications, as they have superior performance in extreme cold.

Figure shows how battery bank is connected to the supply system

III. Deep Cycle Battery

Any battery suitable for PV applications will be a deep-cycle type of battery as opposed to a starting (SLI) type. Although these two fundamental classes of batteries may appear similar on the outside, the internal structure is quite different. SLI batteries are intended to deliver a high-amperage output for a short period of time, but repeated deep discharges cause rapid deterioration of battery performance. These batteries are typically rated in cranking amps, or cold cranking amps (CCA). Deep-cycle batteries are designed to deliver a typically lower current for the size of the battery, but they are capable of withstanding numerous deep discharges without damage. The amount of energy a deep-cycle battery can store is referred to as its capacity. The unit that describes capacity is the amp hour (Ah) . Battery capacity is determined by the manufacturer based on a constant discharge over a period of time. Oftentimes, batteries will appear to have multiple ratings due to this rating process. The 20-hour rate (C/20) and the 100-hour rate (C/100) are referred to most frequently. When determining which battery to choose, be sure to compare all batteries at the same discharge rate. Deep-cycle batteries vary widely in type, price, and quality. Low-cost trolling batteries represent the low end of the scale and are generally not suitable for use in remote power applications. The most expensive battery per amp hour is generally the gel-cell battery.

IV. Lead Acid Battery

Adapted from Photovoltaics Design and Installation Manual (2004), SEI. vs. 85%-95% for lead acid), and restrictive charging parameters make them unsuitable for most applications. At the moment, the comparatively low prices and well-documented performance of lead acid batteries favor their continued use for remote power systems.

In the lead acid class of batteries, two specific types stand out for their applicability to polar power applications: the gel cell and the absorbed glass mat (AGM). These two types of batteries represent good choices not only due to performance characteristics but also because they are both suitable for air transportation. Because the electrolyte solution in both of these battery types is immobilized, they represent a lower hazard class than standard flooded batteries and do not require a great deal of specialized packing before being shipped via aircraft into the field. Although the performance characteristics of flooded deep-cycle batteries may meet or exceed those of the gel-cell and AGM types, the transportation and maintenance issues can prove to be quite problematic. Both of these types of batteries are classed together as valve-regulated lead acid (VRLA) batteries. A battery charging at a high amp rating or an excessively high voltage can release gases (hydrogen and oxygen) due to an overcharge condition. In a VRLA-type battery, gases are not released during a normal, controlled charge cycle. There is a closed loop that keeps the chemical levels balanced and internal pressures below the release threshold of the valve.

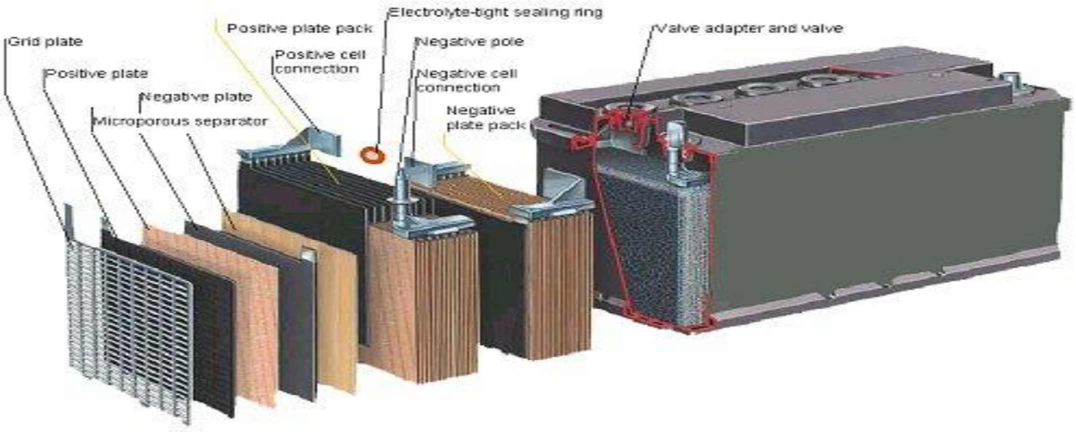


Figure shows Lead Acid Batteries

4.1 Difference between Gell cell and AGM Batteries

One very important difference to note between gel-cell and AGM batteries is that the gel-cell battery is a plate limited design, whereas AGM batteries are an electrolyte-limited design. This can be very important in polar applications where extremely cold temperatures are often the norm. Freezing the electrolyte solution in a battery must be avoided. It causes irreversible damage to the battery, which could lead to catastrophic failure. Also, a frozen battery cannot recharge until it has been thawed out again—not always a simple proposition in the field. Electrolytes freeze at higher temperatures as they discharge and the specific gravity decreases. AGM and flooded cell batteries can continue to discharge until the electrolytes become severely depleted, resulting in a low specific gravity and a relatively high freezing point. A quality load controller somewhat obviates this concern, as it will typically incorporate a low-battery disconnect capable of opening the circuit between the battery and the load prior to the onset of problems. In a plate-limited battery, the chemical reaction that causes the flow of electrons ceases before the electrolyte specific gravity falls too low. This provides a certain measure of inherent protection by design. Similarly, gel-cell batteries can recover more easily from a deep discharge due to the fact that they can more readily accept a charge when energy from the PV array once again becomes available. For small, low-current solar systems, gel-cell batteries seem to be the best choice. It is important to note, however, that gel-cell batteries are vulnerable to damage in other ways. Charging at excessively high rates can create voids in the gelled electrolyte that significantly reduces the capacity of the battery. Voltage and current must be carefully controlled and cannot exceed the C/20 rate (approximately 5% of the amp hour rating for the battery bank). For larger systems that incorporate other charging sources such as wind turbines or engine generators, AGM batteries may be preferable.

V. Non Lead Based Batteries

Non lead-based batteries such as nickel-cadmium batteries are costly but can last a very long time if they are not discharged excessively. A new type of nickel-cadmium battery, fiber-nickel-cadmium, has outstanding longevity at a 25% discharge rate. Nickel-cadmium (NiCad) batteries have different operating and maintenance characteristics than lead-acid batteries that must be considered. For example, it is difficult to measure the depth of discharge that is occurring with a NiCad battery since its output is constant right up to the last moments before being completely discharged. Check with the suppliers in the Resources section about the operation and maintenance characteristics of the NiCad batteries they offer.

Figure shows non lead acid batteries

VI. Conclusion

Batteries accumulate excess energy created by your PV system and store it to be used at night or when there is no other energy input. Batteries can discharge rapidly and yield more current that the charging source can produce by itself, so pumps or motors can be run intermittently.Battery capacity is listed in amp hours at a given voltage, e.g. 220 amp-hours at 6 volts. Manufacturer's typically rate storage batteries at a 20-hour rate:

220 amp-hour battery will deliver 11 amps for 20 hrs This rating is designed only as a means to compare different batteries to the same standard and is not to be taken as a performance guarantee. Batteries are electrochemical devices sensitive to climate, charge/discharge cycle history, temperature, and age. The performance of your battery depends on climate, location and usage patterns. For every 1.0 amp-hour you remove from your battery, you will need to pump about 1.25 amp-hours back in to return the battery to the same charge state of charge. This figure also varies with temperature, battery type and age

Acknowledgement

We would like to thank School of Electrical Engineering, KIIT University for providing necessary experimental platform for research and analysis for the completion of the paper.

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