AJ's Technical Tips: Lead Acid Batteries and the Problem of Over-Charging

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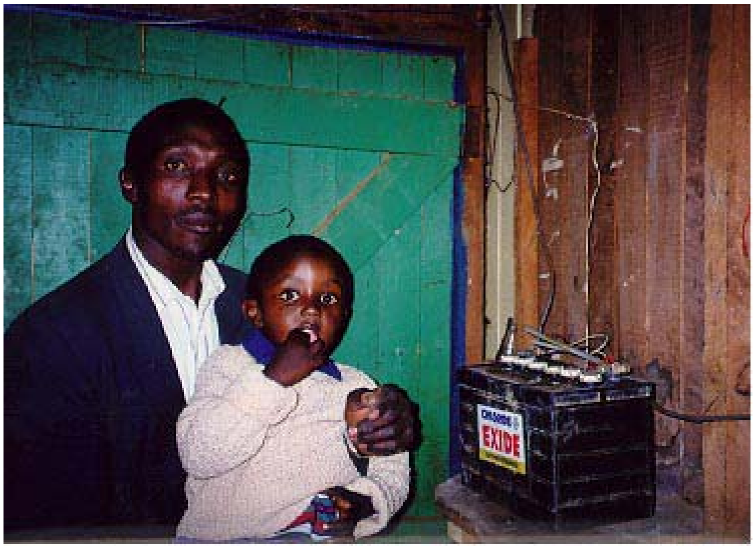
In this article I will discuss a set of issues related to the care and use of lead acid batteries in solar systems. Batteries are one of the most important components in a solar PV system, and they are also the hardest part of the system to manage properly.

I will start by highlighting the importance of good practices for battery care. Over the lifetime of a solar PV system, batteries are the most expensive part of the system. This may seem like a strange statement, since solar panels often cost more than batteries do. However, once you consider that a good solar panel might last 20 years, while the battery is often replaced every two to three years, this statement makes sense. I recently made some economic calculations related to the cost of using a 20 Watt solar PV system for a period of 20 years. This calculation included the initial cost of purchasing the solar panel, the battery, and other system components (such as wiring, lights, and the labor to install the system). It also included the cost of maintenance and repair of the system over 20 years. I found that over this 20 year period, approximately 50% of all expenses related to the system were for purchasing a new battery every two to three years as well as other battery care costs. The solar panel, while it is a big expense at first, only accounted for about 25% of the expenses over 20 years of system use. The remaining 25% of the costs were related to purchasing other components as well as for general system maintenance and repairs.

This cost analysis is based on the idea that the batteries will last about two years on average. However, it is possible to make the battery last longer than this if you buy a good quality battery and if you take good care of it. If the battery lasts four years instead of two, this adds up to a major savings over a period of 20 years. At the same time, it is possible to damage the battery very quickly through careless practices and this can add up to a major added expense. This highlights the importance of taking measures to take good care of the battery!

One of the ways that a battery can be damaged is through over-charging. Over charging occurs on sunny days when the battery is already fully charged. In some small solar PV systems over-charging is not a big concern because the solar panel is small and the battery rarely gets a full charge. However, there are many systems where over-charging is a concern. This is especially true for systems with a solar panel that is larger than 20 Watts. Over-charging is also a very important concern for systems of any size that include a sealed lead acid battery rather than a "wet cell" battery.

The most common batteries used in solar PV systems are "wet cell" lead-acid batteries. If you are working with a system that that uses a wet cell battery, you may have noticed that there are times on a sunny day when the battery in a solar PV system begins to bubble and fizz. When this happens there is often also a strong smell of battery acid in the room. This bubbling is a sign that the battery is beginning to be over-charged. It is OK to allow the battery to bubble for a little while. In fact, a little bit of bubbling is good for the battery, and it is important to reach the point where the battery begins to bubble on a regular basis. It is even good to allow the battery to bubble for several hours ONCE every three to four months (this is called giving the battery an "equalization charge").



Battery replacement is a major cost over the lifetime of a solar system. It is important to take good care of the battery!

However, too much over-charging is a bad thing for a battery. In other words, if the battery is allowed to bubble for a few hours per day on a frequent basis, the battery can be damaged and this will reduce its performance and shorten the life of the battery.

The information in Figure 1 shows the voltage of a battery over the course of one day in a system that is installed in the Naivasha area of Kenya. The system has three 12 Watt solar panels (for a total of 36 Watts) and a 100 ampere-hour battery, but at the time that I collected the information for Figure 1 it did not have a charge controller. During sunny periods the battery often got a full charge, and over-charging was a big problem.

The figure shows the voltage of the battery over one day. The time of day is shown across the bottom (8:00:00 is 8 AM in the morning, 12:00:00 is noon, and 16:00:00 is 4 PM in the afternoon, et cetera), and the voltage of the battery is listed on the left hand side. Early in the morning (from midnight until just before 8:00:00) the voltage of the battery was about 12.8 volts (this is shown by the black line with the small circles). A voltage of 12.8 volts at a time when there is no sun shining on the solar module (that is, at a time when the battery is not being charged at all) indicates that the battery is nearly at a full state of charge. At about 8 AM in the morning the sun began to shine on the solar panel, and it began to charge the battery. At this point the voltage in the battery began to go up. Over the morning, the voltage of the battery rose quickly, and by about 10 AM in the morning the voltage of the battery had reached 14.5 volts. At this voltage the battery will be bubbling and fizzing strongly. If the system had a charge controller, the controller would regulate the voltage so that it did not go too high. However, this system did not have a controller, so the battery voltage kept on rising above 14.5 volts, and by noon (12:00:00) the voltage had gone above 15 volts. The battery stayed at a high voltage level until after 4 PM in the afternoon (16:00:00) when the sun began to get lower and the sky and the charging from the solar panel began to slow down. After the sun went down (around 6 or 6:30 PM), the battery voltage dropped down below 13 volts.

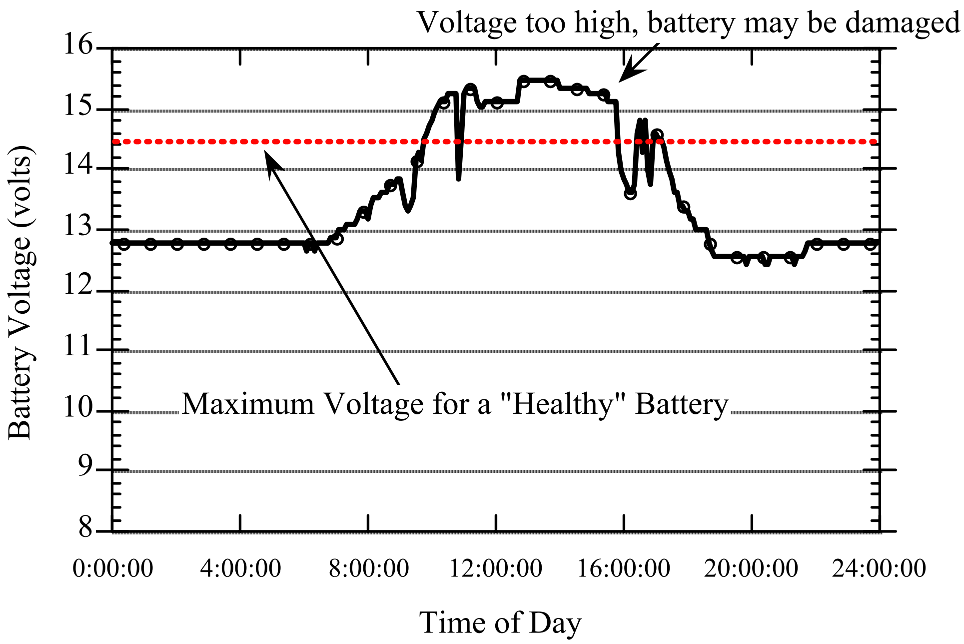


Figure 1: Battery Voltage versus Time of Day for a 36 Watt Solar System in Kenya; the system does NOT include a charge controller.

During the period that the voltage was above 14.5 volts, the battery was being over-charged. As I mentioned above, if the battery is allowed to go above 14.5 volts on a regular basis, it will be damaged quickly and the battery will have a short lifetime. I have drawn a dashed line across the graph to show where the battery was above 14.5 volts. In general, 14.5 volts is the maximum voltage for charging a wet cell lead acid battery.

The best way to make sure that the battery does not get over-charged is to use a charge controller. As I discussed in a recent article, one of the main functions of a charge controller is to prevent over-charging (see Solarnet, vol. 5, no. 2 from Jan., 2004). Therefore, the solution to the problem of over-charging is usually to make sure that the system includes a charge controller. In the case of this 36 Watt system, I convinced the owner of the system to add a charge controller in order to protect the battery from over-charging. Figure 2 shows the same system on a sunny day after the charge controller was added to the system.

The situation in the morning in Figure 2 is similar to what happened in Figure 1. That is, the battery voltage started the day at about 12.8 volts, which indicates that the battery was nearly full. Over the morning the battery voltage increased, but when it got up near 14 volts the charge controller began to regulate the charging in a way that kept the voltage below 14.5 volts. During the middle of the day (from about 10 AM until 4 PM) the charge controller kept the battery at a safe voltage. Then in the late afternoon the voltage dropped as the sun went down.

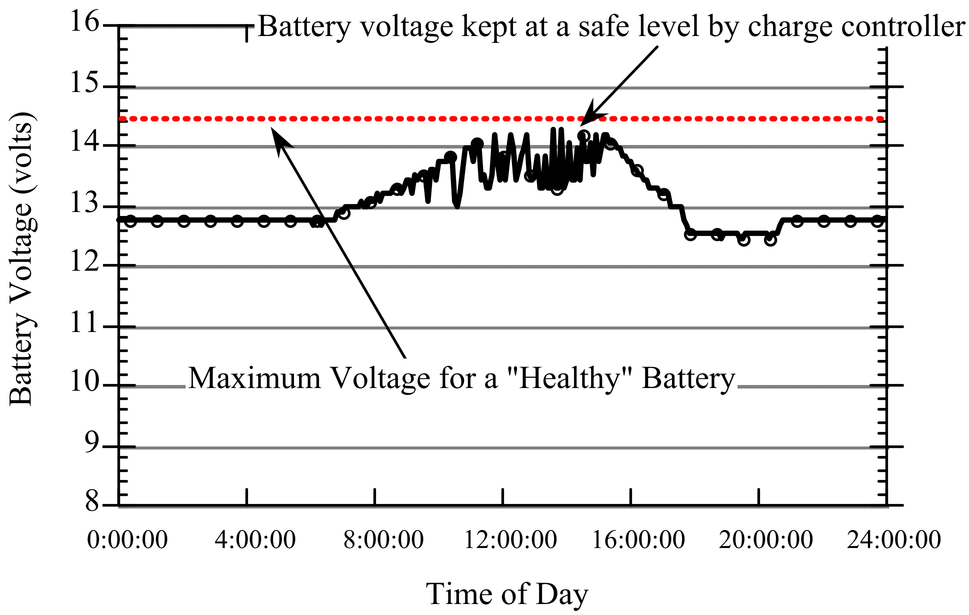


Figure 1: Battery Voltage versus Time of Day for the Same 36 Watt Solar System after a Charge Controller Was Added.

This comparison of what happened with the battery without a charge controller (Figure 1) and after the charge controller was added to the system (Figure 2) shows the important role of the charge controller for making sure that the battery does not get over-charged.

If you are working with a system that does not have a charge controller, there are ways that you can check to see if the battery is being over-charged. One sign that the battery may have a problem with being over-charged is given by the bubbling and fizzing that I talked about earlier. If the battery bubbles on a regular basis, then the system may have a problem with over-charging. Many system owners will notice if over-charging occurs frequently because it is possible to hear the bubbling, and there is also often a strong odor of battery acid in the room.

In addition, the acid level will go down quickly in batteries that are being over-charged. In these batteries it is necessary to add distilled water on a frequent basis. If you notice that you or the system owner needs to add distilled water very frequently (e.g. every 3-4 months), then the system may have a problem with over-charging.

If the system does have a problem with over-charging, then the best solution is to add a good quality charge controller to the system. See my recent Solarnet article for recommendations about how to select a good charge controller. I know that it can be difficult to convince a customer of the need to purchase a charge controller. One way that I have found to convince customers is by measuring the battery voltage at a time when the battery is being over-charged, showing the customer how high the voltage is, and explaining that this high voltage will damage the battery.

You can make this measurement on a sunny day using a volt meter when the battery has a high charge level. The measurement should generally be made in the middle of the day (between noon and 2 PM on a sunny day is best) at a time when the battery is bubbling strongly. If the battery voltage is above 14.5 volts, and especially if the voltage is above 15 volts, you can explain to the customer that this voltage is too high and that the battery is being damaged.

In this article I have focused on the problem of over-charging in wet cell lead acid batteries. Over-charging occurs when a battery that is fully charged continues to receive a charge. A small amount of over-charging is OK, and it is even good to over-charge the battery once every three to four months. This is called giving the battery an equalization charge. However, if the battery is allowed to over-charge on a frequent basis, it can be damaged quickly. Adding a charge controller to the system is the best way to solve this problem.

Over-charging may not be a problem for small solar systems (for example, systems smaller than 20 Watts), but it can be a problem for larger systems. In addition, sealed lead acid batteries (including “gell cell” batteries) are especially sensitive to over-charging. In general, systems that use a sealed battery should always include a charge controller, regardless of the size of the solar panel.

Until next time, *kwaherini*, and remember to send me letters at my NEW email address (arne@humboldt.edu).