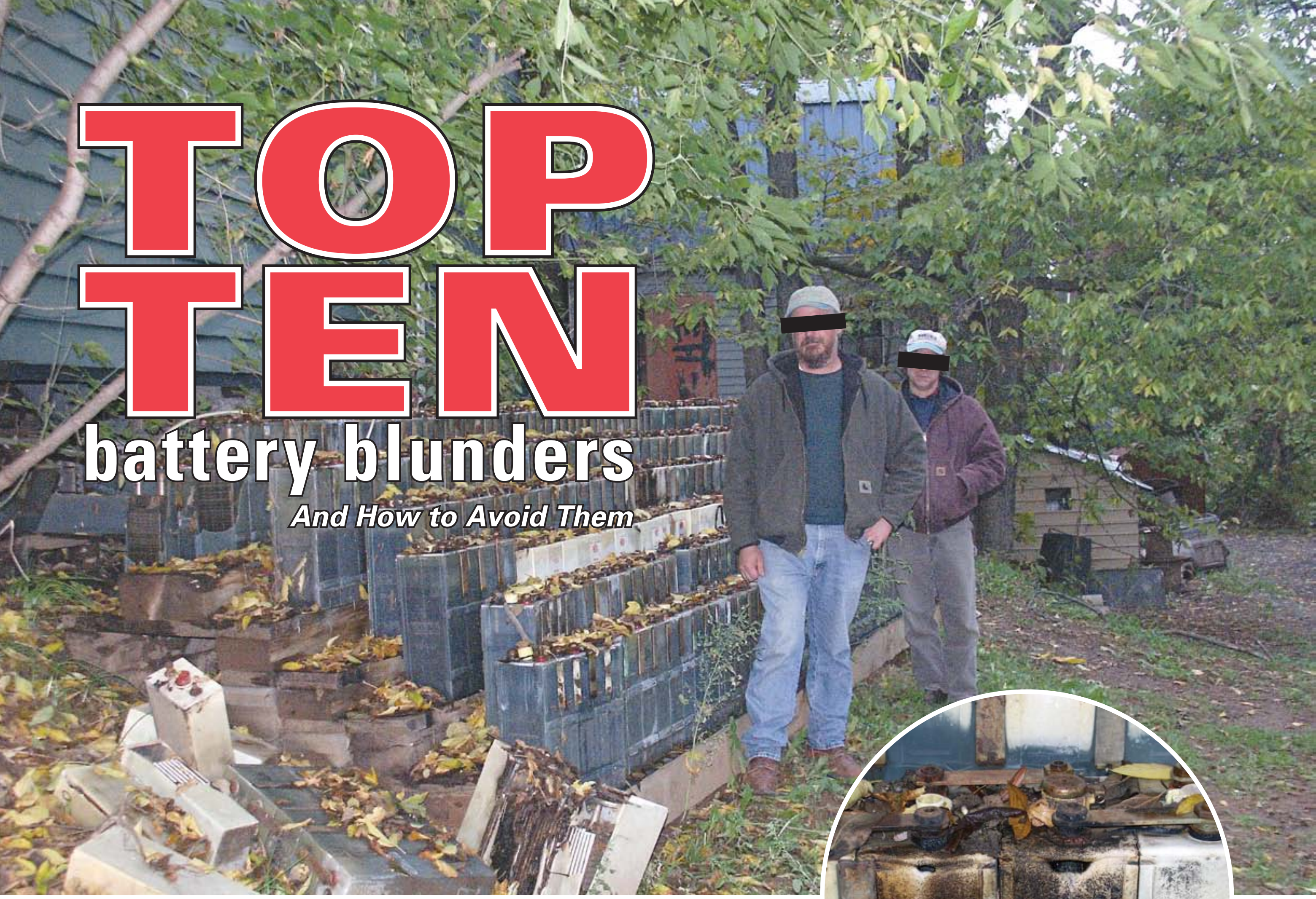
TOP TEN battery blunders

And How to Avoid Them



Above: Big battery, big mess. Don't try this at home.
Right: These batteries have definitely seen better days.

Windy Dankoff

Batteries allow us to store our renewable energy (RE) for times when the sun isn't shining and the wind isn't blowing. They are often called the "weakest link" in renewable electricity systems, but battery problems nearly always are the result of bad equipment choices, installation errors, and lack of attention—the human factor!

In my 27 years as a system supplier, I have seen serious battery-related mistakes made repeatedly, by amateurs and professionals alike (and I've made a few myself). The results can be expensive, hazardous, and damaging to the reputation of renewable energy. That's why I am presenting these classic blunders, and their ready solutions. High-quality batteries can last ten to twenty years, but they can die in one or two years if abused.

Nearly all battery-based RE systems use lead-acid batteries. So this article applies only to them (not to other battery chemistries). It applies to batteries charged by PVs, wind, microhydro, and engine generators, the utility grid, or any combination of sources. It applies to off-grid independent systems and also to grid-tied systems with battery backup.

BLUNDER #1

Wrong Battery Type

Batteries are built with a variety of structures and materials, according to the application. If you choose the wrong type, you will get poor longevity.

RE applications require batteries to discharge to below 50 percent of their storage capacity, repeatedly. This is called "deep cycling." A full-time, off-grid home system will typically experience 50 to 100 cycles per year at 30 to 80 percent depth-of-discharge. Always use high quality, deep-cycle batteries in RE applications. Engine-starting (car or truck) batteries are designed for quick, high-power bursts, and will survive only a few deep cycles.

The batteries used in grid-tied, emergency backup (standby) systems will only be deep cycled occasionally when there is a utility outage. Periodically, flooded, deep-cycle batteries need to be actively charged to mix the electrolyte. This prevents stratification of the solution. Because battery cycling/active charging may be very infrequent in standby applications, it's best to use batteries that are specifically designed for emergency standby or float service. They might not be good for hundreds of cycles, but they will stay in working order through years of light usage.

Starting batteries work great in your car, but will quickly fail if used in deep-cycle applications.

Another distinction is between "sealed" (maintenance-free) and "flooded" (liquid-filled) batteries. Most deep-cycle batteries are flooded. They require occasional watering, but tend to last the longest. Emergency standby batteries are often sealed, and they require no regular maintenance. Deep-cycle, sealed batteries are sometimes chosen because they eliminate need for a ventilated space and for easy access. Sealed absorbed glass mat (AGM) batteries are designed for float applications, and are a great choice for grid-tied PV systems that include battery backup. They typically cost up to twice as much as flooded batteries, and require more careful recharging regimens, but are the best battery type for standby applications.

BLUNDER #2

Improper Size

To design a stand-alone renewable energy system, you first establish an "energy budget"—the number of watt-hours you will consume per day. Next, you need to determine how many days of stored energy (autonomy) is required. This variable can range between three and six days (or more) depending on your average daily electrical consumption, the output of the RE charging sources and their seasonal availability, and your willingness to use a backup engine generator.

Most home systems grow larger over time. Loads are added, a PV array is enlarged, but a battery bank cannot be readily expanded. Batteries like to work as a matched set. After about a year, it is unwise to add new batteries to an established bank. If you foresee growth in your system, it is best to start with a battery set that is larger than you need. But be sure you have sufficient charging capability, or the battery bank will be chronically undercharged, which will lead to sulfation and premature failure.

A large battery bank requires a large charging source.

BLUNDER #3

Improper Watering

Flooded batteries require the addition of distilled water every two to six months depending on battery type, battery temperature, and on the charge controller settings and system usage. Some people forget to water their batteries. The photo at right shows a system that was ignored for more than two years. The low fluid level caused excessive gassing, and the plates to warp, short out, and spark, ultimately igniting an explosion.

But don't overfill your batteries, either. There is no need to fill them more frequently than required to keep the plates submerged. Fill them only to the level recommended by the manufacturer. Otherwise, during final charging, bubbles will cause excessive spatter and possible overflow, leading to corrosion of the battery terminals and wiring. Though an additional expense, a battery watering system simplifies battery watering.

An extreme result of battery neglect.

BLUNDER #4

Many Small Batteries in Parallel Strings

Use bus bars to parallel multiple series strings.

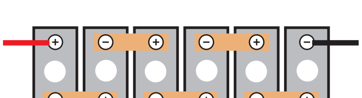
The ideal battery bank also is the simplest, consisting of a single series string of cells that are sized for the job. This design minimizes maintenance and the possibility of random manufacturing defects. Suppose you require a 700-amp-hour (AH) bank. You can approximate that with a single string of 700 AH industrial-size batteries, or two parallel strings of 350 AH (L-16 style) batteries, or three strings of 220 AH (golf cart) batteries. The diagram below shows these three variations.

A common blunder is to buy the smaller batteries because that approach is less expensive up front. The problem is that when current splits between parallel strings, it's never exactly equal. Often, a slightly weak cell or terminal corrosion will cause a whole battery string to receive less charge. It will degrade and fail long before other parallel strings. And because partial replacement aggravates inequalities, the only practical solution is to replace the entire battery bank. One way to reduce or avoid parallel battery strings is to use the highest DC voltage standard that is practical. The same batteries that would form two strings at 24 V can be wired all in one string for a 48 V system (now a common standard). The quantity of energy storage is the same, but the layout is simpler and the current at critical junctures is cut in half.

If you must have multiple battery strings, avoid stacking cable lugs at the battery terminals to make parallel connections. Instead, bring wires separately from each string to two bus bars outside the battery box. This reduces corrosion potential and helps create electrical symmetry.

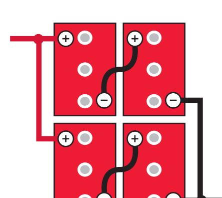
Single String

Large 2-volt cells wired in a single "string"—literally, one big battery.



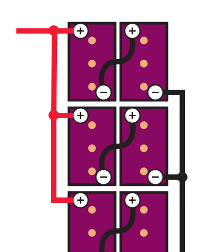
Two Parallel Strings

Medium-size batteries, two strings in parallel. Same amount of lead, equal energy storage.



Three Parallel Strings

Smaller batteries, three strings in parallel. Again, equal energy storage, but much more to go wrong.



BLUNDER #5

Failure to Prevent Corrosion

The fluid in flooded batteries gasses (bubbles) during the final stage of charging. When using flooded batteries, a trace of acid mist escapes and accumulates on the battery tops. This can cause terminal assemblies to corrode, especially any exposed copper, which causes resistance to electrical current and potential hazards. It's an ugly nuisance, but it's simple to prevent.

The best prevention is to apply a suitable sealant to all of the metal parts of the terminals before assembly. Completely coat battery terminals, wire lugs, and nuts and bolts individually. If the sealant is applied after assembly, voids will remain, acid spatter will enter, and corrosion will appear. Special products are sold to protect terminals, but many installers prefer petroleum jelly. It will not inhibit electrical contact. Apply a thin coating with your fingers, and it won't look sloppy.

Exposed wire at a terminal lug should be sealed, using either adhesive-lined, heat-shrink tubing or carefully applied tape. You can also seal an end of stranded wire by warming it gently, and dipping it in petroleum jelly, which will melt and wick into the wire. Or, you can solder the lugs. Whatever the method, these connections must be very strong mechanically. Batteries protected this way show very little corrosion, even after many years.

It's also important to keep battery tops clean of acid spatter and dust. This helps prevent corrosion and stray current across battery tops. Keeping battery tops clean is easy if you keep up on the job. A good habit to get into is to wipe the tops of the batteries with a rag or paper towels moistened with distilled water each time you water the batteries. Do not apply baking soda to the battery tops, since it might enter the batteries, neutralizing some of the electrolyte.

Notice the parallel connections on the left side of the photo—the worst corrosion is at these stacked cable lugs. Batteries with corroded terminals will receive less charge, and will fail early.

BLUNDER #6

Lack of a Protective Environment

Lead-acid batteries temporarily lose approximately 20 percent of their effective capacity when their temperature falls to 30°F (-1°C). This is compared to their rated capacity at a standard temperature of 77°F (25°C). At higher temperatures, their rate of permanent degradation increases. So it is desirable to protect batteries from temperature extremes. Where low temperatures cannot be avoided, buy a larger battery bank to compensate for their reduced capacity in the winter. Avoid direct radiant heat sources that will cause some cells to get warmer than others. The 77°F temperature standard is not sacred, it is simply the standard for the measurement of capacity. An ideal range is between 50 and 85°F (10–29°C).

Arrange batteries so they all stay at the same temperature. If they are against an exterior wall, insulate the wall and leave room for air to circulate. Leave air gaps of about 1/2 inch (13 mm) between batteries, so those in the middle don't get warmer than the others. The enclosure should keep the batteries clean and dry, but a minimum of ventilation is required by the *National Electrical Code*, Article 480.9(A).

A battery enclosure must allow easy access for maintenance, especially for flooded batteries. Do not install any switches, breakers, or other spark-producing devices in the enclosure. They may ignite an explosion.

A beautifully installed 48 V battery bank—sixteen 6 V batteries connected in two strings of eight. These big Surrette batteries have two holes on each terminal, so cable lugs don't have to be stacked. The peaked battery enclosure allows for excellent hydrogen venting.

BLUNDER #7

Lack of Proper Charge Control

Proper controller settings are critical for battery longevity.

When installing new charge controllers or inverters in your system, make sure to program the appropriate charge setpoints for your specific battery type. Battery-based PV systems will usually have a solar charge controller and an AC battery charger, for use with an engine generator or the grid. The AC charger will typically be built into your inverter. Voltage settings appropriate for your type of battery must be programmed into these devices. If incorrect charge setpoints are chosen, sealed batteries can be overcharged and lose their internal moisture. Flooded batteries will be deprived of a full finish charge and will deteriorate if charge setpoints are too low.

When batteries are cold, they require an increase in the maximum charge voltage to reach full charge. When they are warm, they require a reduction in the voltage limit to prevent overcharge. Choose a charge controller and inverter/charger for your system that includes temperature compensation. To use it, you must have a temperature sensor located at the batteries. You may need a temperature sensor for each charging device (including the inverter), but networked systems communicate the temperature from a single sensor to all charging components. Some small charge controllers have temperature sensing built in. In that case, be sure the controller is located where its temperature is similar to that of the batteries. Otherwise, it will be "fooled" into setting improper charge limits.

BLUNDER #8

Lack of Monitoring Devices

Battery management is sometimes called a "black art." That's true only if the user (or supplier) is in the dark. Have you ever driven a car without a fuel gauge? It can be frustrating! Yet, many battery systems don't have an equivalent device to show the state of charge (SOC), the level of stored energy.

Metering is not just bells and whistles. It provides crucial information for battery management, which in turn significantly increases battery longevity. Use a digital monitor, like the TriMetric (Bogart Engineering), IPN-ProRemote (Blue Sky Energy), or XBM battery monitor (Xantrex). These devices keep track of accumulated amp-hours and display the charge status of the battery bank. They also display other data that can be useful for maintenance and troubleshooting.

Install your monitoring device where it can be seen easily—in a central place in your home. Be sure the device is programmed properly, based on the parameters of your system. This needs to be done just once, during meter installation.

Two examples of modern battery monitors (amp-hour meters).

BLUNDER #9

Improper Charging

The surest way to ruin batteries within a year or two is to keep them at a low state of charge (SOC) for weeks at a time. Active battery material will crystallize, covering the plates, which will become permanently inert. We call this "sulfation." Ideally, batteries should receive a 100 percent full charge about once a week for good longevity, and more frequently is better. If this takes a full day of backup charging with a generator, do it! Use your monitoring system to know when full SOC is reached. If you don't have an amp-hour meter, watch for the voltage to reach maximum and the charge current to drop to a low level. This means the batteries are unable to accept much more energy, and are accepting only a "finish" charge.

In winter, some people run their backup generator for an hour a day—just enough to prevent the system from shutting down. Bad idea! It may be better to run it for ten hours, once a week, or whatever it takes to fully charge the batteries, instead of partially charging them more frequently.

Finish-charging a battery bank with an engine generator is an inefficient use of fuel, and results in extremely long generator run times. As a result, generators are typically shut down once the absorption charging stage is finished. But at this point in the charging process, the battery bank will only be at about 85 percent SOC. Since regular, full battery charging is important for battery longevity, make sure that your RE sources are topping off the battery bank after the generator has done the bulk of the charging. Relying on your PV system to provide the finish charge may be difficult during winter months. Another option is to set the inverter–charger to equalizing mode (see below) during generator charging about once a month to ensure that the battery bank is getting fully recharged.

The extreme of undercharging is called "overdischarging." Voltage should never, and I mean never, be drawn below about 11 V (for a 12 V system), or 22 V (24 V system), etc. System controls and inverters usually include a "low voltage disconnect" (LVD) function. If you have DC loads connected directly to the batteries without LVD, you are asking for trouble. It's better to lose power than to squeeze out another watt-hour and damage your batteries. Metering is vital here, because if you wait for the inverter to shut down or the lights to go dim, it's already too late—batteries will likely have lost a portion of their capacity and life expectancy.

Finally, flooded batteries need to be equalized at least four times a year. Exactly how often depends on several factors, including the size of the battery bank in relation to your charging sources and the average depth of discharge during cycling. During normal battery discharging/charging, the individual cells of each battery will stray from a common and consistent cell voltage. Equalization can be thought of as a controlled overcharge of the battery bank that serves to both equalize cell voltage, and provide an aggressive and necessary mixing of the battery electrolyte. Equalization charging can be done with your PV system if your array is large enough, or with an engine generator or the grid. Most PV charge controllers and inverter–chargers have battery equalization functions.

BLUNDER #10

Exceeding Your Energy Budget

If you remove more energy from your battery bank than you put in, your batteries will suffer. It's not the batteries' fault, yet this is the most frequent cause of complaints about batteries "not holding a charge."

Here is one common scenario: A well-meaning appliance seller or mechanical contractor sells you a device that uses "very little electricity." Ha! They don't know about the initial expense of solar electricity. For example, about US$3 will buy you about 40 KWH per month of grid electricity. But adding more PV and battery storage to meet this load could mean an investment of several thousand dollars! Or, without upgrading your system, this would require frequent generator backup (especially in winter). The same blunder also happens when a resident decides it's trivial to leave a coffee maker or large TV on all day. Even low power loads will add up if they're running 24/7. When people don't accept this reality, they overdraw their energy account, and often blame the batteries.

Warning!

Electrolyte in flooded lead-acid batteries is an acid solution. It will burn eyes and skin, and eat holes in clothing. When working around batteries, wear goggles, gloves, and old clothes. Keep baking soda at hand to neutralize acid spills, but never allow any of this alkaline solution to get into the battery. This will diminish the strength of the acid and reduce the battery's capacity.

Gassing (bubbling) of hydrogen and oxygen is a normal occurrence, especially during final, or heavy, charging. This gas is potentially explosive, so keep sparks or flames away from batteries.

Batteries can produce thousands of amps if a direct short occurs. Be very careful when working with metal tools around battery terminals. If you do not feel competent to install or maintain your battery bank, do not hesitate to hire an experienced professional.

Love Your Batteries!

If I had more pages, and I could show the Top 40 blunders, from transportation nightmares to eye injuries to divorce. The lesson: Accept professional advice and service.

Lead-acid batteries are an old but durable technology. They are about 80 percent efficient at releasing stored energy—few high-tech storage systems come close to that efficiency—and they rarely fail suddenly. With good management, you'll know when to replace them before they let you down. And even then, they are fully recyclable. Give your batteries what they need, and your batteries will do the same for you.

Access

Windy Dankoff • windy.hp@mac.com

Other Resources:

Frequently asked questions and answers about batteries • www.batteryfaq.org

"Batteries: How to Keep Them Alive for Years & Years…" by Windy Dankoff in *HP69*

"What is a Charge Controller?" by Windy Dankoff in *HP72*

Using the TriMetric (or other battery system monitor) to Maintain Your Battery System • www.bogartengineering.com/UsingTriMetMaintain.pdf

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