

The Importance of Batteries to Renewable Energy

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Lima, February 12, 2001

Renewable energy—clean, virtually unlimited, and free—is wonderful. Over the past decade or so, enormous progress has been made toward developing cost-effective methods of converting renewable energy to electricity, so that it can be used in the many applications now dependent on fossil fuels. Renewable energy is the cornerstone of the solution to what has been called the “trilemma” of

1. Securing energy and resources
2. Maintaining economic growth
3. Preserving the natural environment

However, as we know, while renewable energy is plentiful, it is also fickle. The sun doesn’t shine all the time and the wind blows sometimes too hard and sometimes not at all. That’s why we need to store the energy when it can be made, so that we can use it when we need it. That’s why many forms of renewable energy need batteries. Batteries are what make renewable energy practical.

This is not news to people active in renewable energy. They have been using batteries with wind systems and solar PV systems for a very long time. However, my message for you today is that there are great differences among

batteries and that the success of renewable energy, from cost and reliability standpoints is heavily dependant on the choice of battery—among a wide variety of types—and also on how the battery is used.

The simplest form of renewable energy system is a solar panel and a car battery. It works and, if all you want is a light or run a radio, it may be a cost-effective approach. However, as we try to become more sophisticated in our use of renewable energy, we have to recognize that we must take a systems approach to each application. One of the most important components of the system is the battery.

While, there are a number of different battery types, from a cost-performance standpoint, the only real choice for energy storage for renewable energy is the lead-acid battery. A French physicist, Gaston Planté, first constructed the lead acid battery in 1859. Basically, the lead acid battery works through an electrochemical reaction involving lead, lead dioxide, and sulfuric acid. The lead-acid cell consists of a negative electrode or plate of porous lead on a lead metal grid, and a positive electrode or plate of lead dioxide, also on a lead metal grid, both of which are immersed in an aqueous solution of sulfuric acid. The reversible reaction yields electrical energy when discharged and stores electrical energy when charged. In theory, these charge-discharge cycles can go on indefinitely. However, in practice the materials making up the battery are subject to degradation over time and, eventually, the battery fails. Much of the technology that has been brought to bear on the lead-acid battery over the years since it was invented has been aimed at improving the efficiency of the

electrochemical reaction, reducing the weight of the battery, and increasing the life of the battery. The modern car battery, termed a starting, lighting, and ignition battery (SLI) is a result of that technology. The car battery, which accounts for nearly 75% of all batteries sold, is optimized to provide starting power and to provide for car lighting and ignition requirements. However, because the batteries recharge whenever the car's engine is running, it is rare that the battery is fully discharged. It does happen, such as when you leave your headlights on all day and find that the car won't start when you get back to the parking lot. The battery is then recharged, after the engine is started or by a battery charger, and everything is fine. But, if you forget too often and you discharge your battery too often, you will find that the battery will completely fail much earlier than its design life. Car batteries simply aren't designed for "deep discharge". But "deep discharge" is exactly the kind of service that renewable energy demands.

Batteries capable of "deep discharge" tend to be heavier batteries, with thick plates. These types of batteries are typically used in industrial lift trucks, golf carts, and submarines. Until recently, these batteries were almost invariably of the "flooded" type, meaning that the batteries were filled with liquid sulfuric acid. While these batteries are rugged and are well suited to use with renewable energy systems, they do require frequent maintenance, particularly watering. Water losses in lead acid batteries are mainly the result of the gas evolution during electrolysis, and the water must be replaced. This watering requirement

can pose difficulties in remote areas and failure to add water on a regular basis can cause rapid failure. Leakage can also be a problem.

In the 1970's a new "sealed" type lead acid battery was introduced into the marketplace. These batteries use the principle of "oxygen recombination" to avoid the loss of water and, therefore, the batteries can be sealed and never need watering during their lifetime. In these batteries, the oxygen evolved at the positive electrode is transported and recombined with hydrogen at the negative electrode to form water. Because of the use of new alloys in the construction of the batteries, there is very little gassing, but a small amount of pressure may build up. A one-way valve that vents the gases controls this pressure. Because of this feature, these advanced lead acid batteries are called valve-regulated lead acid (VRLA) batteries. Also, the acid in VRLA batteries is immobilized either in fiberglass mat separators or in a silica gel. For this reason spillage and leakage have been eliminated.

VRLA batteries are very attractive because of their lack of maintenance requirements. Unfortunately, however, the initial experience with VRLA batteries in the field was less than satisfactory. Too often they failed prematurely and got the reputation of being unreliable. This early and somewhat unpredictable failure was termed premature capacity loss (PCL). However, beginning in 1992, a joint lead industry and battery industry research consortium was formed under International Lead Zinc Research Organization (ILZRO). The consortium was called the Advanced Lead Acid Battery Consortium (ALABC). Originally, ALABC's goals were to make technical advances in VRLA technology to assure

that lead acid batteries would be viable for use in electric vehicles. This meant targeting weight reduction, life, cost and recharge time as prime areas of research. Major progress has been made in each of these areas. In particular, the problem of PCL was addressed in a systematic fashion. The causes of premature failure were identified and solutions were brought to bear on the causes. These included the use of alloy additions to improve conductivity, the use of compression in the battery to eliminate discontinuities in the positive plate, and improvement in both the composition of the negative plate and charging regimes to improve charging of the negative electrode. The result of all this has been a demonstrable improvement in cycle life of VRLA batteries.

Because of the improved life of VRLA batteries, these kinds of batteries can now be used with confidence in service with renewable energy. But there are still further choices to be made. Do we choose VRLA's with the acid absorbed in glass mats or contained in a gel? One problem with the glass mat batteries is that, like flooded cells, they are subject to acid stratification. This phenomenon results in the build up of higher strength acid at the bottom of the battery. This is because sulfuric acid has a high density and, when formed during the charging process, can sink to the bottom of the battery container. This results in a decrease in battery capacity because of the uneven utilization of the active materials on the battery plates during discharge. Also if the uneven acid distribution is allowed to remain through many cycles, premature failure of the battery can occur. Acid stratification does not happen with gel VRLA batteries,

so this is a powerful reason for choosing gel batteries for use in renewable energy systems.

In choosing batteries for a given renewable energy application, consideration must be given to the service conditions, the load, and the manner of charging. Cost must also be a consideration, but initial cost also must be balanced against the cost of frequent replacement. In the case of the RESPAR project, which is being carried out in villages in the Amazon Region of Peru, we have a distinct set of circumstances that influenced our choice of batteries. Our main concerns were maintenance, life, and lifecycle cost. Eventually, a VRLA gel battery produced in Australia by Battery Energy South Pacific, called the Energel, was chosen. This heavy-duty battery provides 2 volts and 375 Ah per cell. Each cell weighs 39.5 kg. A total of 720 cells will be installed in the two villages. These batteries were designed in the laboratories of CSIRO, an Australian governmental laboratory and are optimized for remote area power supply (RAPS) duty. Their expected life is at least 8 years and could be longer, depending on the charge regime chosen. The cost is approximately \$160/kWh. Compare this cost to a typical car battery that may cost about \$50. That \$50 is equivalent to about \$70 per kWh, certainly cheaper on an initial basis. But in this service, a car battery would last no more than 18 months, if that long. Therefore, over the 20 year expected life of the RAPS system the cost of using the car batteries would be over double the cost of using batteries appropriate for the purpose. This does not take into account the cost of shipping, replacing, and recycling the car batteries every 18 months. Costs such as these and the poor performance of

inappropriate batteries can and have undermined the economic viability of renewable energy installations.

Therefore, the use of the proper kind of battery with renewable energy systems is important from a performance standpoint as well as from an economic standpoint. That is why I would urge those who are promoting renewable energy, particularly in developing countries, to insist that appropriate batteries be used. The type of battery chosen depends on the requirements of the system and the environment in which it will be operating. The choice of battery must be an engineering decision, not a political one. The success of renewable energy installations can be jeopardized by shortsighted governmental policies which require the use of “local content” batteries, usually meaning car batteries, or which levy high duties on imported batteries, just because batteries are produced in the host countries. The batteries that should be used in renewable energy systems are sophisticated electronic components, not a “commodity”. For pilot installations and for early replication, there should be no barriers placed in the way of using the best components to insure success. When a large market for specialized batteries is established, it is certain that local manufacturing facilities for VRLA batteries will be established to take advantage of savings in shipping and labor. When that occurs, developing countries will have realized the double benefit of having widespread renewables-based electrification and a whole new manufacturing industry.

