Battery Systems Overview

Battery Systems

Batteries are the key component for using renewable energy systems. Most of the energy generated is at non peak usage period. Batteries also represent the largest cost of the energy system. Depending on the type of the battery system used, they may have to be replaced over the lifespan of the solar or wind system, which are typically 20 years. Battery systems are highly dependent on the method to which they are used. Temperature and discharge depth have great effects on the life cycle and efficiency of the system.

Depth of Discharge

The depth of discharge (DOD) effect both the voltage output and the cycle life of the system. The more the cell is depleted the less voltage is outputted. This is how the controller limits how much power the battery can release. Once a battery is a certain voltage the release of charge is stopped or limited. The number of cycles that the batteries have in their lifespan corresponds to the depth of the discharge. The smaller the depth of discharge the longer the battery life span. Battery System are sized to only have certain depth of discharges. Generally non deep cycle batteries will on be drain to a depth of 70-80%. Deep cycle batteries will have a depth of discharge to around 30-40%. Fork truck batteries are popular types of deep cycle batteries that are being used.

State of Charge	12 Volt battery	Volts per Cell
100%	12.7	2.12
90%	12.5	2.08
80%	12.42	2.07
70%	12.32	2.05
60%	12.20	2.03
50%	12.06	2.01
40%	11.9	1.98
30%	11.75	1.96
20%	11.58	1.93
10%	11.31	1.89
0	10.5	1.75

Voltage at different DOD levels

Cycle life of a Battery					
Depth of a Discharge	10%	25%	50%	75%	100 %
No. of Cycles	3200	1200	500	250	200

Cycle life based on DOD

Battery Types

Lead Acid Systems uses an electrolyte of sulphuric acid in conjunction with lead grids to produce around 2.34 [V] per cell.   Usually one battery pack will emit 12 [V]. NiCad batteries will produce 1.2 [V] per cell making the amount needed increase.

Wet batteries – are the most common type of lead-acid type of battery in use today. Generally these types of batteries are cheaper and last longer. The main disadvantage of the wet battery is the accumulation of hydrogen that is emitted for the process. This means that they need to be storage in well ventilated areas. There are two types of Wet batteries one being “Flooded” and the other being Valve Regulated. The flooded types need water added every 6-12 months. The valve regulated does not need the addition of water because the oxygen evolved at the positive plates will recombine with hydrogen at the negative plates. The fluids inside the flooded batteries can become volatile if the hydrogen builds and spills outside the container.

Absorbed Glass Mat (AGM) - Uses fiberglass as a separator to hold the electrolyte in place. These types of batteries were originally developed for the Concorde airplane, thus can be orientated in any direction. These types of batteries do not require maintenance. The negative side is that there are limits as how it can be drained or charged. High variances can shorten the life cycle of the product.

Gel batteries - Use a silica compound to immobilize the electrolyte. If the container is cracked or broken the cell will continue to function. These types of batteries can be easily damage if over charged.

Lead Acid Batteries					
Type	Volts [V]	Amp-Hours [AH]	Discharge Time [hr]	Price [$]	Weight [lbs]
AGM	12	104-212	20	202-244	66-138
Flooded	12	220-357	20	75-1178	111-272
Gel Cell	12	97	20	255	74

Lead Acid Battery Systems

Nickel Cadmium batteries are more expensive but have a lot longer life cycle. The batteries can also be deeply discharge without affecting the life of the battery. NiCad batteries are hard to gauge when they are close to the end of their life. This is due to the difficulty in measuring the depth of the discharge. Another plus into using these types of batteries is that they are smaller and lighter. NiCad are dry batteries that require almost not maintenance.

Nickel Iron batteries have a long life cycle that last from 5- 35 years. The efficiency is only around 60-70%. This is mainly due to the slow charge and discharge rates. They have to be charged at a constant rate otherwise the can be a thermal runaway. Besides their longevity the batteries they can handle high vibrations, temperatures, and physical stress.

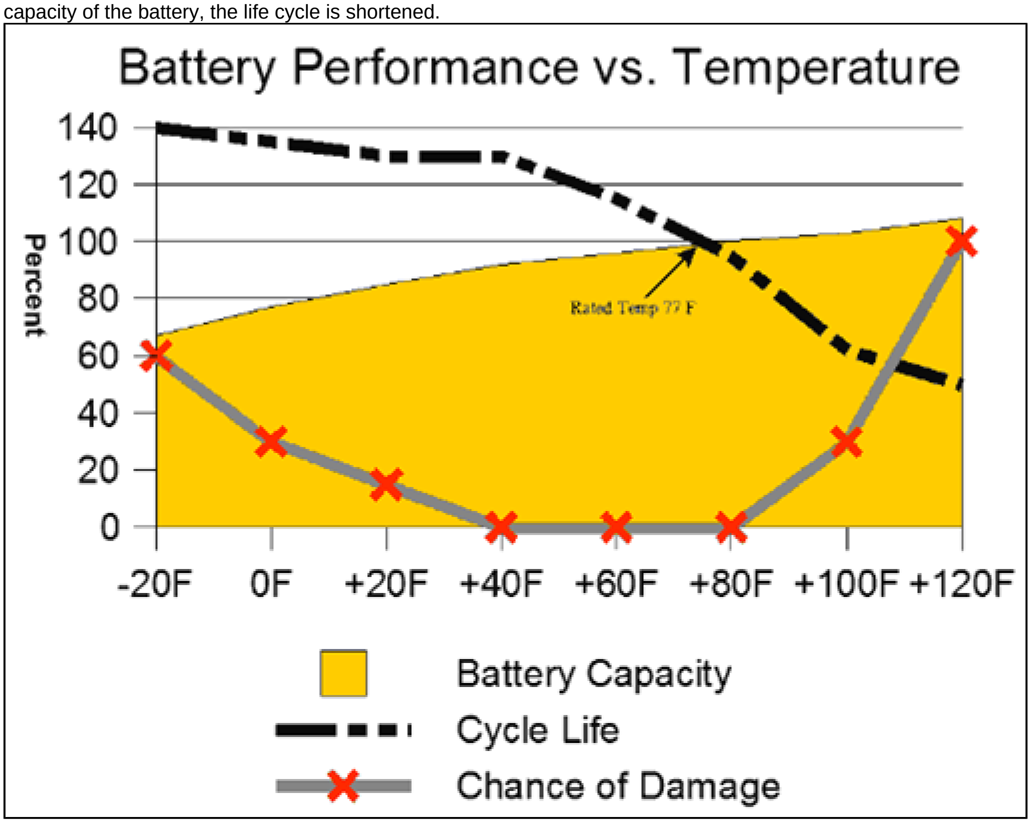
The configuration of the batteries depends if the system can be tied to the grid or not. Off grid systems have appliances that use less voltage, but may have to be run longer. Battery banks are wired in series to produce higher voltages or wired in parallel to produce higher amp hours. There are essentially two types of batteries, lead acid and everything else. Lead acid provides less cost per unit of storage, but there are pros and cons that may need to be justified.

Lithium Ion batteries have the most potential of any of the commercially available battery types. The price is currently declining at a fast rate. Li Ion batteries were better at lower temperatures such as 50-70 °F. The main draw backs to Li ion batteries are their sensitivity to non ideal conditions. They cannot be deeply discharged or overcharged. They can explode if operated outside normal operating conditions.

For more types of batteries Types of batteries

Battery Efficiency Based on Temperature Effects

The temperature also has a large effect on the batteries efficiency. For Lead-acid batteries the capacity is reduced when the temperature goes down and increases at higher temperatures. Typically a battery has a optimal operating temperature at 77°F. When the temperature reaches below 20 °F the capacity of the battery is cut in half. Temperatures above 120 °F the capacity increases by about 12 percent. This wide range of temperature affecting the capacity of the system calls for the need for the battery system to be stored in a climate controlled setting. Although higher temperatures improve the capacity of the battery, the life cycle is shortened.



Effects of Temperature on Battery output and cycle life

Sizing and Wiring a Battery System

Sizing a battery system depends on how many days of backup and depth of discharge that is desired. Typical systems will provide enough energy backup for 4-5 days without any energy source. Single source systems will also have more battery energy backup than hybrid systems. In general to find the total number of batteries need the follow ing equation can be used:

$$\frac{\#\ of\ Wh\ per\ day\ consumed * \#\ of\ days\ need\ for\ backup}{Voltage\ Output\ of\ Battery * \%\ of\ DOD * \#\ of\ Ah\ per\ battery} = \#\ of\ Batteries$$

The configuration of the batteries depends if the system can be tied to the grid or not. Off grid systems have appliances that use less voltage, but may have to be run longer. Battery banks are wired in series to produce higher voltages or wired in parallel to produce higher amp hours. There are essentially two types of batteries, lead acid and everything else. Lead acid provides less cost per unit of storage, but there are pros and cons that may need to be justified.

AGM system wired in Parallel and Series

Back to Small Scale Home Energy Integration

References

Hankins, M. (2010). *Stand-Alone Solar Electric Systems.* Washington DC: Earthscan.

Kemp, W. H. (2009). *The Renewable Energy handbook.* Tamworth: Aztext Press.

Maeda, M. (2010). *How to Solar Power Your Home.* Ocala, Florida: Atlantic Publishing Group.

Wind Sun. (2011). Retrieved April 2011, from Northern Arizona Wind Sun: http://www.windsun.com

Solar Blvd. (2007). Retrieved April 2011, from Solar Batteries: http://www.solarblvd.com/Batteries-For-Solar-Batteries:-Sealed-AGM/c3_30/index.html

Solaray. (1997). Retrieved April 2011, from Batteries: http://www.solarray.com/TechGuides/Batteries_T.php

Free Sun Power. (2011). Retrieved April 2011, from Solar Home: http://www.freesunpower.com/solarhome.php