STUDIES ON BATTERIES CONFIGURATIONS FOR ISOLADED POWER GENERATION SYSTEMS [1]

Weschenfelder, F.[2]
Schaeffer, L.[3]

Abstract

This article is based on the study of the best topology battery to be used in isolated power generation. An isolated system consists of solar panels, for example, the power generating source can vary, we can use wind, biomass. Also part of the system charge controllers, inverters and batteries. Currently, there are several types of batteries such as nickel-cadmium, lead-acid, among others. It is necessary to assess the feasibility of each for the desired application, according to the characteristics of the system being implemented. A solar generation system has several advantages, among which we can highlight its extreme simplicity, the absence of any moving mechanical part, its modular feature (from mW to MW), the short terms of installation, high reliability level systems and their low maintenance. Furthermore, solar PV systems represent a source silent, non-polluting and renewable electricity very well suited to integration in urban and isolated places, almost completely reducing the transmission losses of energy due to the proximity between generation and consumption.

Keywords: Batteries; Systems isolated power generation, Solar Energy.

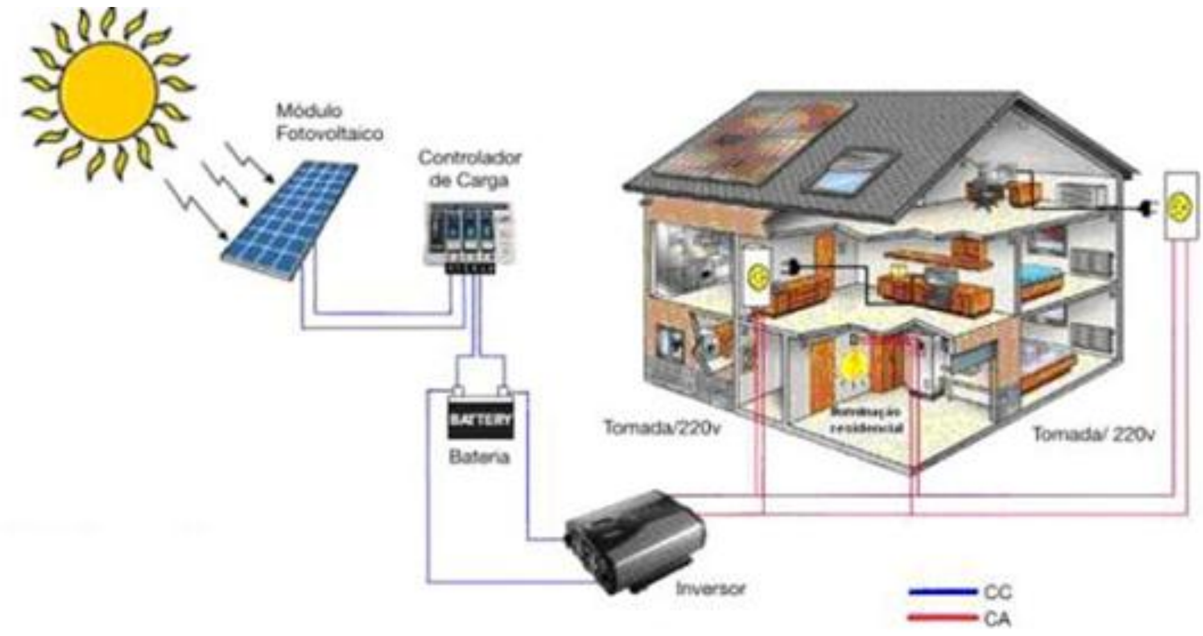
1 SENAFOR/2nd International Conference on Materials and Processes for Renewable Energy
2 Master's Student / UFRGS / franciele.weschenfelder@ufrgs.br
3 Teacher and Coordinator Laboratório de Transformação Mecânica – LdTM/ UFRGS.

1 INTRODUCTION

The last decades have been characterized by an important development and maturation of technologies for using renewable energy sources. Since 1980, photovoltaic systems, wind and biomass have increased the efficiency and consequently to become more economically viable. These systems have been running in various forms and strengths in various parts of the world with great success. Technologies for use of renewable energies, can no longer be regarded as unrealistic solutions within the overall context of rational use and energy saving [1].
Photovoltaic solar energy, renewable energy source obtained by converting light energy into electrical energy, is an option for isolated systems. The isolated systems are characterized by not connecting to the power grid. The system supplies directly appliances that use energy and are usually built with a specific purpose and location. This solution is widely used in remote locations since it is often the most economical and practical way to obtain electricity at these places. Examples of use are water pumping systems, electrification of fences, refrigerators to store vaccines, light poles, signal replicating stations, etc.. The energy produced is stored in batteries that guarantee supply during periods without sun [2].
The capacity and the electrochemical characteristics of various types of batteries available in the market show that for a project of this magnitude, knowledge of batteries is critical to a good choice. For any PV system with batteries, choosing the type of battery used will dictate the success or failure of the project [3].

2 ISOLATED SYSTEMS

The isolated systems for generating solar photovoltaics, simply, are composed of four components, Figure 1 shows a schematic of this system.



Font: Macroblock (2010)
Figure 1. Simplified schematic of an isolated system of solar generation.

2.1 Solar Panels

They are the heart of the system and generate the electricity that supplies the batteries. Has the property of turning solar radiation into electric current. A system can have only one panel or several panels interconnected as shown in Figure 2 [3].

Font: Solar EnergiesUK
Figure 2. Solar Panels

2.2 Controllers load

They are the heart valve and ensure the correct supply of batteries avoiding overload and deep discharge, increasing its life [3].

2.3 Inverters

Are the brain of the system and has the function to transform direct current (dc) into alternating current (AC) and cause the voltage, eg from 12V to 127V. In some cases it may be connected to another type of generator or the grid itself to supply batteries [3].

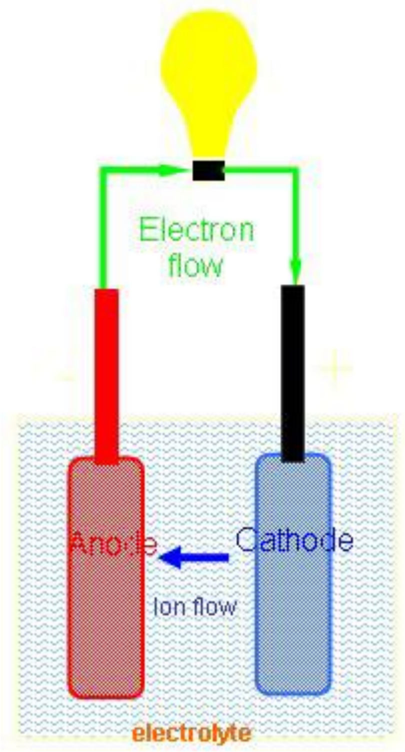
2.4 Batteries

They are the lungs of the system and store electricity for use at times when there is no power generation and no other sources of energy [3].

3 REQUIRED CHARACTERISTICS

A battery consists of four basic elements: an anode made of material that can contribute electrons, a cathode that will accept electrons, electrolyte and separator. The arrangement of these elements is shown in Figure 3, during battery discharge, the anode contributes electrons for oxidation, which generates positive ions. Similarly, the cathode generates negative ions in the process of accepting electrons [4].
A key element of a battery is a separator between the anode and cathode while permitting free flow of ions, flow of electrons is forced to travel on the external circuit,

completing the circuit. In a rechargeable cell the process is reversible, in the discharge cathode is the positive terminal and the negative terminal anode. However, during charging, the reverse occurs, now the positive terminal is the anode and the cathode negative terminal [4].



Font: (Vehicle Technologies Program)
Figure 3. Principal constituent parts of an electrochemical

3.1 Capacity

The capacity is characterized as the maximum current that a battery can deliver continuously for an hour, without causing their destruction. Its unit of measurement is given in ampere-hours (Ah). A battery that can provide two amperes at a time, not necessarily in two hours provides only one ampere, since the higher its discharging time, the greater its efficiency [5].

3.2 Rate “C”

The rate "C" is a measure of the current loading or unloading, in terms of capacity in one hour. As an example, a standard AA battery has a capacity at a time of about 500 mAh. Consequently, a charge rate of 2C is A 1 and a C/10 rate is 50 mA. Manufacturers usually specify the best discharge current to a particular battery type [5].

3.2 Discharge curve

The discharge curve of a battery can be characterized as the peak voltage value, nominal and when fully discharged. Generally, the charts provided by manufacturers to discharge curve are functions of the rate "C", as can be seen in Figure 4 [6].

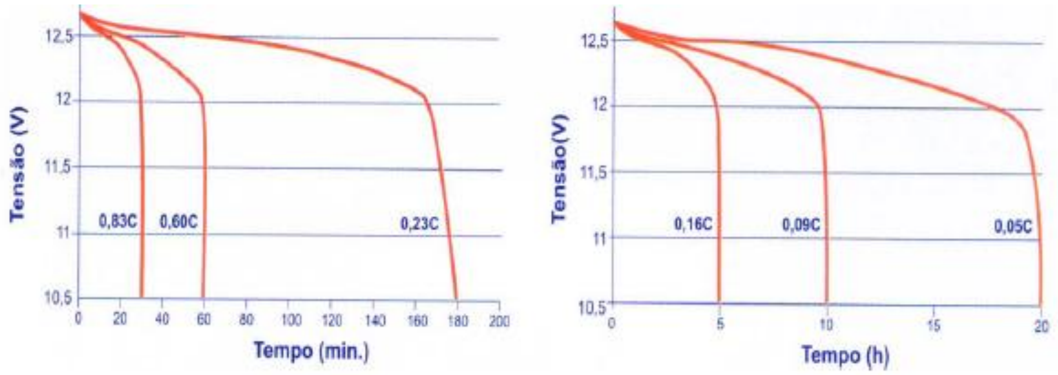


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Figure 4. Discharge curve for a lead acid battery manufacturer Moura

3.3 Energy Density

Energy density is how much energy a battery can store and provide for the application with a given battery size — the more energy dense the battery, the less volume and weight is needed [7].

3.4 Self Discharge

The self-discharge is the loss of stored energy when the battery suffers when it is not being used (loading or unloading). This effect is caused by the electrochemical process internal and resembles the effect caused by a small load connected to the battery, Table 1 shows the monthly discharge rate of some batteries [8].

Table 1: Monthly discharge of some batteries

Battery type	***Monthly discharge***
Lead-Acid	4% - 6%
Nickel - Cadmium	15% - 20%
Nickel - Metal Hydride	30%
Lithium	2% - 3%

Font: Marques, 2012.

3.5 Life cycle

Is given in numbers of cycles, followed by unloading cargo, that a rechargeable cell can provide. When considering the life of the battery can distinguish between aging and wear of the battery of the battery. The aging relates to processes and factors which tend to limit the duration of the battery physical integrity and their ability to perform the function predicted. Battery wear refers to processes that tend to limit the amount of electricity that can be stored or delivered [9].
Corrosion is a major component of the battery aging, this process can be greatly accelerated by harsh environmental conditions or improper maintenance, but these can presumably be controlled. Battery wear, moreover, is very much a function of a history of charging / discharging the battery is in particular subject to a standard of

abuse may cause the battery to fail long before it would be feasible only through processes aging [9].

4 ANALYSIS OF BATTERIES

4.1 Lithium-ion

Advanced technology that requires a protection circuit built into the battery. Li-Ion battery is used which states that a battery lighter and more hours of use (better than NiMH). Approximately 35% lighter than NiCd. State of the art in terms of chemical composition. Not develop memory effect. No need for conditioners. It provides more hours of usage and a longer operation than NiMH. Is not suitable for solar since it has longer charging time, has good performance in low temperatures and is the most expensive commercial battery [10].

4.2 Nickel Cadmium (NiCd)

The battery Nickel - Cadmium consists of an anode formed by an alloy of cadmium and iron hydroxide and a cathode (oxide) nickel (III) immersed in an aqueous solution of potassium hydroxide with a concentration between 20% and 28% by weight . The main drawback of this technology is its susceptibility to memory effect. Originally, the term memory effect was coined to describe a memory problem where the cyclic Ni-Cd battery would "remember" the amount of discharge for discharges previous life and limit the battery recharge. The problem is less prevalent with modern Ni-Cd batteries, which are designed to prevent memory problems cyclic. Contains elements toxic to the environment and must be recycled [10].
The battery has a good performance if left in the charger and only used for short periods of time, which prevents its use in solar systems, as this application will be carrying throughout that period there brightness [10].

4.3 Nickel-Metal Hydride (NiMH)

The nickel-metal hydride (Ni-MH) can be considered as the successor of nickel-cadmium batteries, with the advantage of not containing toxic heavy metals in its composition, and have greater energy density. Moreover, they are considered more environmentally correct as they may reduce the problems associated with the disposal of rechargeable nickel [11].
The metal hydride electrode has a higher energy density than a cadmium electrode, so the mass of active material for the negative electrode used in a nickel-metal hydride batteries can be smaller than that used in nickel-cadmium batteries. This also allows one to use a larger amount of active material for the positive electrode, resulting in an increased capacity or discharge time for this battery [10].
It has poor charge retention, since it undergoes a process of self-discharge of approximately 2% per day. It has moderate memory effect. Generally provides more "run time" (time between each recharging of use), but a lower life cycle (the number of times that the battery can be charged / discharged) than most NiCd. Not active at temperatures as low as NiCd. Discharge more quickly when stored for long periods of time without use. Are more sensitive to damage caused by heat [11].

There are two main factors that hinder the use of this type of battery for isolated systems, the first is the high cost of the same and the second factor is the high self-discharge [11].

4.4 Lead acid

The lead-acid batteries were invented in the nineteenth century has as basic components lead or lead oxide and sulfuric acid. As the battery lead / acid is discharged, the sulfuric acid is consumed and water is produced. The composition of sulfuric acid in the electrolyte and its density varies from 40% (m/m), and 1.30 g/cm3, in the fully loaded state, to about 16% (m/m), and 1.10 g/cm3; in the discharged state [12].
Among the advantages that make it viable is the application of energy generation can be mentioned that have inexpensive, available in large quantities and a variety of sizes and shapes. They have good charge retention for applications in intermittent loads. Available in the form of free maintenance, low cost compared with other secondary systems. The cell components are easily recyclable, Figure 5 shows the components thereof [12].
The limiting this option are the low life cycle (50 - 500 cycles). Energy Density limited - typically 30-40 Wh / kg, long term storage conditions of discharge can cause irreversible polarization of the electrodes (sulphation). Difficulty in manufacturing in small sizes, hydrogen release some models can cause an explosion (flame inhibitors are installed to prevent this), the release of some toxic gases when present can be hazardous to health. And, there is heat loss in improperly designed batteries [12].

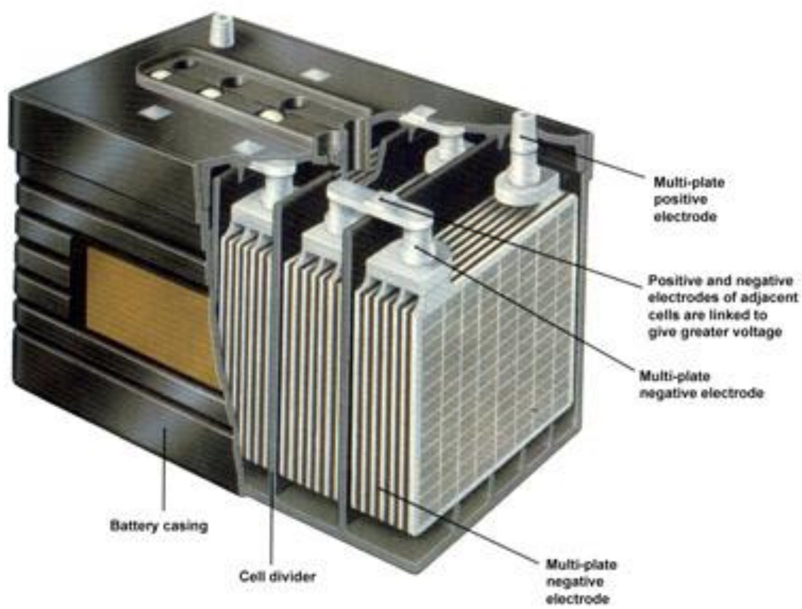

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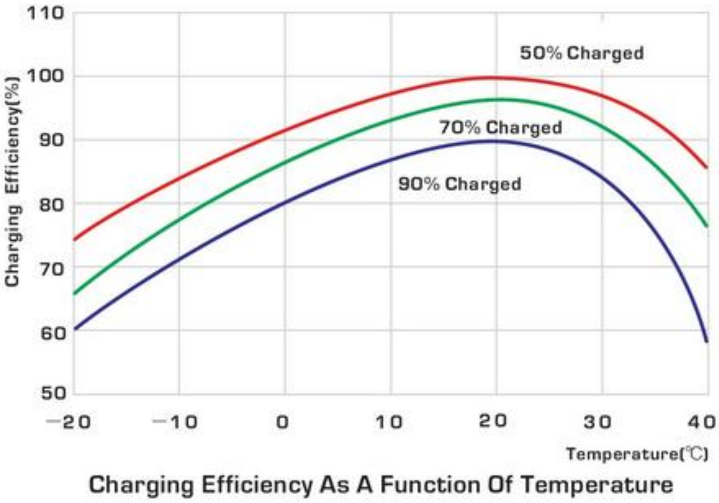
Figure 5. Lead-acid Battery

4.5 Iron - Nickel (Battery Edison)

Edison batteries (Ni-Fe) are rechargeable batteries are designed to store DC power systems for power generation alone, without a network connection. The optimum temperature of operation thereof is between -20 ° C and 50 ° C. Unlike lead acid batteries that have a life cycle of approximately 7 years, nickel-iron systems have an expected lifetime of 25 years or more and therefore become a choice for environmentally sensitive off-Grid systems and applications storage of renewable energy [13].

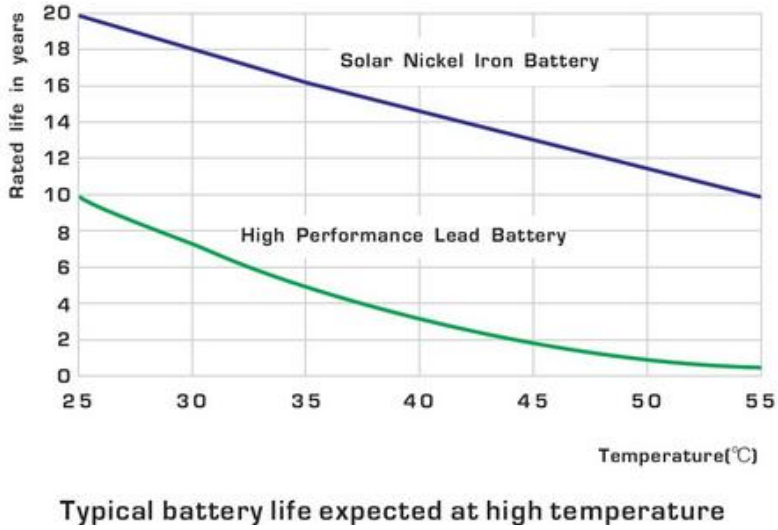
Fonte: (Alibaba product -131277179)
Figura 6. Edison Battery

The efficiency of loading depends on the temperature at which the cell is exposed, and also the state of charge that it lies. Figure 7 shows the variation in the efficiency of this process related to temperature. You can see that the efficiency can be 50% and reaches 90% if the two parameters are controlled [13].



Font: (Willians, 2011)
Figure 7. Efficiency Battery Edison [13].

Cells nickel-iron (Edison) are designed for a lifetime of 20 years but the temperature increase of the electrolyte will reduce the useful life. In general, all 9°C of temperature increase above the normal ambient temperature of 25 °C reduces the lifetime of the cell Edison 20%. For lead acid batteries, every 9 °C of temperature increase, a reduction of 50%. Figure 8 shows a graph comparing the expected life at high temperature, for both types of batteries [13].



Font: (Willians, 2011)

Figure 8. Estimated battery life of Edison and Lead Acid.

5 CONCLUSION

By analyzing the characteristics of all the batteries mentioned in this article, one can see that the most appropriate for applications in isolated power generation batteries are lead-acid and nickel-iron batteries (Edison batteries).

Between these two, it is possible to be done for a comparative particular application, the lead battery takes advantage to present a more consolidated market, have good charge retention for applications where intermittent loads which makes them very attractive, since the power generation solar has this feature.

In contrast, Edison battery have a life cycle than the cycle of lead acid batteries, which can make the systems more affordable cost. Another point in favor of this configuration is Nickel-iron batteries do not have the lead or cadmium of the lead-acid and nickel-cadmium batteries, which makes them a lesser burden on human and ecological health.

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