European Association for the
Development of Renewable Energies, Environment
and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality
(ICREPQ'12)
Santiago de Compostela (Spain), 28th to 30th March, 2012

Batteries comparison for an optimal accumulation performance on PV isolated systems

A.Daniel Rey Rey[1,2],A. López Aguera [1] ,I.Rodriguez Cabo[1], E. Vieites Montes[1] , G.G. Demetino[2], I. Pepe[2]

[1] Laboratorio de Aplicaciones Energetica Sostenibles
Departamento de Física de Partículas, Universidad de Santiago de Compostela
Campus Vida – Santiago de Compostela, 36310 (Spain)
Phone/Fax number:+0034 981563100 Ext:14000
e-mail: daniel.rey.rey@gmail.com, a.lopez.aguera@gmail.com
[2] Laboratório de Propriedades Óticas
Instituto de Física, Universidade Federal da Bahia
Campus de Ondina – Salvador, 40210 340 – Salvador (Brasil)
e-mail: jdemetino@gmail.com, lapo.if@gmail.com

Abstract.
The Pierre Auger Project is a macro-grid of 1600 PV identical systems installed on Argentina. Each of this PV is fully monitored. All the data are sent to a central building and recorded for data analysis. In this paper performance of batteries from different manufacturers is studied and compared, trying to find the optimal solution for this experiment, taking in account climate and operation conditions.

Key words

Batteries performance, battery discharge, quality control

1. Introduction

The Pierre Auger Observatory has been built with the aim of cosmic ray study, but due to the necessity of using solar energy in each station, this experiment give us the opportunity of studying the performance of this system. In fact, the experiment constitutes the hugest database of stand-alone photovoltaic system data in the world[1]. Since the start of the experiment, huge amounts of data have been recorded, both for cosmic rays study and solar system performance. The PV grid has been designed to be in continuous operation during at least 20 years. This requirement and the extreme weather conditions dominate the quality check procedures, in particular, the need of an accurate selection of each element. In the following, we present an experimental comparison among different battery candidates.

2. Work Flow

The battery lifetime depends not only on the charge-discharge regime but also on the temperature, the humidity or the regulator response. So, the selection of an optimal candidate of battery is a rather complicated issue. Each working condition of the battery, as well as their correlation, needs to be taken into account. Fortunately, our system is strongly monitored, and the data available for this purpose are:

- Maximum and minimum voltage for each Battery per day.
- Maximum and minimum temperature for each battery per day.
- Maximum and minimum night voltage (0-4h) for each battery per day.
- Maximum and minimum current load.
- Maximum and minimum voltage for solar panels per day
- Maximum and minimum current for solar panels per day

These data are obtained automatically each day with data sent to the central facility, so data analysis can be automated. The Monitoring application has been developed for allowing the users to take advantage of an easy analysis of the array with plots. Figure 1 shows a typical map of the monitoring output; in this case, the Maximum Voltage for Battery. The colour code makes a fast quality control possible. As an example, blue dots point to death batteries (with maximum voltage close to zero).
The developed application is focused on specific data, but recorded data allow us to analyse with script language such as Python. The data can also be analysed by means of ROOT [3], for more specific requirements and for a prolonged period of time with flexibility.

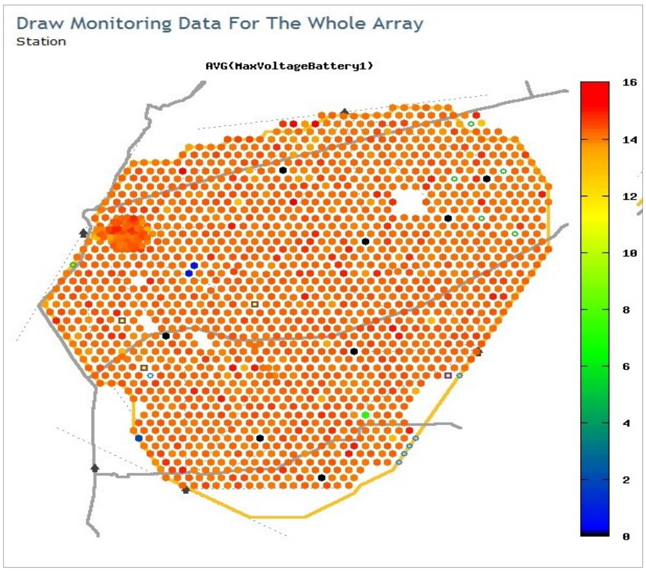


Fig. 1. Battery Maximum Voltage for the full 1600 PV system.

3. Battery comparison

The replacement of one or two batteries requires high maintenance costs, because the detectors are distributed in a 3600 Km^2 area and the access is difficult. With the scope of evaluating performance of batteries in the field, exhaustive tests have been carried out. Different brands of batteries are being used in the experiment and the fact off finding the optimums one will make solar system more robust and efficient.

This analysis will cover the whole year for allowing a performance analysis with climatic conditions: one battery can show a good performance at high temperature and lower to a lower temperature or vice-versa. The experiment works over extreme temperatures so finding the best performance for the whole range of temperature is needed

In the present work, different types of Pb-acid batteries are studied. The main differences are related to the internal resistance, the electrolyte viscosity and the temperature dependence. In particular, we selected as candidates: Yuasa UXH100-12N, Odissey 31PC2150, Clean Moura 12MC105, Freedom DF200.Technical data is shown on Table1 [4,5,6,7]:

Table I – Batteries

Model	*Capacity 20h (Ah)*	*Capacity 10h (Ah)*	*Internal resistance*	*Battery type*
Odyssey 31PC2150	*100*	*92*	*2,2*	*VRLA*
Yuasa UXH 100-12N	*100*	*93*	*3,5*	*VRLA*
Freedom 2000	*100*	*94*	*Nd*	*Standard*
Clean Moura 12MC105	*105*	*95*	*4,9*	*Standard*

For maintenance issues a database has been created, providing the collaboration with the knowledge of where each model of battery has been installed. With this information we are able to study the batteries behaviour.

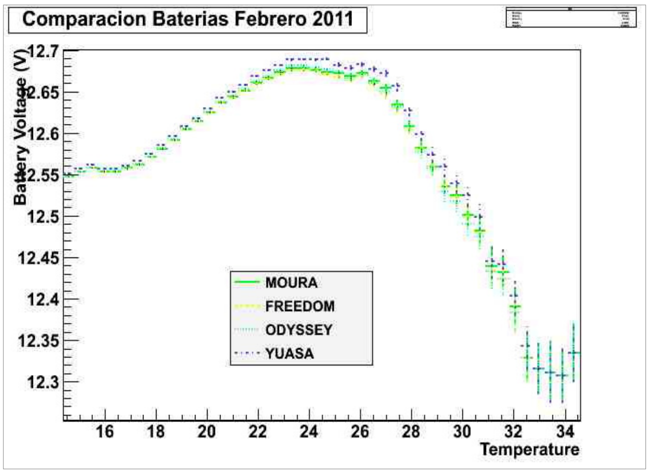


Fig. 2. Battery voltage as a function of the working temperature for the candidates.

As an example, figure 2 shows a comparison between the candidates: The behaviour of the battery working voltages with respect to the temperature. Yuasa battery presents higher voltage values than the others at the working temperature interval.

Once the full sample of critical working parameters are studied, we will be able to select the optimal candidate for our purpose.

Battery performance

The performance of a battery depends on multiple factors. Two batteries from the same manufacturer, brand and model can show different performance under different conditions. In other paper [8] we have studied the influence of factors such as the season of installation or time between delivery and installation.

Now we will focus on the study of the performance of different brands, taking into account climatological conditions. With the available data we will study the differences appeared during different month/year, trying to find the behaviour of each kind of battery and the response of each of them to high and low temperatures over different seasons. The replacement of batteries of different brands will also be studied, using the Part Management System (PMS).

For each month, the voltage distribution will be studied for different year, which will allow to compare allow us to compare the performance over different conditions (different months during a year) and similar conditions (same month during different years).

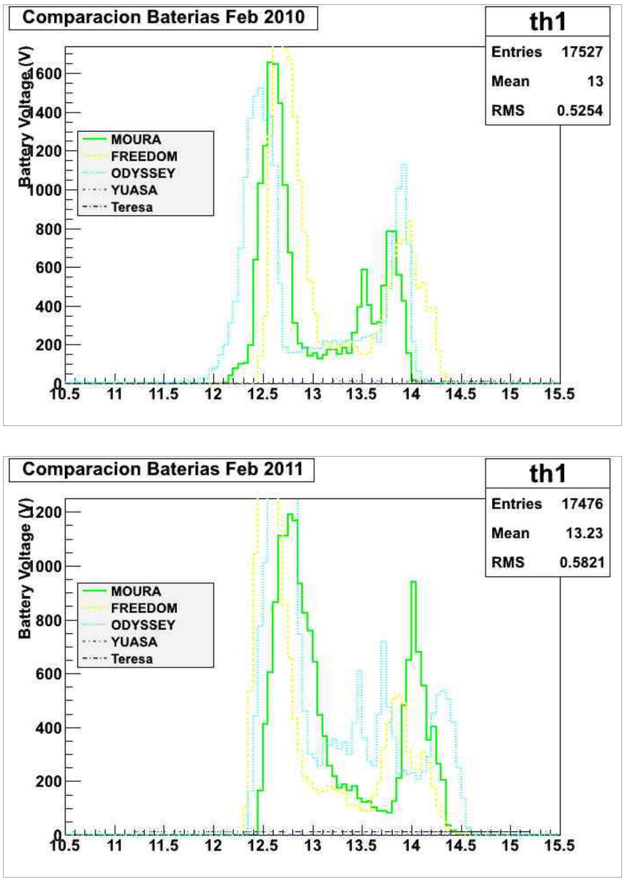
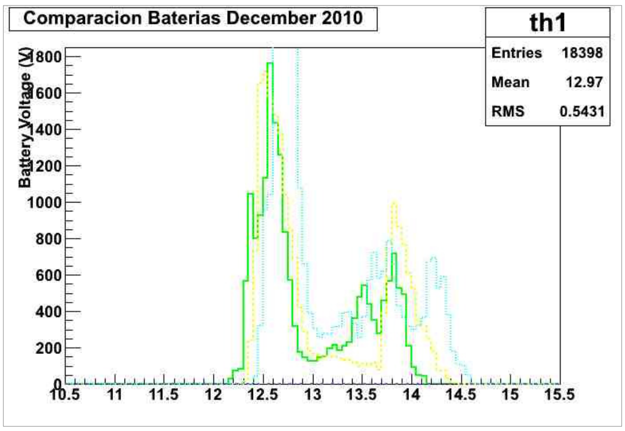


Fig. 3. Battery voltage distribution for the month of February for year 2010-2011.

As an example, we will show in the following the behaviour of our candidate during the year (winter, summer, and spring) to check the effect of the seasonal changes. The best candidate will be the less sensitive to both ageing and climatic variations. So, the data for the month of February (spring) in years 2010 and 2011 are shown (in Fig 3.). Focusing on the differences in discharge and regulation peaks we can see that Oydssey works with at lower values in discharge and higher values on regulation, while Moura batteries works in a narrower interval.

It is quite worth noting that the Moura's voltage distribution function width increase was higher that that of the others, which points to quicker ageing mechanisms for this batteries.



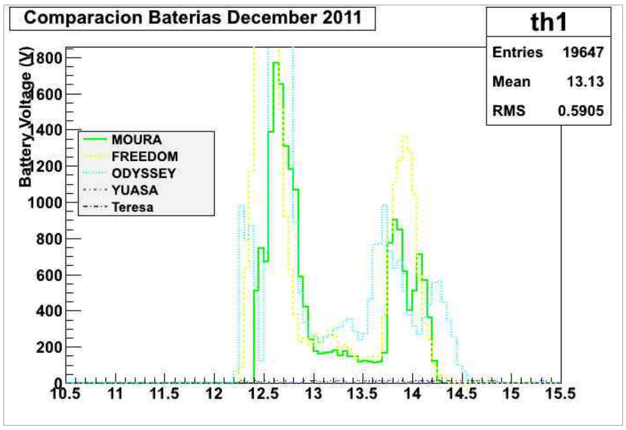


Fig. 4. Battery voltage distribution for month of December (summer) for years 2010-2011

In Figure 4, a different case is shown: the peaks for regulation and discharge are nearly the same. Moura batteries works in the same interval as in February meanwhile Odyssey batteries increase their values for the discharge peak. This could be due to the effect of the temperature on the performance of batteries, showing a higher dependence on Odyssey batteries, specially in discharge.

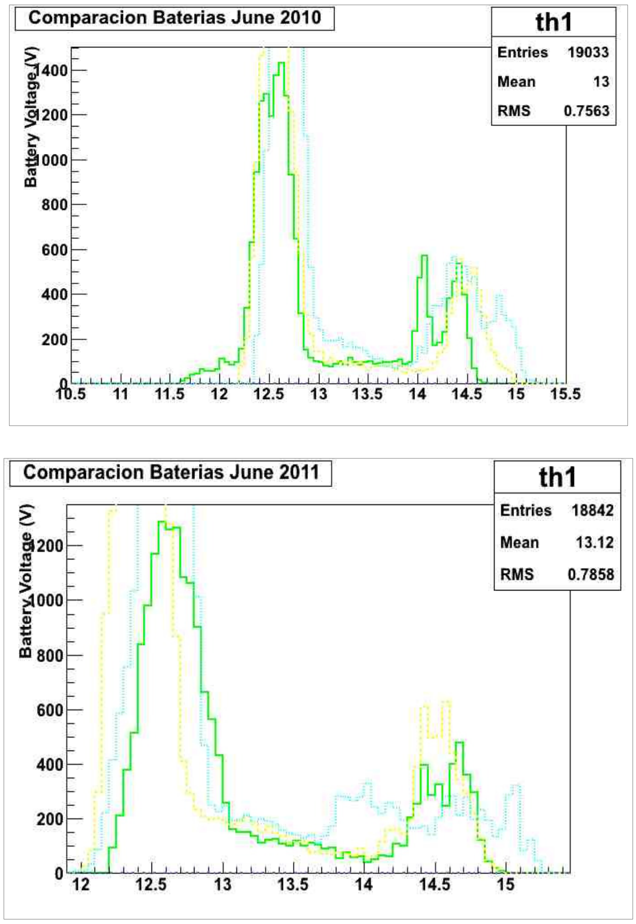


Fig. 5. Battery voltage distribution for month of June for years 2010-2011.

A similar behaviour is shown for June (winter) in Fig. 5, specially in discharge, while in regulation Odissey still shows higher values.

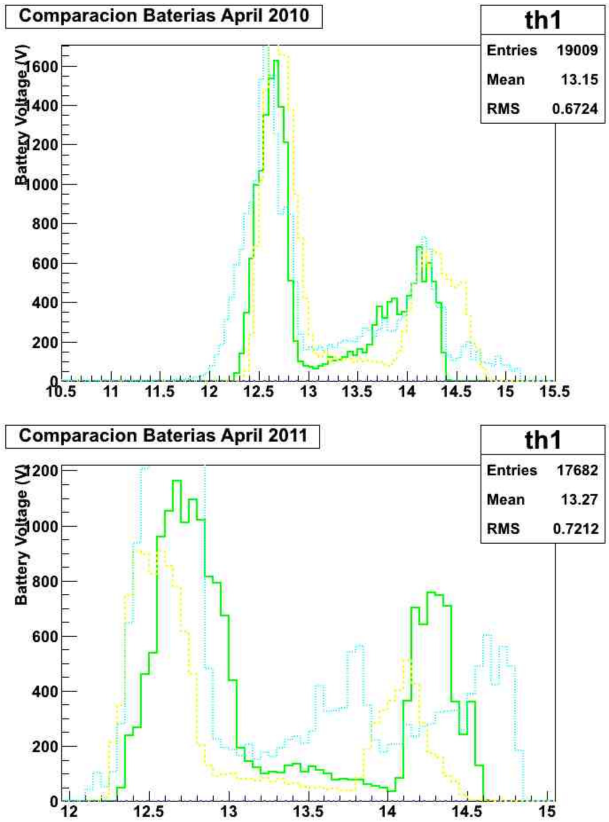


Fig. 6. Battery voltage distribution for month of April for years 2010-2011.

Independently of the intervals, the width in Moura's batteries increase with ageing and the voltage values in discharge are more sensible to seasonal change than Oddisey batteries.

4. Conclusions

A quality control monitoring program has been developed. The protocol allows carrying out an accurate analysis of each parameter of the PV system. In the current paper, the data for a whole year have been analysed in order to compare the different batteries performance. The capacity of the program to select the best elements of a PV system has been shown.

In particular, it will help:

- On choosing the most suitable battery for the experiment.
- To study the performance at high temperatures of batteries.
- To use the experiment as a bank test for new batteries, comparing the performance of new batteries with that of the others over the same conditions.

The studied data have evidenced a dependence of voltages on the temperature for discharge regions, specially for one two of the studied batteries. Concerning the parameters to preliminarily work out which of them shows the better behaviour, the signs of ageing (at first, the most important) and the sensitivity to different weather conditions are considered. In this sense, the standard lead-acid batteries (Moura, Freedom) are in disadvantage against the others, since Moura evidence a slight more noticeable ageing effect (higher discharge voltage distribution function width increase) and Freedom reaches lower voltage values during winter. As mentioned before, this last also happens to Odyssey but AGM batteries are less affected to low voltage values.
The study of data for more years, and the study of battery replacement for each brand of batteries during this years will be necessary for extracting more parameters and patrons of behaviour as well as for showing which kind of batteries fits better with the experiment conditions for the whole year.

References

[1] A. López Agüera, I. Rodríguez Cabo. The Pierre Auger Project as a challenging tool for surveying PV systems. ICREPQ'06.
[2] M. Avenier, C. Berat, C. Lachaud, F. Melot, A. Stutz Auger Monitoring Web Site User Guide: General layout and Surface Detector monitoring GAP2010_038.
[3] root.cern.ch
[4] http://www.odysseybattery.com/battspecs.html
[5] http://www.innovative.co.nz/uploads/UXH100-12N_flattened.pdf
[6]**http://www.freedomestacionaria.com.br/caract_eletricas.htm**
[7]**http://www.moura.com.br/site_pt/produtos/produto4/especificacoes.php**
[8] Algorithm for Lifetime Estimation of Batteries Based on Voltage Distribution Shape
Angeles López AGÜERA, Iago Rodriguez CABO, Daniel Rey REY
University of Santiago de Compostela – SPAIN. 3rd conference on sustainable energy. 10-11 November 2011 Brahov, Rumania