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CPV Hybrid System In ISFOC Building, First Results

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Abstract. PV Off-Grid systems have demonstrated to be a good solution for the electrification of remote areas [1]. A hybrid system is one kind of these systems. The principal characteristic is that it uses PV as the main generator and has a backup power supply, like a diesel generator, for instance, that is used when the CPV generation is not enough to meet demand. To study the use of CPV in these systems, ISFOC has installed a demonstration hybrid system at its headquarters. This hybrid system uses CPV technology as main generator and the utility grid as the backup generator. A group of batteries have been mounted as well to store the remaining energy from the CPV generator when nedeed. The energy flows are managed by a SMA system based on Sunny Island inverters and a Multicluster-Box (figure 1). The Load is the air-conditioning system of the building, as it has a consumption profile higher than the CPV generator and can be controlled by software [2].
The first results of this system, as well as the first chances of improvement, as the need of a bigger CPV generator and a better management of the energy stored in the batteries, are presented in this paper.

Keywords: Stand Alone, CPV, Hybrid System.
PACS: 88.40ff, 88.40.me

INTRODUCTION

This paper presents an overview of the hybrid system installed at ISFOC building with the initial operation results and conclusions obtained.

The principal characteristic of a hybrid system is that it uses PV as the main generator and has a backup power supply, like a diesel generator, for instance, that it is used when the PV generation it is not enough to meet demand.

ISFOC hybrid system was started up in September 2011; it was designed as to install the different CPV technologies to be tested and investigated by ISFOC on its performance. With this purpose in February 2012 a refilling of the PV generator was carried out and in the near future 4 concentrators will be connected to the system, from three different CPV suppliers.

DESCRIPTION OF THE SYSTEM

This system is based on SMA technology for energy flow management: PV generator is CPV technology, backup generator is the Utility Grid and load is the air conditioning system of ISFOC building.

Energy powered by the CPV generator is used for feeding the air conditioning system of ISFOC headquarters, the batteries are in charge to store the energy remaining when the generation is higher than the load demand; then it can be used by the air conditioning system when needed. If the air conditioning demand is higher than the CPV generator plus the energy stored in the batteries, then the energy is supplied by the grid that it is used as the backup generator.

System Management

The system is based in SMA hybrid system technology. The 3-Phase Multicluster Box is the solution of SMA for big Off-Grid hybrid systems: it is scalable, since the maximum power of the installation can be increased by adding more clusters in parallel. The system is capable of managing up to 110 kW. This power means that it can feed to the Load 110 kW and can have a PV Generator of 110 kW. However the maximum energy that can be taken from the batteries is harder to determine because it can vary from 100 kW to 48 kW, depending on the temperature, the time that the system has to manage this energy and the number of Sunny Island inverters installed.

This system has now 9 Sunny Island inverters, 3 for each phase. This is the most important piece of the installation, since it creates the grid for the PV generator and for the Load and manages the energy flows from the Utility Grid, the PV Generator and

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from and to the Batteries. A basic scheme of the system is presented in figure 1.

CPV Generator

The main idea is that the CPV generator will be built in phases and therefore it can be easily modified, with different technologies whose performances are going to be anlysed.

Backup Generator

The backup generator is the Utility Grid. In this way, there is always energy available although a cut-off occurs, what is mandatory to assure the demand of the ISFOC headquarters. The system is configured to avoid feeding energy to the Grid. In the future, if the self consumption laws are developed in Spain, this system will be able to feed the excess of energy to de Utility Grid.

Batteries

The batteries chosen are Lead Acid with gas recombination system. They are divided in 3 battery banks, one for each cluster, with a capacity is 800 Ah and 48 V.

Monitorization

The 3 AC circuits are monitored with Grid Quality Analyzers. The data obtained from these instruments is stored once a minute in a SQL Database, in order to analyze it.

Also the SMA inverters provide valuable information about the status of the installation such battery charge, temperature and energy flows.

Finally, meteorological data are obtained from the ISFOC meteorological station, which includes DNI, GNI, Ambient temperature, Wind, Solar Spectrum…This data make possible to analyze the performance of the CPV generator.

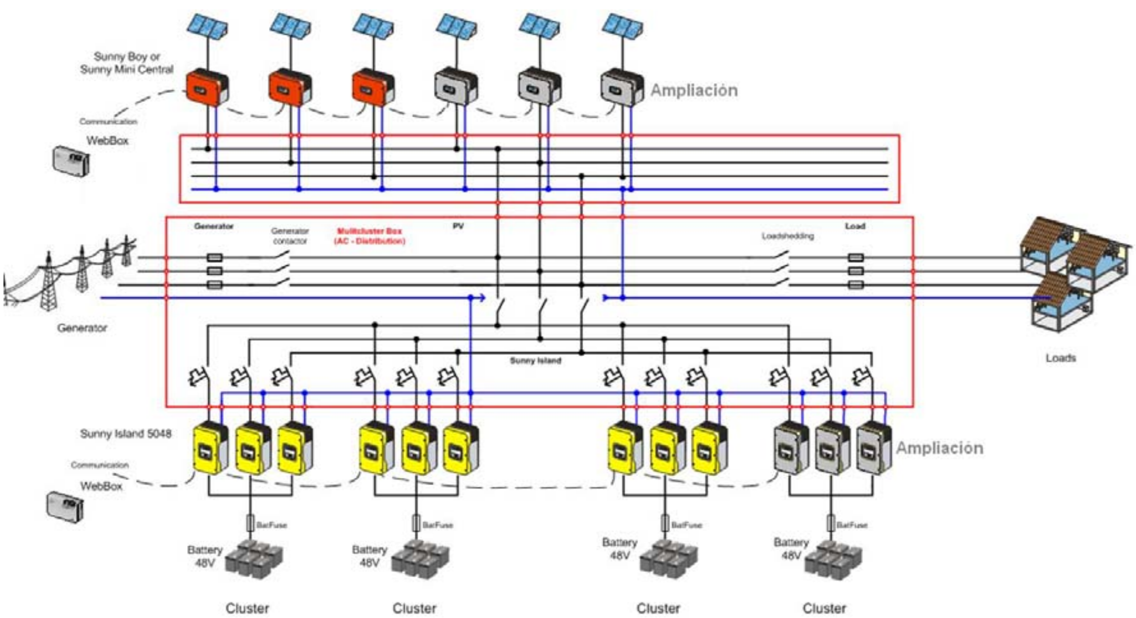

FIGURE 1. Hybrid System Basic Scheme

FIRST EXPERIENCES

The system has been working since September 2011. Over these first months it has been working as a demonstration project in order to test different loads and profiles, to stablish the improvements and final design of the installation. In this way the connection and disconnection of the system to the Grid has been held manually to assure that there is no power cut-off for the Air Conditioning.

CPV Generator

The CPV generator has been feeding to the system since September 2011 until February 2012. It has been dismantled in order to improve its performance. Because of this, a improved tracker has been installed and will soon feed energy to the system. Together with this modification three new concentrators have been installed, from two new suppliers.

Load Consumption

During the last year the consumption profile of the air conditioning system has been analyzed.

The consumption of the Load in summer is quite constant during the working hours. However in Winter, there is a gap of time in the morning, when the consumption is bigger, while during the rest of the day, the consumption has some peaks. This is because the building is cold in the morning and, until it reaches the desired temperature, the air conditioning system needs a big amount of energy.

In Spring and Autumn, the consumption is lower. However, it never reaches zero, as Puertollano has not a mild climate.

Also, the profile of other Loads are being studied (lighting, computers, kitchen…) in order to connect them to the hybrid system and complement the consumption of the air-conditioning system and adapt better the Load Consumption to the CPV Generation.

System Management

The CPV Generator is the main Generator, which means that the Load will be fed firstly by the CPV. During this first months of operation, if the CPV generator is not capable to feed all the energy the Load needs, then the Utility Grid will feed the rest (see Figure 2).

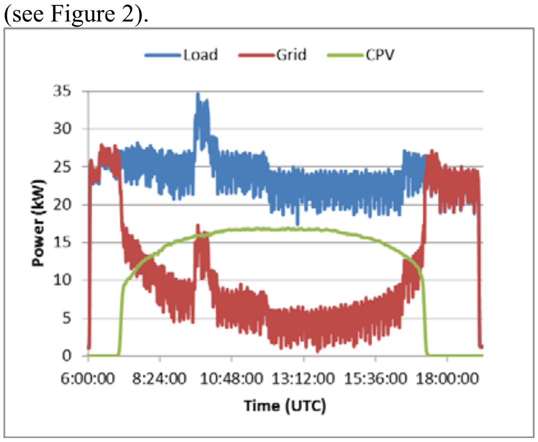

FIGURE 2. The consumption of the air conditioning is supplied from the CPV Generator and the Utility Grid September, 19th 2011.

At the beginning, it was difficult to think about a system with such a high power with the Utility Grid as Backup Generator as the normal was a diesel generator. Therefore, the system has worked as a backup for the first months. That means that both generators are always connected and, the batteries are only used when they are not capable to feed the Load needs. In this case, the Utility Grid is always capable to feed all the power the Load needs.

The next paragraphs show examples of daily profiles where different operation modes of the system has been tested.

While analysing very cold days (See Figure 3) it is shown that in the morning, the Utility Grid (in red) feeds all the energy that the Load needs (in blue). Later, when the CPV generator starts to generate (in green), the consumption from the Utility Grid is reduced. When the Utility Grid is disconnected, all the energy needed by the Load is fed only by the CPV Generator that is limited when the consumption of the load drops, since the batteries are also full of charge (in purple). Later, at night, when the CPV Generator cannot feed energy to the system, the energy is taken from the batteries.

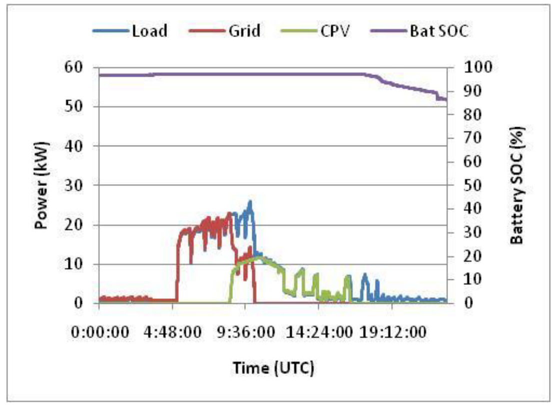

FIGURE 3. January 30th 2012.

The following day , the consumption of the Load is high again in the morning, what makes the energy accumulated in the batteries drop to 40%, the safety value defined to avoid a state of discharge which can reduce the life of the batteries (see Figure 4) and the Load is disconnected. Then, the Utility Grid has to be again connected to the system to feed the energy needed by the air conditioning and charge again the batteries. While the batteries are not full, the CPV generator feeds its maximum power. However, when the batteries reach a safety value, to avoid overcharge, the CPV Generator is limited again.

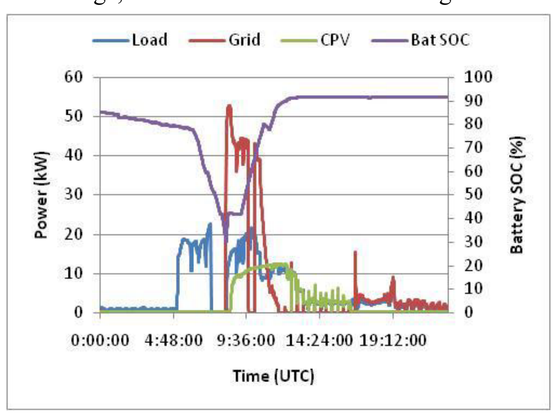

FIGURE 4. January 31th 2012.

In Winter, the high consumption from the air conditioning system in the morning makes impossible to work in this way, since the CPV generation starts later and it is mandatory to have a bigger amount of energy stored in the batteries.

Another example of problems with the energy management is shown in figure 5. The behavior in the morning is the same as in figure 4; the energy consumed in the morning is too high to be supplied by the batteries and the CPV generator. Although a new problem appears in the evening; first the consumption of the Load is low during the evening and limits the power supplied by the CPV generator and, after the sunset, the temperature of the building drops so the consumption of the air conditioning system cannot be supplied by the CPV generator.

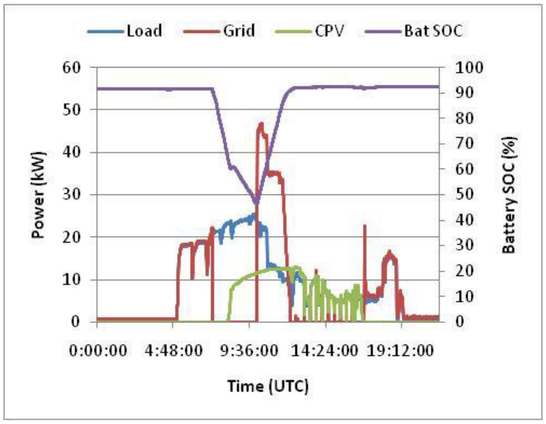

FIGURE 5. February 13th 2012.

These situations shown in the examples should be avoided in the future, since the objective of this system is to adapt the consumption of the Load to the generation of the CPV.

CONCLUSIONS

A new application of CPV technology is being tested and will be improved in ISFOC. The first results have been presented and have demonstrated that the management of Load consumption depending on CPV generation is of main interest in this system.

The self consumption policies will determine also, in the future, the management that can be done with this system, since it will be maybe possible to feed the excess of energy to the utility grid.

FUTURE WORK

In the next paragraphs, issues to be improved are presented.

CPV Generator

The tracker of the initial system has been replaced for another Titan Tracker with better characteristics. Also, 2 other technologies will be connected to the system in a short time. With all these changes, the maximum power of the CPV generator will be 55 kW. It is a challenge to manage this amount of energy taking into account the capacity of the batteries. However, this amount of energy available will let the system to feed a high percentage of the demand using clean and renewable energy.

Batteries Energy Management

Although these results show that the capacity of the batteries is not enough to supply the energy needed from the Load for a long time, the high cost of this component of the system (almost €20,000 in this case) makes very important to adapt the consumption of the load to the generation of the CPV systems. Also the backup generator has to be used in a more accurate way, the charge from the utility grid should be avoided for making the best use of the renewable energy.

The final objective of this project is to manage the energy flows depending on the predictions of CPV production and Load demands [3].

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