Photovoltaic systems installed at the University of Jaen

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Abstract— The use of photovoltaic for electricity generation purposes has recorded one of the largest increases in the field of renewable energies, and this trend is expected to continue in the coming years. Consequently, a growing number of new PV components and devices, mainly arrays and inverters, are being brought to the PV market. The integration of grid-connected PV systems into buildings or public areas is one of the most usual applications of the photovoltaic solar energy in developed countries. The University of Jaén (Spain) is a pioneering public organism in the field of grid-connected PV systems, as it proves the milestones developed by its IDEA research group in the last decades.

Keywords— Building Integration, Grid-Connected, Design, Photovoltaic potential.

I. INTRODUCTION

PHOTOVOLTAIC solar energy is a clean renewable energy with a great potential, easy to install and to maintain, highly reliable and long-lasting. In last years, this kind of energy has experienced an outstanding and rapid growth due to the recent environmental commitments submitted by the developed countries and their comparative advantage. PV systems have special characteristics that provide some added value as systems of power generation. In fact, the rise of PV as a formula to obtain electricity is one of the highest registered in the field of the renewable energies and this tendency is expected to continue in the next years. As a consequence, a soaring number of new PV components and devices, mainly arrays and inverters, are coming on to the PV market [1]. Although PV systems -particularly grid-connected photovoltaic systems- have had a technological breakthrough, efforts are still required in research, technological development and innovation (R&D&I) and they must be achieved mainly by improving the different parts of the systems.

The integration of grid-connected PV systems into buildings or public areas is one of the most usual applications of the photovoltaic solar energy in developed countries [1] [2] The new Spanish feed-in tariff regime, through the development and application of the Royal Decree 1578/2008, tries to recognize the advantages of the PV systems integrated in buildings, either on façades or on top of roofs, due to their advantages as a distributed source of energy, the lack of increase of the territory occupation and their contribution to the social diffusion of the renewable energies. [3] This favorable social and economical environment settles the opportune foundation for the creation of a socially sustainable energy project.

The University of Jaén is a pioneering public organism in the field of grid-connected PV systems, as it proves the milestones developed by the IDEA research group in the last decades. The initial research and development of this kind of systems made by the IDEA group was manifested in 1995, during the design and implementation of the “Photovoltaic Pergola”, which was a 2 kWp gridc onnected system in the terrace of the Engineering College [4] [5]. At the same time, a deep analysis was carried out in the “Condestable project”, which was an attempt of integration of renewable energy sources in the Historical center of Jaen (Spain) [6] [7]. In 2001, it was inaugurated the UNIVER Project, a 200 kWp installation which was the largest PV system integrated in a public area in Europe. Its design and installation meant a great advance in areas such as the electric protection on PV systems [8] [9].

Nowadays, the performance analysis of a two-axis tracker (“El Girasol”) and the previous studies that are being carried out for the installation of several Concentrator Photovoltaic systems.

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II. Photovoltaic Systems Installed at the University of Jaen

A. Pérgola Fotovoltaica

The "*Pérgola Fotovoltaica*" is a 2 kWp grid-connected photovoltaic system integrated at terrace of a old building of the Engineering College. The system was installed in 1995 and was dismantled in 2005 because the building was demolished. The system was one of the first building-integrated made in Spain

The generator is made up by 23 photovoltaic modules Isofotón I-88 with a 15.45 A current at maximum power point. This generator is divided into four series-connected subgenerator, three of which are made up by 6 series-connected modules; meanwhile the fourth one only has five modules. Subgenerators orientations are 6º, 21º, 36º and 51º East respectively, and all of them show the same tilt, 15º.

Fig. 1 Pérgola Fotovoltaica

Fig. 2 Old building of the Engineering College of the University of Jaén

B. The Univer Project

The Univer Project consists of the installation of a grid-connected photovoltaic system, with a total power of 200 kWp, in Jaen University Campus (Figure 3). We can find four subgenerators with a similar configuration, changing only the generator power, and three different architectural solutions: Two subgenerators which are part of the University parking covers and two subgenerator embedded in the building where the Transformation Center and the inverters are located. The system is made up by two subsystems based on 60 kW-inverters and twenty four subsystems with 2 kW-inverters.

Fig. 3 University Campus

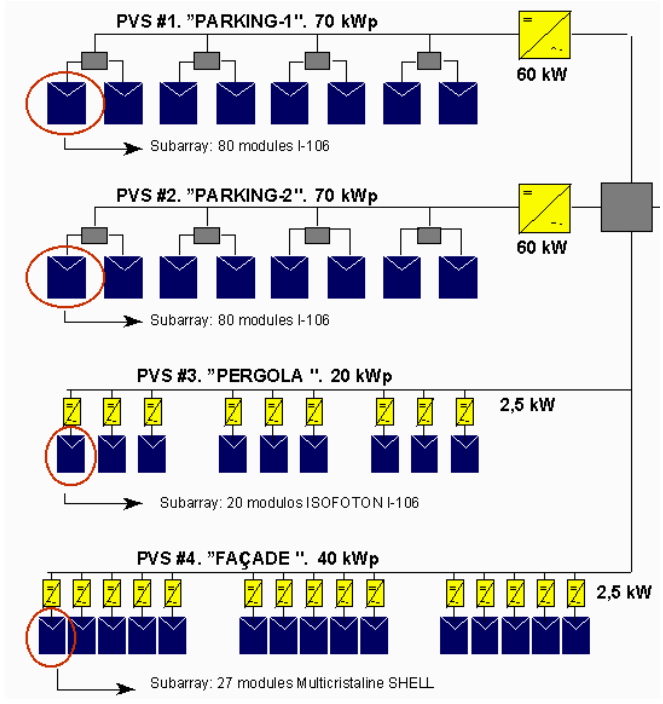

Fig. 4 General Layout

Photovoltaic System 1&2 “Parking”

System “Parking 1” is integrated in one of the parking covers at the University Campus. It consists of a photovoltaic generator with 68 kWp nominal power and a 60 kW triphase inverter. The photovoltaic generator consists of 640 modules of model ISOFOTON I-106, 80 modules series connected each one, and 8 parallel arrays. For the integration of the photovoltaic generator, we use the existing parking covers at this University Campus, which are totally free of shadows and with a 30º southeast orientation and tilted 7,5º. System “Parking 2” is the same as “Parking 1”, and it is located in a parallel cover in the same parking (see Figure 5).

Fig. 5. Photography of ‘Parking’ system

Photovoltaic System 3 “Pergola”.

This PV generator is integrated in the Connection and Control Building of the project [10] [11]. In this building are located the inverters, the data acquisition system and the safety and protection systems. The PV system consists in a photovoltaic generator with a 20 kWp of nominal power, made up by 9 subgenerators (2 kWp) and string oriented inverters. One of the aims of this integration is to get an area of shadows that improves the environment climatic conditions, very necessary in this part of Spain, and at the same time, it can be useful for students (see Figure 6).

Fig. 6. Photography of ‘Pergola’ system

Photovoltaic System 4 “Façade”.

This PV generator is integrated in the south façade of the building, which is located close to the Connection and Control Building. It consists of 15 subgnerators with a total of 40 kWp PV polycrystalline modules and a 40 kW string oriented inverter (see Figure7).

Fig. 7. Photography of ‘Façade’ system

With the aim of keeping people protection, the Univer Project includes passive and active measures that avoid direct contacts with the active system parts (earth grids and an permanent insulation controller to detect the earth faults of the generators). This is one of the most outstanding aspects of the Project, and it has also been the most studied because of the high number of students at this Campus. The studies carried out about the installation safety and protection have been developed from two points of view: on the one hand, from the installation itself, and on the other one, from people safety. In this sense, it is important to point out the lack of a legal regulation related to such aspects in this type of installations in Spain.

In general, the risks that can affect an electric installation are due to overvoltages and overcurrents, although in our particular case, and because of the phovoltaic system working, we will only be affected by overvoltages as a consequence of the eventual presence of atmospheric discharges, induced inductions, etc. In this sense, the installation includes voltage limiters that reduce it to a value under the insulation level required to the equipment. These limiters are placed at the inverter input and output, at the DC junction general cupboard, and at the junction boxes of the different generators arrays. As for people protection, the installation includes the necessary elements to avoid possible direct and indirect

contacts. In this sense, there are three levels of protection: floating system, insulation control and earth connections

C. "El Girasol" PV System

El Girasol (The Sunflower) is a 9.6 kWp grid-connected photovoltaic system .The installation, located at the University of Jaen Campus, is made up by three main systems:

- a dual axis tracker,
- a generator, divided in three 3.2 kW photovoltaic subsystems which are connected to the grid through single-phase inverters
- a monitoring system.

The Sun-Tracker is a pedestal type one with a single foundation plate, on which a mechanical transmission block for azimuth and elevation control is set.The Photovoltaic Generator has a total power of 9,600 Wp and it is made up of 48 polycrystalline silicon photovoltaic modules. All of them produce a 200 Wp maximum power at standard test conditions, and have been made by Kyocera (model KC200GHT-2). In order to connect the Photovoltaic Generator to the grid, we have used a DC/AC converter made up of three single-phase inverters, model Ingecon Sun model by Ingeteam Company, with a nominal power of 3.3 kW. Each inverter feeds energy into a different phase, so the whole performs like a three-phase system.

Fig. 8 El Girasol PV system

III. CONCLUSION AND FUTURE ACCTION

The University of Jaén has installed several integrated photovoltaic systems in buildings and is an expert body in the field of photovoltaic systems connected to the grid.

Recently, the University has proposed an ambitious project, the so-called UNIVERSOL project, where the necessary tasks will be carried out in order to evaluate the "photovoltaic potential" of the Campus of the University. This project is the previous step to convert this Campus in a big public area which combines the PV electricity generation with the common uses of a university place, in other words, to create a mixed space where the generation of knowledge can be combined with the electricity generation

Fig. 9 Potential PV areas University Campus

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