Study of PV systems for self-consumption at the UPC based on simulations by using PVSol

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Abstract

The aim of this work is to carry out a sustainability study in five campuses of the Universitat Politècnica de Catalunya BarcelonaTech (UPC) around Catalunya, i.e. Campus North and South Campuses in Barcelona city, Campus Baix Llobregat, Campus Manresa and Campus Vilanova i la Geltrú. The amount of consumed energy included in the study for each campus corresponds to monitoring data of previous periods. The study analyses the expected energy production, as well as the self-consumption that can be achieved by using photovoltaic (PV) systems of 25, 50 and 100 kWp and c-Si, Poly or CdTe Technology in order to reduce the environmental impact in each campus. An economic analysis of all the proposed facilities was conducted to examine their financial feasibility.

Keywords: PV Systems, Simulation, Self-consumption.

INTRODUCTION

The photovoltaic (PV) grid parity has been achieved in several countries as Spain, where the Levelized Cost of Energy (LCOE) of the PV technology can be compared with their local retail electricity prices in a competitive way. However, feed-in tariff and/or net metering incentives are still not well defined. This fact is partially due to the bad past renewable energy regulations and to a very sophisticated regulatory framework [1-2].

This study focuses on the analysis, through simulation using PVSol, taking into account the real profiles of consumption, irradiance and temperature in the buildings included in the analysis, of the potential energy production of different photovoltaic systems considering several photovoltaic technologies.

METHODOLOGY

The Universitat Politècnica de Catalunya BarcelonaTech (UPC) is a public Spanish University with more than 30,000 students focused on the fields of engineering, architecture, science and technologies [3].

The UPC schools and faculties are at the service of learning, research and knowledge. The UPC engineering schools are sited in Barcelona and in several nearby towns: Castelldefels, Manresa, Sant Cugat del Vallès, Terrassa, and Vilanova i la Geltrú, as it can be seen in Fig. 1.

Fig.1. Map of UPC Campuses in Catalonia (Spain).

To carry out this study, five UPC campuses were selected: Campus North and South Campus in Barcelona, Baix Llobregat Campus, Campus Manresa and Vilanova i la Geltrú Campus. From each one of them, given that the contracted power is not the same for the entire campus but it depends on how they are divided, the analysis has focused on one or more buildings in particular. As for the North Campus, all the A classrooms buildings where chosen, in the case of the South Campus, the building of the faculty of mathematics was selected, at the Baix Llobregat Campus, the D4C building, on the Manresa Campus the MN123 and at the Vilanova i la Geltrú Campus the VG4 building.

Real consumption profiles were used in the study for the selected buildings of each campus. The data was taken from an internal UPC monitoring platform called SIRENA. The irradiance and temperature profiles were

obtained from the data base included in the PVSol simulation tool for each one of the selected locations, as it can be seen in Fig. 2.

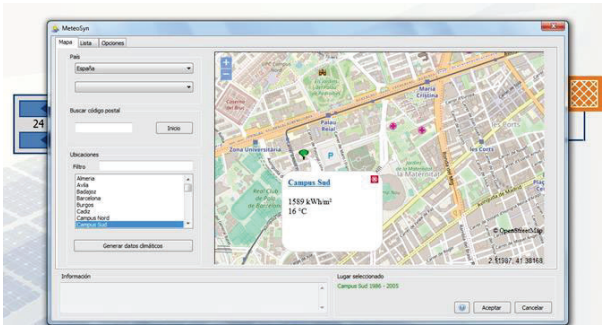

Fig.2. Selection of Irradiance and temperature profiles for South Campus UPC in Barcelona City (Spain).

The selection of PVSol [4] for the simulation of the PV systems is based in the good data base of PV system components included in this tool that allows working with real model parameters of all components included in the system, especially PV modules and inverters.
Moreover, PVSol is used in the simulation practices included in two PV courses at the UPC: Photovoltaic Solar Energy, an elective course of the Master's degree in Energy Engineering at the ETSEIB-UPC [5] and Photovoltaic Systems, an elective course at the Master's degree in Electronic Engineering (MEE) at the ETSETB-UPC [6].
These Master Degrees are aligned with the objectives of the European SET plan and the objectives of KIC InnoEnergy in the field of renewable energies and aim at delivering education for high competency and quality engineering skills in the field. In particular, these courses are focused on technical skills required for engineers in the field of PV applications.
The duration of both courses is one semester: 15 weeks-5 ECTS, and the courses include stand-alone and grid connected applications of PV systems considering both technical and economic criteria to select the most appropriate electrical equipment for a given application and solutions for a smart control and fault detection in the generation systems in order to optimize the energy generation and costs.

The PV modules forming part of the PV arrays included in the simulation study are the following:
c-Si PV module : Suntech Power STP250S-20/wd, CdTe PV module: First Solar FS-390, Poly Silicon PV module: Atersa A-150P.

The inverters selected for all PV systems are inverters Ingecon Sun 25, 50 and 100 kW by Ingeteam SA.
The methodology used in the simulation study is shown in the flowchart included in Fig. 3.

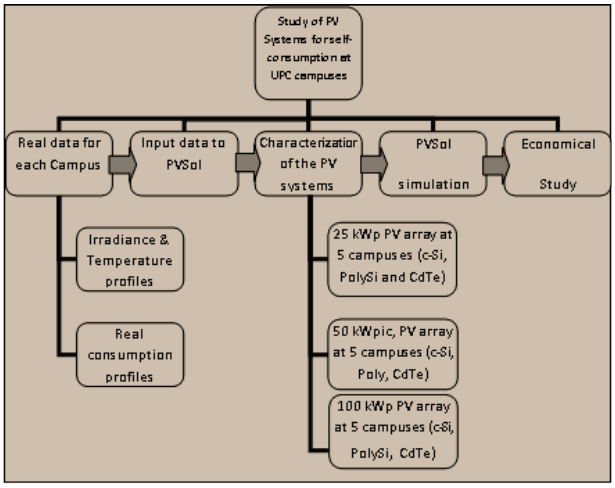

Fig.3. Flowchart of the simulation analysis carried out.

RESULTS

As an example of the results obtained, main parameters obtained in the simulation results for the case of a PV array of 100kWp formed by c-Si PV modules in the five UPC campuses analysed in the study are shown in Table 1.

Fig.4. North Campus UPC in Barcelona and A buildings in red.

Fig.5. Installation of PV system at the roofs of buildings A classrooms.

At the end of this study, the installation of a new solar plant on the north campus of Barcelona has begun as can be seen in Figs. 4 and 5. The PV array is formed by 510 c-Si PV modules of 310 Wp each and a total area of

2,067 m^2 on the roofs of the buildings A of classrooms: A1, A2, A3 and A4.
The PV system includes three Sunny Tripower CORE1 inverters with a nominal power of 50 kW each. The new plant will have an annual output of 225,000 kWh, that is, 50% of the energy consumed by these buildings.

c-Si 100 kWp	Campus Nord	Campus Sud	Campus Baix Llobregat	Campus Manresa	Campus Vilanova i la Geltrú
PV power (kWp)	95	96	94.5	92	93.5
PV surface (m^2)	618.2	624.8	614.9	598.6	608.4
Radiation on the PV array plane (kWh)	1,133,719	1,143,455	1,147,777	1,196,036	1,178,337
Energy produced (AC) (kWh)	140,062	141,706	142,515	146,819	146,209
Energy injected into the grid (kWh)	2,888	0.00	596	38,974	122,091
Load demand (kWh)	624,709	988,331	719,879	271,487	40,032
FV energy directly used (kWh)	137,174	141,706	141,918	107,844	24,118
Energy supplied by the grid (kWh)	487,539	846,629	577,965	163,647	15,918
Performance Ratio (PR)	80.3%	80.5%	80.7%	79.8%	80.6%
Anual Yield (kWh/kWp)	1,474	1,476	1,508	1,596	1,564
CO_2 avoided (kg/year)	86,781	87,005	87,664	100,745	122,978

Table 1. Results obtained for a PV system of 100kWp including c-Si PV modules in all campuses analysed.

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