System of Photovoltaic Solar Electric Power for Buildings: "Solar facade with variation of the β-angle"

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Abstract. Based on a previous work, this paper presents a system for the use of photovoltaic solar energy for the facades (vertical claddings) of the buildings, applied to a specific modern building. The system presents regulation to one axis, which will vary the ß-angle (the or inclination of the solar cells) in order to be placed in the most perpendicular possible way to the solar radiation.

This particular application is based on optimization algorithms developed for the supervision, control, and management of photovoltaic solar electric power in singular buildings dedicated mainly to apartments. The basic principles of performance of these algorithms are kept within two big guidelines: renewable energy generation (to produce so much electric solar energy as possible), and demand side management (to reduce the demand peaks of the buildings).

The presented system is integrated in the buildings in order to present a particular aesthetic appearance. Then the algorithms and procedures of the system are designed in combination with the information of the different commercial solar panels in the market.

Key words: Renewable energies, Photovoltaic solar energy, Sustainable building, Solar facade, Solar tracking.

1. Introduction.

The road toward the sustainability, as new and essential paradigm of our society, should drive us to a search of the reduction of the energy consumption, as well as the increase of the energy efficiency in our buildings, in combination with the substitution of fossil energy for renewable energy.

A system for the use of photovoltaic solar energy for the facades (vertical claddings) of the buildings [8] is presented (Figure 1). The outlined system presents regulation to one axis, that is, the regulation varies the angle ß, or inclination of the solar cells, in order to be placed in the most perpendicular possible way to the solar radiation (Figure 2).

Figure 1: Building presenting photovoltaic solar panels in its facade

This particular application is based on optimisation algorithms developed in previous works [1] for the supervision, control, and management of photovoltaic solar electric power in singular buildings dedicated mainly to apartments [14, 15]. The basic principles of performance of these algorithms are based in two main objectives:

- Renewable energy generation (GER): It is necessary to control and to know the production systems in order to produce so much electric solar energy as possible [2, 3].

- Demand side management (DSM): It is also necessary to know the demand characteristics in the building, in order to develop a system able to reduce the demand peaks [4, 5, 7, 9].

The presented system is also integrated in the building so that the aesthetic result constitutes a special characteristic. With this objective a model of this system (which is being patented) in combination with the different commercial solar panels in the market, has been designed.

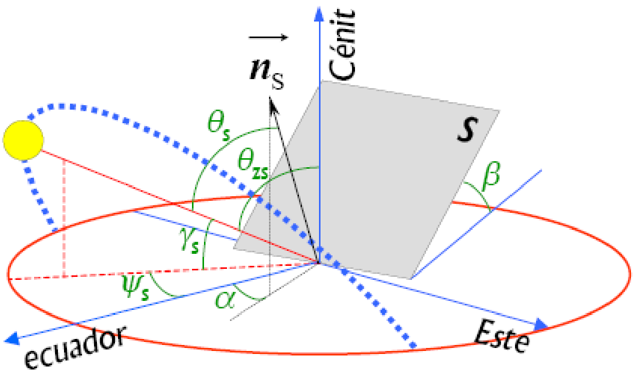

Figure 2: Different orientation angles of a photovoltaic solar panel

2. Description of the system

The buildings present different materials in their facades. In the case of the curtain walls, they are based on the employment of glass panels, that should usually be reflective for the solar radiation, in order to avoid that it passes inside the building, causing excesses of temperature, annoying brightness, dazzles, etc. For this reason, if the reflective glasses are substituted for solar cells, the desired solar absorption will be obtained, besides obtaining from the sun an energy that will be transformed into electric power. Thus, the integration of solar cells in the buildings can be profitable, besides presenting a modern and aesthetic aspect.

The buildings usually adapt to the parcel that they occupy. Their shape habitually is prismatic with four external facades. These facades can form diverse angles to each other but they habitually tends, if the parcel allows it, to be right. It is necessary to highlight that one of the four facades will be oriented mainly to the south. This facade will present an angle with the geographical south that doesn't usually reduce the efficiency in a significant way. But, from the analysis of solar applications, it is deduced that the solar utilization should be added to the usual urbanistic criteria. This south facade is the appropriate one for the implementation of the solar cells, discarding the other three facades for their low solar energy efficiency.

The system presented parts from the study of the optimal dimensions of the solar panels, to adapt them to the facade of the building. In practice, the commercial solar panels are rectangular with proportions that oscillate from 1,5 up to 2,5 m. The solar panels are distributed in lines occupying the width of the facade. These lines will be object of regulation of the ß-angle, starting from the rest position, which corresponds with 90º. So many lines as the facade allows will be formed, according to their height, and keeping in mind several factors to be studied, as:

- The height of the lowest line from the floor. This will depend on factors of security, vandalism problems, etc.

- The minimum equidistance between lines, according to the minimum ß-angle that will project shades in the panels if they come closer too much. This distance is object of energy study. For ß=90º, it is similar to zero, and for the smallest ß it will be maximum. A commitment will exist among maximization of the production against lost of installed power.

3. Description of the system of modification of the β-angle.

In order to vary the ß-angle of the whole line of solar panels, a revolving structure is needed, with a motorized engagement in order to be controlled [12, 13].

The ß-angle will be 90º (the rest position), which corresponds to a position aligned to the façade, in nocturne time or in case of alarm (wind, hail, etc.). The rest of the time the angle will vary from the solar rising until the sunset time, returning to the rest position at that moment.

The solar position is calculated at any moment in order to adjust the ß-angle, being the solar height the parameter that is needed. Then, the solar coordinates are obtained depending on the date and the time, in real time, and according to the latitude of the place. Also the global irradiance in the sloping panel Gi (W/m²) is obtained. This value is basic in order to be able to calculate in real time the information of the electric generation power of the panel. With this value and with the algorithm of following of the point of maximum power, for a value of tension of bars of DC we will be able to obtain the intensity of the current of the photovoltaic generation.

The optimisation algorithms for supervision, control, and administration of the system will be implemented in PC by means of industrial software. The PC will be located in the technical room (TR) of the building. In small buildings a touchscreen will be placed in the control square instead of the PC.

The control system will present communication with the different subsystems, as well as with the possible digital and/or analogical inputs and/or outputs that must be read/written in any area of the building, by means of a WLAN. The elected software on which the application will be implemented belongs to the SIEMENS ® company: WinAC ®, for control and Flexible WinCC ®, for supervision. In both of them the routines of optimisation will be implemented.

WinAC and Flexible WinCC are products of technological vanguard, on which novel code will be implemented. The STEP7 ® Professional Edition application will be used for programming WinAC ®, and the programming package SCL ® will be used to generate function blocks (FB) in pseudoPascal, according to the EN normative. Algorithms of optimization will be implemented in Flexible WinCC ® by means of VBS ® in order to standardize them.

The presented logical system is characterized to be deterministic and in real time, which allows completing the requirements.

4. Description of the developed system

The developed management application can be appreciated in Figure 3. The screen of introduction of information corresponding to the panels which form the basic element of the photovoltaic solar power station is presented, as well as the configuration of the series and number of them, in order to obtain the photovoltaic generator. The variables that must be measured are also represented, such as, the ambient temperature Ta(ºC) and the cell temperature Tc(ºC).

If a calibrated cell exists, which moves with the panels, the measure of the global irradiance in the sloping panels Gi(W/m²) is also taken. This way it is possible to contraste this value with the value taken by the data acquisition system, in order to generate a real database that models the photovoltaic solar power station [6, 10, 11].

Figure 3: Screen of data introduction corresponding to the developed application of management of photovoltaic electric power in the building

In Figure 4 the main screen of the management application can be appreciated. In the top part can be seen, from left to right:

- Module of obtaining in real time of the date and the time of the system.
- Module of calculation of the solar time, the rise and sunset times, the slope of the photovoltaic panel (ß-angle), and the global irradiance in the sloping panel Gi (W/m²)
- Module with analogical and digital indication of the solar position: azimuth and solar height (º).
- Module of representation in real time of the date and the time of the system.

The symbolic drawing of a building in which the photovoltaic panels are presents in the south facade can also be seen in the figure. These panels rotate in a dynamic way in real time.

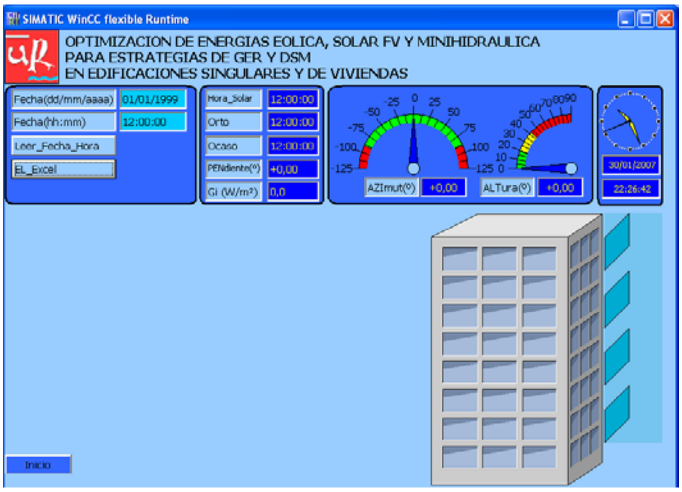

Figure 4: Main screen of the developed application, with the 4 modules and the panel orientation sketch.

As an illustrative example, a graphic has been included in Figure 5 with the obtained data corresponding to the resolved algorithms for input data of the 31st January 2007, at 12:00 AM local legal time. The slope obtained for the panels is of 62,64º with respect to the horizontal plane (being 90º the orientation of the vertical facade), just as it is appreciated in the sketch of slope of the panels. The solar height is 27,36º and the azimuth is –22,32º (East). The solar time is 10h 37m 13s, AM.

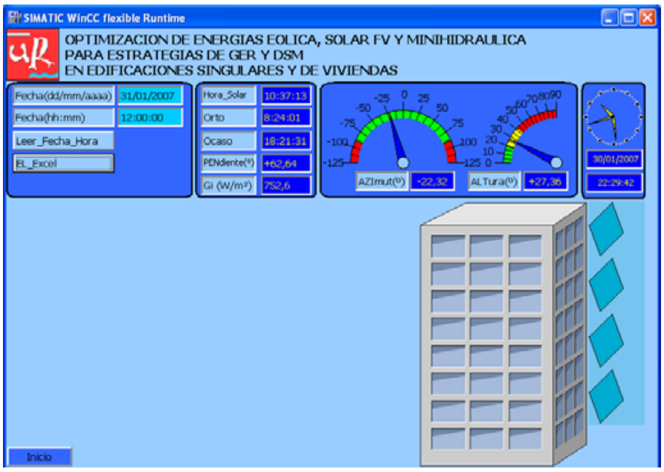

Figure 5: Illustrative example of the operation of the developed application, in real time, in the specific building at a determined moment.

5. Conclusions.

In this work a procedure that is framed in the European programs of R&D for renewable energy and sustainable buildings is presented.

The work presents an application for the use of photovoltaic solar energy for the facades of the buildings based on optimization algorithms developed for the supervision, control, and management of photovoltaic solar electric power in singular buildings dedicated mainly to apartments.

The system presents regulation to one axis, (the ß angle, of inclination of the solar cells), in order to be placed in the most perpendicular possible way to the solar radiation, taking into account the buildings characteristics in order to present a particular aesthetic appearance.

From the basic work that constitutes the presented procedures, apart from the scientific production a series of utility models and a patent are being generated, for which some companies are already willing to their exploitation.

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