BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Volumul 62 (66), Numărul 2, 2016
Secţia
CONSTRUCŢII. ARHITECTURĂ

THE INFLUENCE OF THE BUILDING INTEGRATED PHOTOVOLTAIC PANELS POSITION ON THE CONVERSION EFFICIENCY

BY

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Received: July 26, 2016
Accepted for publication: August 30, 2016

Abstract. The paper presents the analysis of the efficiency of a photovoltaic system integrated in buildings, located in Iaşi city. Generally, the position of the panels is fixed and the conversion efficiency is studied depending on the intensity of solar radiation and the operating temperature of the photovoltaic cells. The numerical model of the system and the functioning parameters determination is realized with TRNSYS software. The case study is done for variable position of the photovoltaic panel, such as horizontal and vertical-south. The results are presented in terms of the produced energy and photovoltaic panel efficiency, for annually, monthly and daily time interval.

Keywords: photovoltaic panels; conversion efficiency; solar radiation.

1. Introduction

The solar radiation is one of the most common source of energy available on Earth. Despite its diurnal and annual variation, it can be directly converted and accumulated into electric and thermal energy, using photovoltaic (PV) panels and solar collectors.

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The photovoltaic panels have important advantages, such as direct conversion, no moving elements, less noise and long life. On the other hand, the most disadvantageous aspects consist in their high dependence to the climatic conditions (clouds, dust), diurnal variation of solar radiation and operating temperature of the cells.

The performances of photovoltaic panels, characterized by voltage, current, power and efficiency, are dependent of its operating temperature (Dubey *et al.*, 2013) and of the intensity of solar radiation. Almost 80% of incident solar radiation on the photovoltaic panel is converted into heat, determining operating temperatures between 65…80°C, in accordance with intensity of solar radiation. Studies related to the efficiency dependence on the cell's temperature (Jafari Fesharaki *et al.*, 2011) consider a proportional relation between the two parameters, Fig. 2. Therefore, the temperature increase causes lower conversion efficiency, with approximately 0.3,…,0.5 %/°C (http://www.solar-facts.com...).

Increasing the performance of PV panels can be achieved by reducing the operating temperature, while the other uncontrollable parameters remain constant. For instance, in the particular case of integrating PV panels into facades of buildings, the intensity of solar radiation cannot be controlled.

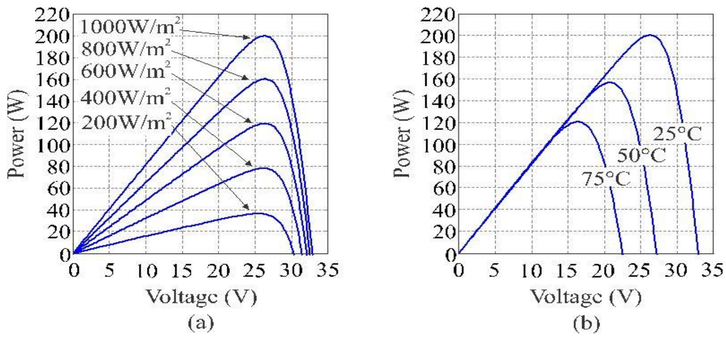

Fig. 1 – The influence of the temperature and solar radiation on the photovoltaic panel efficiency (http://www.intechopen.com...).

Methods and relations to determine the influence of the operating temperature are studied in (Skoplaki & Palyvos, 2009). The main solutions for cooling the photovoltaic panels consist in using water (Yang *et al.*, 2012) or air (Popovici *et al.*, 2016; Tonui & Tripanagnostopoulos, 2007), resulting hybrid photovoltaic/thermal (PV/T) systems. Whereas the efficiency of photovoltaic panel is lower than a solar thermal collector, it is estimated that is possible to use PV/T systems as a solution to improve the functioning of the entire ensemble.

The vast majority of cooling solutions come with the objective of making the excess of heat available for other use, determining a shorter payback time, comparing to the simple PV systems (Cuce *et al.*, 2011).

The modelling of heat transfer for photovoltaic systems, for variable atmospheric conditions is studied in (Armstrong & Hurley, 2010; Hudişteanu *et al.*, 2015).

2. Case Study

The study is focused on the analysis of the main parameters of a photovoltaic panel, with 1 m^2 surface, integrated on the roof or on the façade of a building. The analysis is realized on a default PV panel from software database with 36 cells connected in series.

The main purpose was to realize a comparative investigation of the energy produced by the photovoltaic panel during a year, month or day, for variable positions (vertical/horizontal) and south orientation.

The numerical study of the performance of the PV panel is accomplished by means of TRNSYS software. The climatic conditions were considered for Iasi city for both positions of the panel. The components of solar radiation are variable, with 1 h of averaging time. The block diagram of the model is presented in Fig. 2. There are components corresponding to the climatic data, PV panel, conversion unit and output parameters.

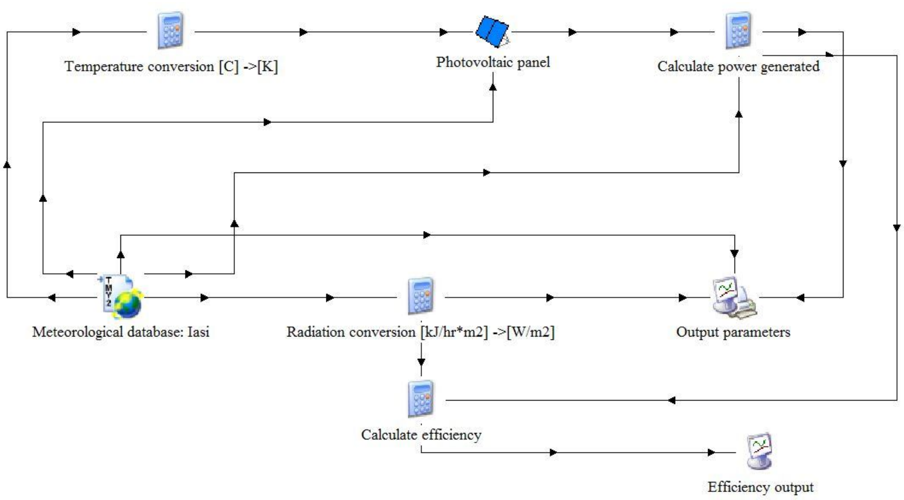

Fig. 2 – The block diagram of the photovoltaic system realized in TRNSYS.

The following parameters of the PV panel were used in the analysis:
– short-circuit current: I_{sc} = 6.5 A;
– open circuit voltage: V_{oc} = 21.6 V;
– maximum power output: P_{mp} = 100.3 W_p;
– maximum power current: I_{max} = 5.9 A;

– maximum power voltage: V_{max} = 17 V;

– normal operating cell temperature: t_{NOCT} = 47 °C.

The main inputs are the south orientation of PV panel, the vertical/horizontal position and variable intensity of solar radiation, according to the climatic conditions of TMY of Iaşi.

The output data from the model are the effective operating temperature, efficiency, current, voltage and power of PV panel.

3. Results

The results of simulations realized in previous conditions are presented as images and charts, Figs. 3,...,8, and numerical data, Table 1.

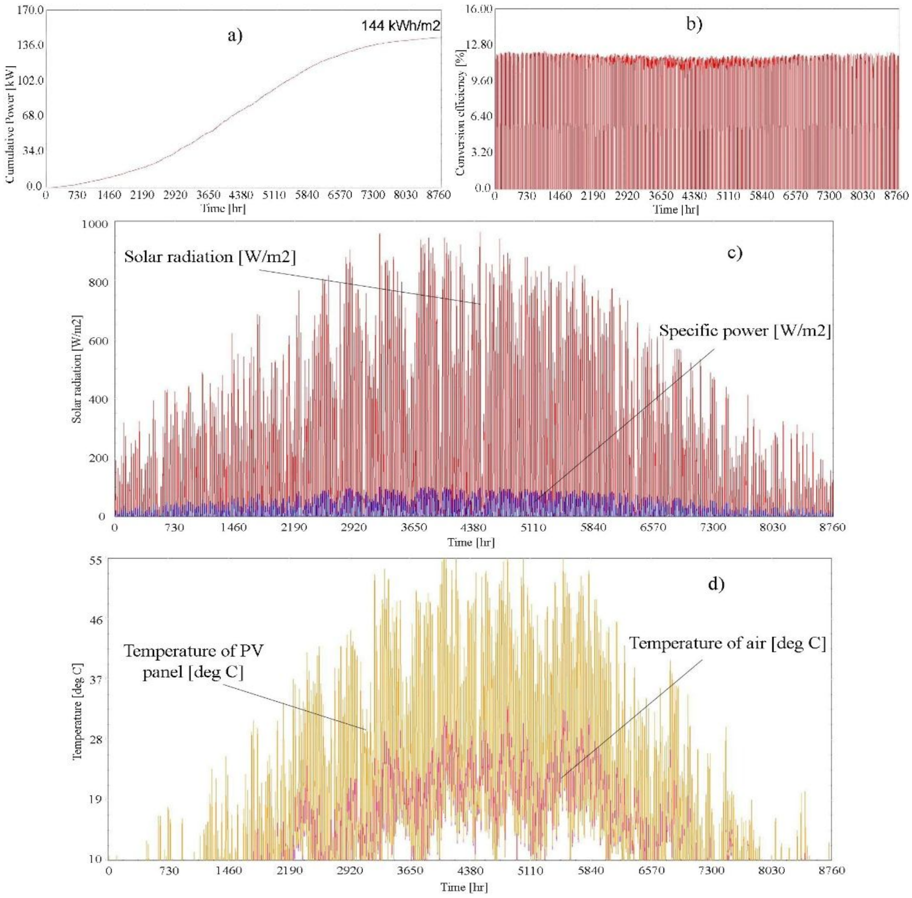

Fig. 3 – Horizontal position, annually time interval: a) total energy; b) efficiency; c) solar radiation and electric power; d) exterior temperature and photovoltaic panel temperature.

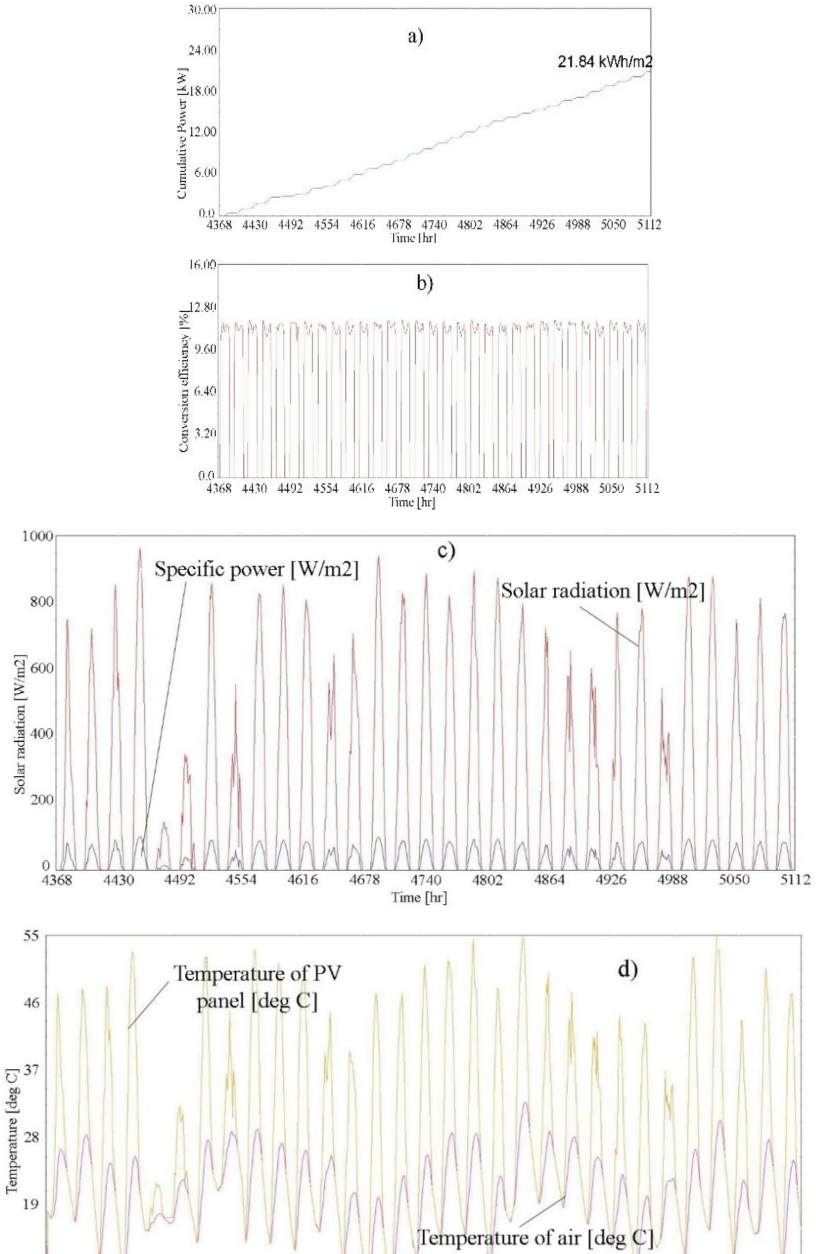

Fig. 4 – Horizontal position, monthly time interval (July): a) total energy; b) efficiency; c) solar radiation and electric power; d) exterior temperature and photovoltaic panel temperature.

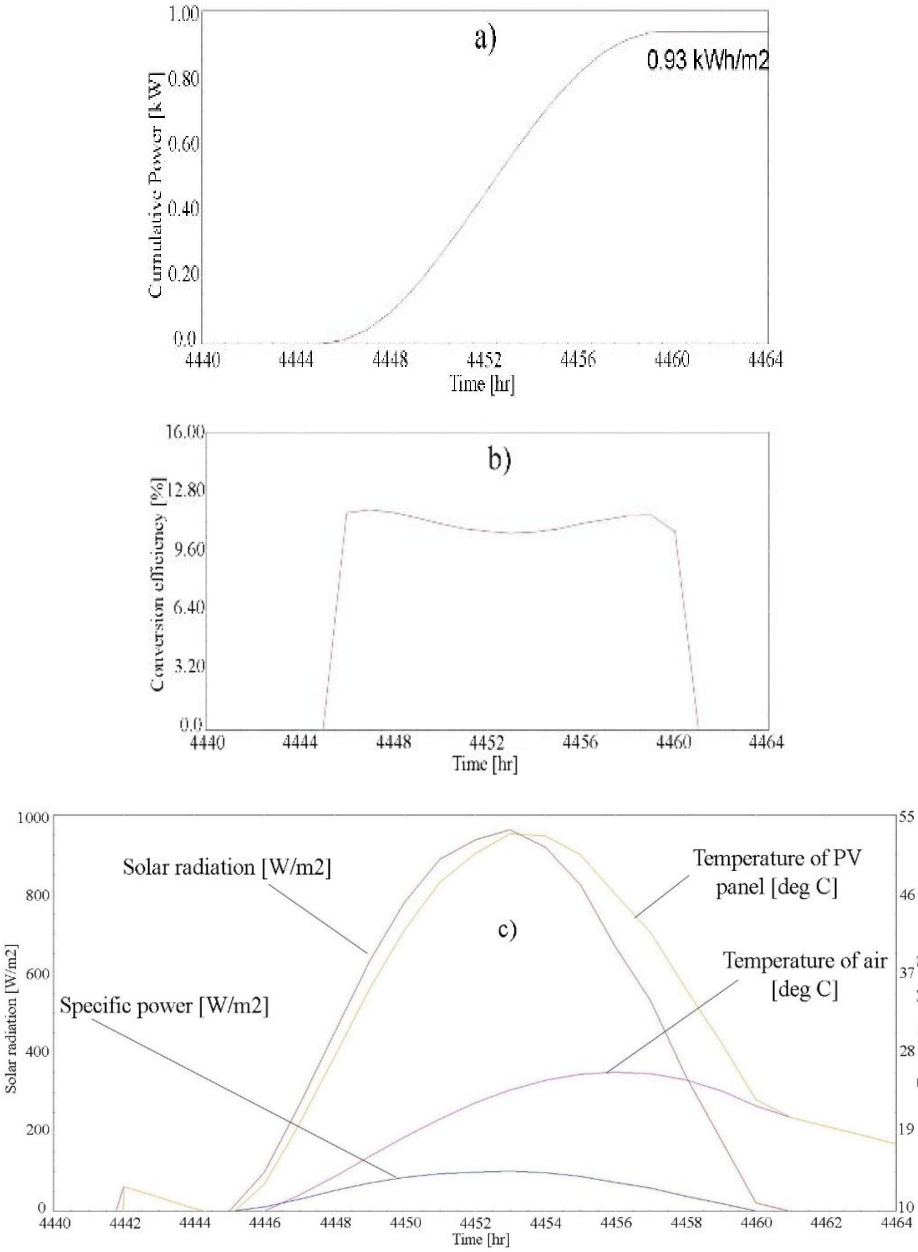

Fig. 5 – Horizontal position, daily time interval (July): a) total energy; b) efficiency; c) solar radiation, electric power, exterior temperature and photovoltaic panel temperature.

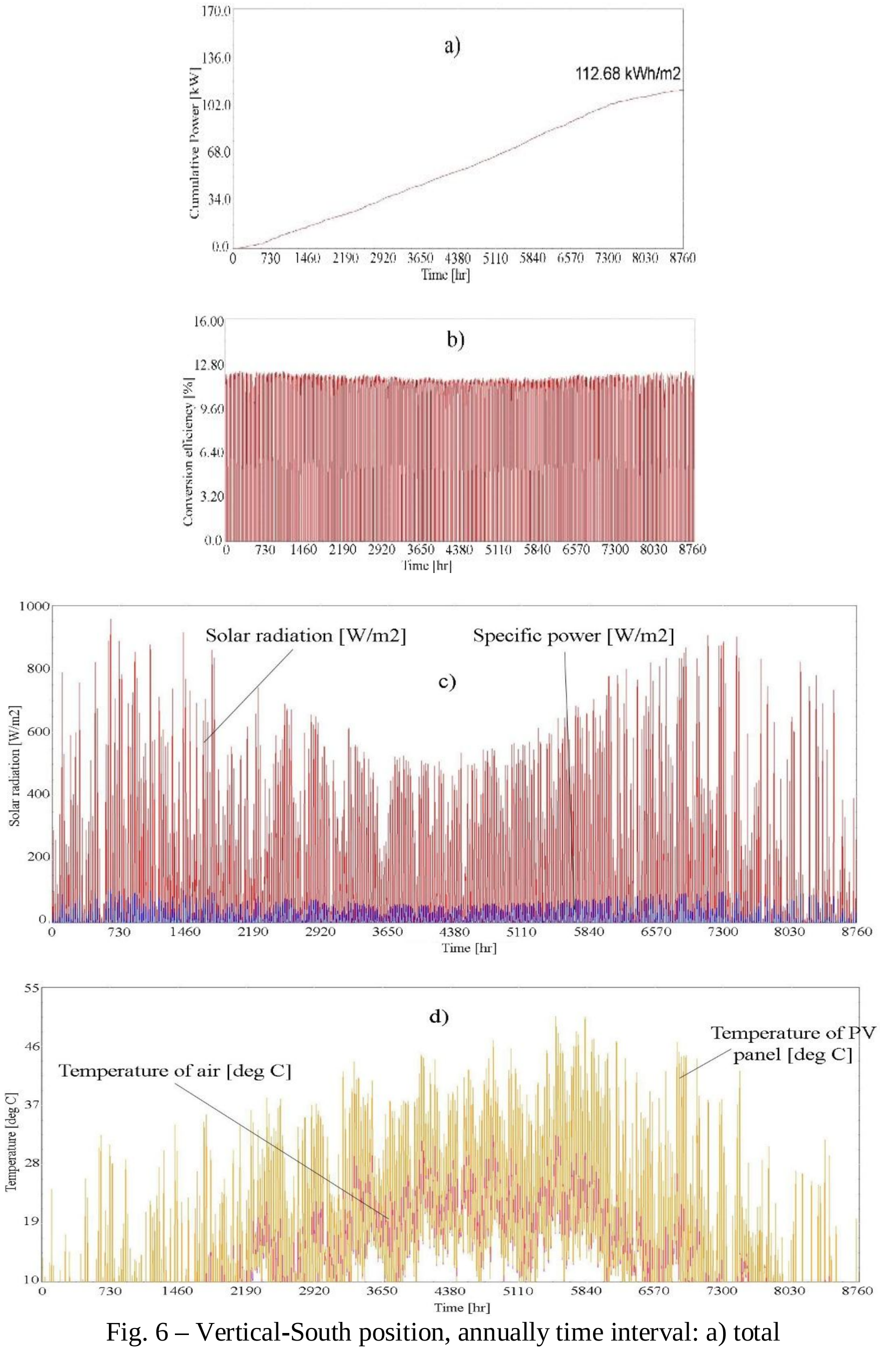

Fig. 6 – Vertical-South position, annually time interval: a) total energy; b) efficiency; c) solar radiation and electric power; d) exterior temperature and photovoltaic panel temperature.

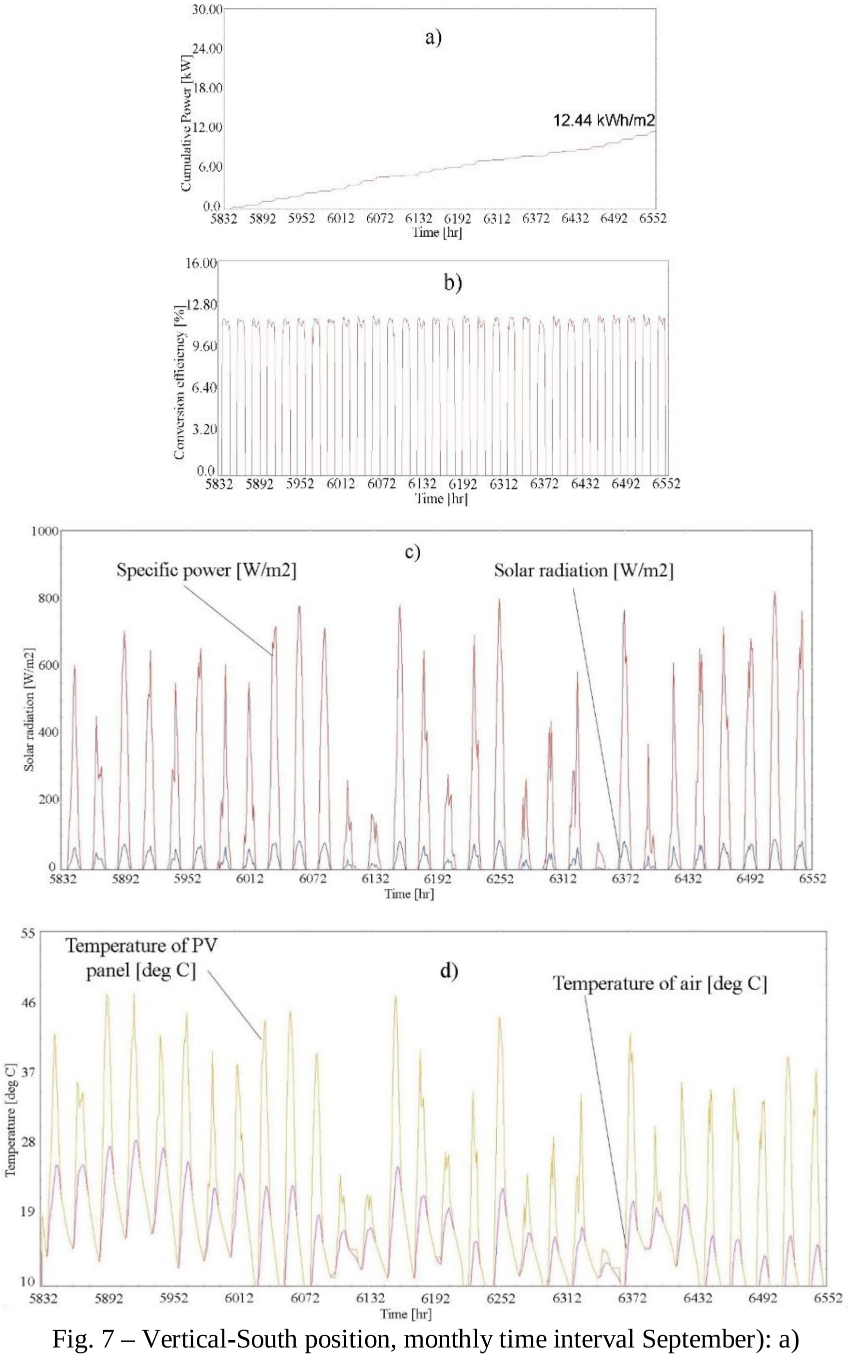

Fig. 7 – Vertical-South position, monthly time interval September): a) total energy; b) efficiency; c) solar radiation and electric power; d) exterior temperature and photovoltaic panel temperature.

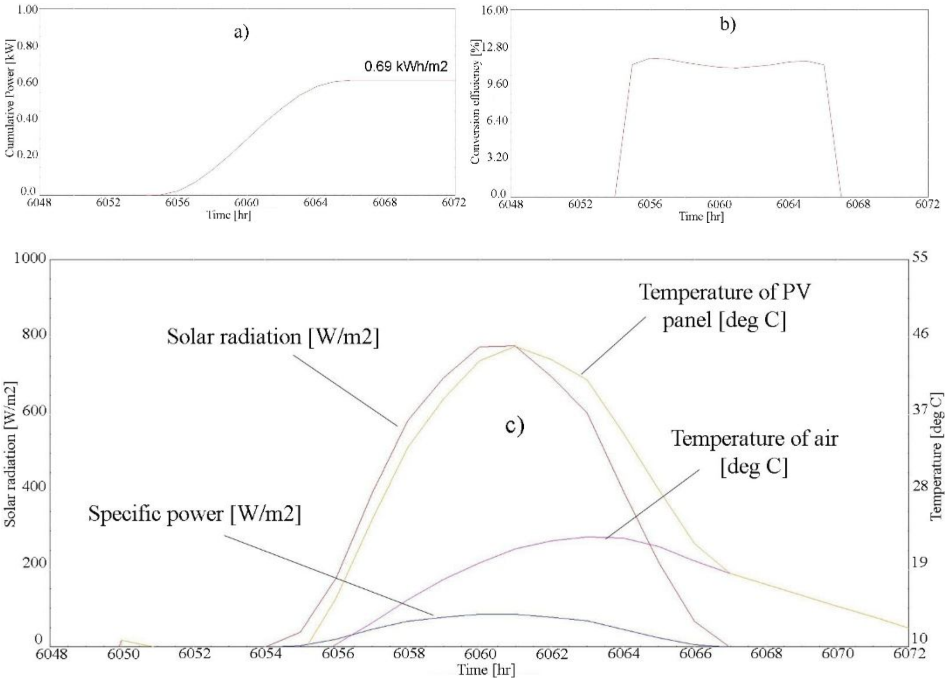

Fig. 8 – Vertical-South position, daily time interval (September):
a) total energy; b) efficiency; c) solar radiation, electric power,
exterior temperature and photovoltaic panel temperature.

In Figs. 3,...,8 are presented the values of the main parameters during annual, monthly or daily analysis. On the left axis it is represented the scale of intensity of solar radiation and specific power generated by PV panel [W/m^2], while on the right axis it is figured the scale of temperatures [°C] for external air and surface of the panel.

The operating temperature of the PV panel is directly influenced by intensity of solar radiation and by ambient temperature. The power generated by photovoltaic panel is also dependent of solar radiation and inversely proportional with the cell's temperature.

Table 1
The Produced Energy and the Photovoltaic Panel Efficiency

Time interval	Horizontal position		Vertical-South position	
	E kWh/m^2	*η* %	*E* kWh/m^2	*η* %
Annually	144	11.62	112.68	11.63
Monthly	21.84	11.21	12.44	11.41
Daily	0.93	11.02	0.69	11.54

In these conditions, the photovoltaic panel is functioning with parameters shown in Table 1. The maximum average efficiencies are less than 12%, with a peak value of 11.63% for annual average. A higher amount of energy is produced for horizontal position comparing to the vertical one, but at lower values of efficiency.

The annual balance emphasizes a percent of 77% of energy produced for vertical-south position related to the horizontal one.

For improving the efficiency of PV panels integrated into buildings, a cooling solution would be necessary. Thus, considering a cooling to the 25°C, equivalent to the standard test conditions, the efficiency could raise with 20%. For south orientation, the best interval for cooling is 10:00 – 17:00.

4. Conclusions

The efficiency of photovoltaic panel is directly influenced by the intensity of solar radiation and also by its operating temperature. The temperature of the PV panel can reach values of 55°C for horizontal position and 48.5°C for vertical one, for intensity of solar radiation of 800 W/m^2 and 500 W/m^2. Taking into account that for large urban areas, the available horizontal surfaces are reduced or occupied, a vertical integration of PV panels could be a viable solution.

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* * * http://www.intechopen.com/source/html/37984/media/image5w.jpg

* * * http://www.solar-facts.com/panels/panel-efficiency.php.

INFLUENŢA POZIŢIEI PANOURILOR FOTOVOLTAICE INTEGRATE ÎN CLĂDIRI ASUPRA RANDAMENTULUI DE CONVERSIE

(Rezumat)

Lucrarea prezintă analiza eficienței energetice a sistemelor fotovoltaice integrate în clădiri, având ca locație oraşul Iaşi. În mod obişnuit, poziția panourilor fotovoltaice este fixă, iar randamentul de conversie este analizat din punctul de vedere al intensității radiației solare şi al temperaturii de operare a celulelor fotovoltaice. Modelarea sistemului şi obținerea parametrilor de funcționare este realizată cu ajutorul softului TRNSYS. Studiul este realizat pentru poziții variabile ale panourilor fotovoltaice, respectiv orizontală şi verticală-sud. Rezultatele analizei sunt prezentate în raport cu energia cumulată produsă, precum şi cu eficiența panourilor fotovoltaice, pentru intervale de studiu anuale, lunare şi zilnice.