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Research on the use of a photovoltaic system in an urban locality

Cercetare privind utilizarea unui sistem fotovoltaic într-o localitate urbană

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Rezumat. *Sistemele fotovoltaice au atras atenția în România în ultimii ani datorită beneficiilor multiple, precum implementarea într-un timp scurt, independența totală a energiei, protecția mediului și utilizarea unei surse de energie inepuizabile. Soarele este acea sursă de energie inepuizabilă și se estimează că radiația solară va exista încă 4-5 miliarde de ani. Pentru implementarea unui sistem fotovoltaic, trebuie să se ia în considerare condițiile metrorologice din zona în care se va implementa sistemul însă pentru a fi eficiente, panourile fotovoltaice trebuie instalate corespunzător. Lucrarea prezintă studiul realizat pentru a analiza impactul condițiilor meteorologice, precum radiația solară directă, temperatura medie, viteză vântului și durata de strălucire a soarelui, asupra cantității de energie electrică generată de către sistemul fotovoltaic.*

Cuvinte cheie: sistem fotovoltaic on grid, panou fotovoltaic, aplicția “Fusion Solar”, condiții meteorologice, producția de energie electrică, consumul de energie electrică, perioadă de amortizare.

Abstract. *Photovoltaic systems caught attention in Romania in recent years due to the multiple benefits, such as implementation in a short time, total energy independence, protection of the environment and use of an inexhaustible energy source. The sun is that inexhaustible source of energy, and it is estimated that solar radiation will exist for another 4-5 billion years. For the implementation of a photovoltaic system, the metrological conditions in the area where the system will be implemented must be taken into account, but in order to be efficient, the photovoltaic panels must be installed properly. The paper presents the study conducted to analyze the impact of weather conditions, such as direct solar radiation, average temperature, wind speed and duration of sunlight, on the amount of electricity generated by the photovoltaic system.*

Key words: on grid photovoltaic system, solar panel, “Fusion Solar” application, weather conditions, electricity production, electricity consumption, amortization period.

1. Introduction

Solar radiation is an important source for electricity production [1], [2]. In recent years, due to technological development and the advancement in knowledge, new types of solar cells have been developed to increase the efficiency of photovoltaic panels, and thus the efficien-cy of the system [3]. This leads to the reduction of the required number of panels and the space intended for their installation.

The factors that influence the efficiency of the panels are: the solar radiation [4] of the area where the system is implemented, the optimal angle of inclination, the meteorological conditions, etc.

Romania is divided into three sunny areas, depending on the geographical area, so there is the red zone (> 1650kWh / m^2 / year), corresponding to the southern area, respectively southern Moldovia, Dobrogea, Wala-chia and Oltenia, yellow zone (1300 - 1450 kWh / m^2 / year), cor-responding to the Carpathian and sub-Carpathian re-gions of Walachia, the whole Banat, the northern and middle part of Moldovia and Transylvania and the blue zone (1150 - 1300 kWh / m^2 / year), corresponding to the mountainous regions [5].

The angle of inclination of the photovoltaic panel systems help to capture the sunlight efficiently, and in order to generate the maximum electricity, it must be 15^0 [6]. The meteorological conditions witch influence the electricity production will be studied in this paper, with the help of a software. The application monitors in real time the production of electricity of a photovoltaic system on grid, and stores the information for several days

2. Structure of on grid photovoltaic system

A case of study was carried out in Celaru locality from Dolj county, in order to highlight the efficiency of an on grid system, with power range of 3.42 kW, depending on the meteorological conditions, and considering the economical point of view. The study involves two stages:

1. Identifying the impact that meteorological conditions have on the production of electricity generated by the on grid photovoltaic system;

The research was conducted over a period of 128 days, using the application "Fusion Solar" [7], and the weather forecast was provided by the National Meteoro-logical Administration.

2. Determining the payback period of the investment, which depends on a number of factors such as the amount invested in a photovoltaic system, own energy consumption, the amount of electricity delivered to the network, the green certificates obtained, but in this case will be taken into account. considering only electricity delivered to the national grid.

To carry out the research, the existing endowment in a household located in Celaru locality, (figure 1) was used due to the accessibility, the installed power to the existing consumers and the solar radiation.

Fig 1. Location of Celaru locality [8]

The annual solar radiation in Celaru locality, has over 1400 kWh / m^2, but for the sizing of the photovoltaic system, it was considered that the specific intensity of the annual global radiation for photovoltaic modules (PV) mounted at optimal inclination is 1350 kWh / m^2, respectively radiation level at ground level of 1163 kWh / m^2.

To designe the photovoltaic system, the average annual value of solar radiation was used.

Photovoltaic components are presented in table 1.

Table 1

System components

Current number	System components	
1.	12 polycrystalline photovoltaic panels, 285W, mounted on the east side of the roof.	
2.	Accessory	6 pieces, aluminum rail;
		4 pieces, rail connection set;
		22 pieces, XS aluminum middle clamps;
		4 pieces, separator for fuses solar panels;
		4 pieces. fuses for solar panels;
		24 hexagon screws;
		2 solar panel connectors;
		1 circuit breaker;
		1 cofret modular etanș.
3.	1 Huawei single-phase inverter, 3000 W.	
4.	1 Smart Meter Huawei.	
5.	1 Comtec fuse box.	
6.	1 bidirectional meter.	

3. Method for monitoring electriciry production

To monitor the production of electricity, more precisely electricity used from the network or from own consumption but also the one injected into the network, the application "Fusion Solar" [7] is used, available for the Android operating system, in the Play Store and for desktop (figure 2).

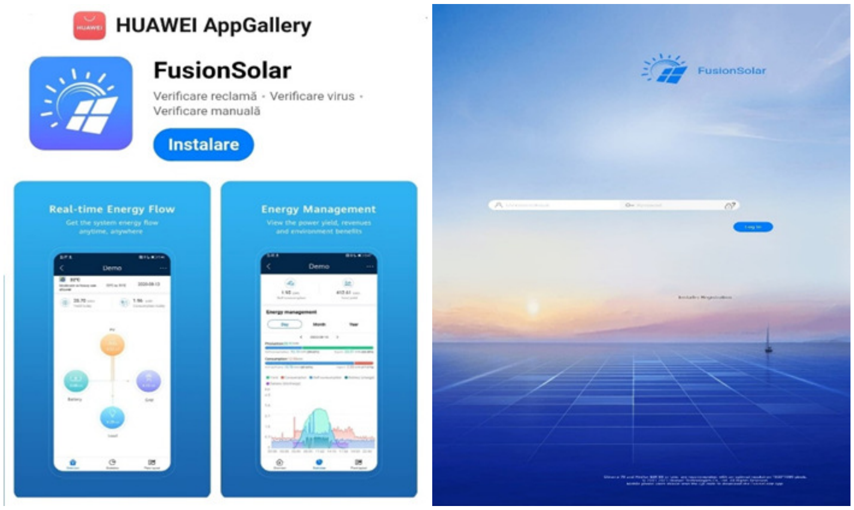

Fig. 2. Interface Fusion Solar for Android (left) and for desktop (right) [7]

A study was conducted over a period of 128 days, between 24.01.2021-31.05.2021. to observe the variation of electricity production, depending on the meteorological characteristics such as the duration of sunshine, solar radiation, temperature and wind speed, these data being provided by the National Meteorological Administration.

3.1. Analysis of meteorological conditions

A graph was made to highlight how it influences the duration of sunlight, the production of electricity (figure 3).

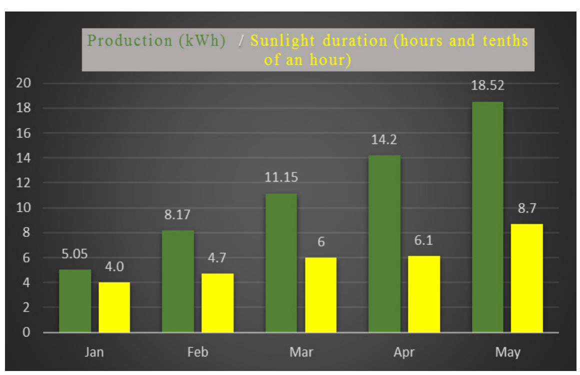

Fig. 3. Electricity production depending on the duration of sunlight

A graph was made to highlight how the average temperature influences the production of electricity (figure 4).

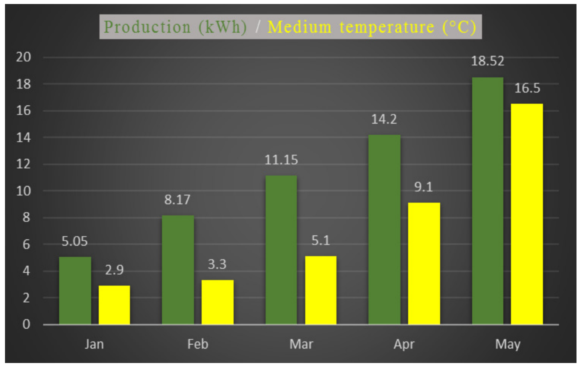

Fig. 4. The amount of electricity generated depending on the average temperature

A graph was made that illustrates the influence that solar radiation has on electricity production (figure 5).

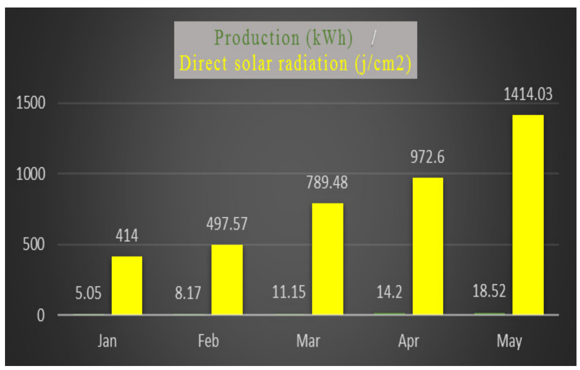

Fig. 5. Electricity production according to solar radiation

In order to highlight the influence that wind speed has on electricity production, a graph was made (figure 6).

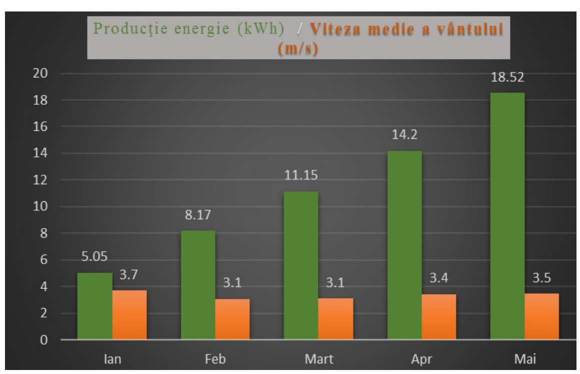

Fig. 6. Electricity production depending on wind speed

According to graphs 3, 4, 5 and 6, the largest amount of electricity generated in a day was in May.

The amount of electricity generated in May is represented in figure 7.

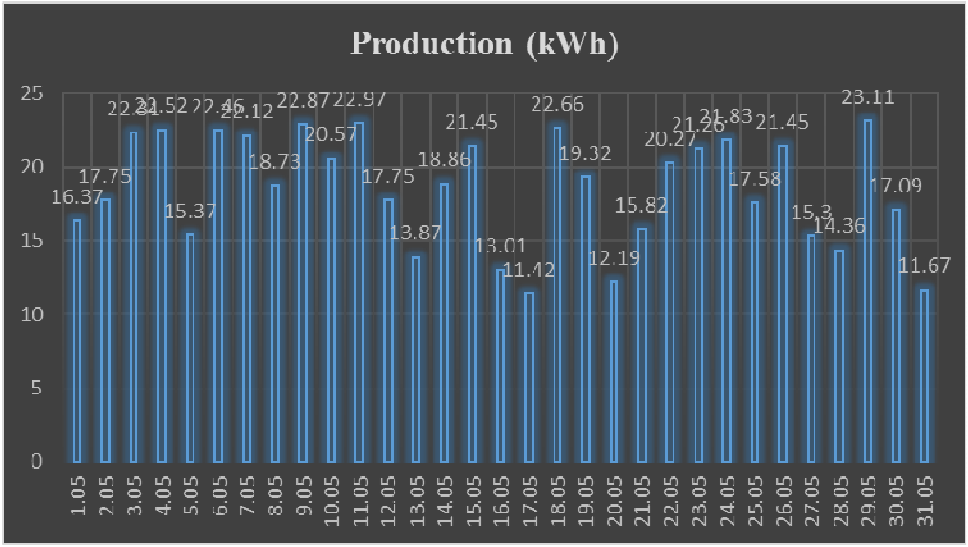

Fig. 7. Electricity generated in May

According to graphs 3, 4, 5 and 6, the lowest amount of electricity generated in a day was in January.

The amount of electricity generated in January is represented in figure 8.

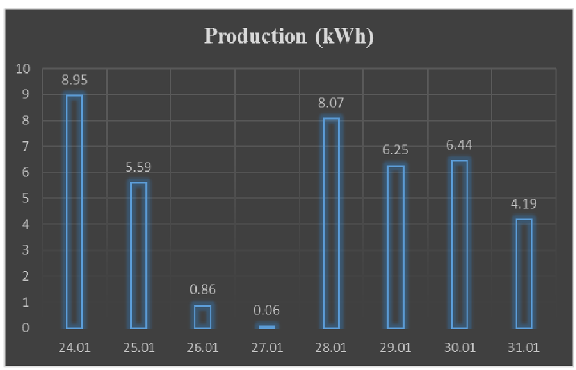

Fig. 8. Electricity generated in January

3.2. Production / usahe of electrical energy

The graphs (figure 9 and figure 10) were obtained with the help of the "Fusion Solar" application [7], a software which is used to monitor the installed on grid photovoltaic system.

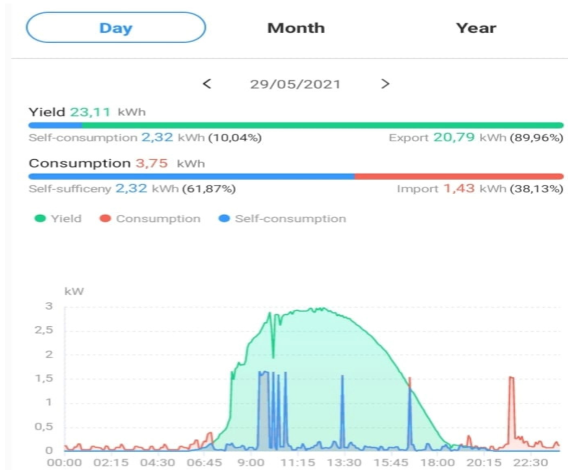

Fig. 9. Usage of electricity from 29.05.2021 [7]

Figure 10 shows only the electricity generated by the photovoltaic system, without illustrating the electricity used from the network or from its own consumption and that injected into the network.

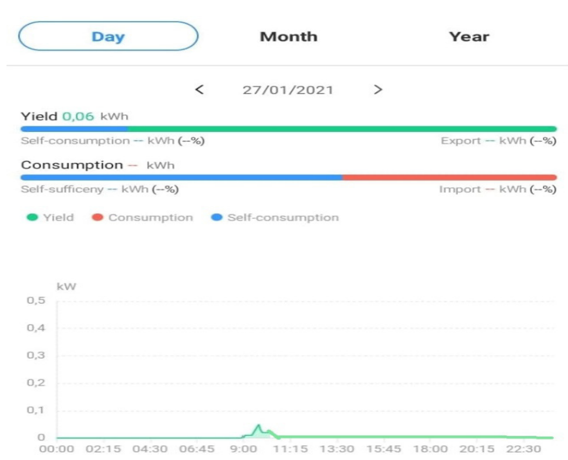

Fig. 10. Usage of electricity from 27.01.2021 [7]

4. Contribution concerning the determination of the investment amortization period

The amortization period of the investment was determined based on the ratio between the amount invested for the acquisition of the system and the electricity delivered in the network.

The case of the household Celaru, was investigated, which benefited from the "Green House"[9] program for which the owner paid the amount of 2220.62 lei and delivered 295 kWh in the network (figure 11), for 2 months.

Fig. 11. The amount of electricity delivered to the network

A simple calculation was made to obtain the amount that was earned from the electricity delivered to the national grid.

The price received for 1 MWh delivered in national grid was 196.56 lei, 0.19 lei/ kWh, could be obtained the amount received for the electricity delivered to the national grid, is presented in the equation (1).

0.19 lei x 295 kWh=57.98 lei (1)

Leul is the monetary unit of Romania.

Was realized the fraction between the amount obtained and the period of time, respectively two months, was obtained the amount received per month, for electricity delivered to the national grid, described by the equation (2).

57.98 lei / 2 months = 28.99 lei/month (2)

Was realized the fraction between the amount invested for the implementation of the photovoltaic system and the amount of money obtained per month, resulted in the period of amortization of the investment, expressed in months, described by the equation (3).

2220.62 lei/28.99 lei=77 months (3)

Taking into account only the electricity delivered to the network, except for own consumption and green certificates obtained, we can estimate that the payback period of the investment will be 77 months.

5. Conclusions

Comparing the meteorological conditions with the production of electricity, within the 128 days of study, we obtained the following data:

- The highest electricity production was generated on 29.05.2021, according to the graph in figure 10, with a value of 23.11 kWh, and consumption of 1.43 kWh;
- The lowest electricity production was recorded on 27.01.2021, with a value of 0.06 kWh.

On this day it can be seen that only the electricity generated by the photovoltaic system, due to the lack of the Huawei smart meter.

Comparing the maximum temperatures of the 128 study days, the day when the highest temperature recorded was on 02.05.2021, with a value of (+22.6 ^{0}C).

The highest electricity production was generated on 29.05.2021, the temperature recorded off (+17.6 ^{0}C). According to these data it can be concluded that temperature may be one of the factors that does not influence the production of electricity. Taking into account these values, it can be concluded that the duration of the sunlight can influence the energy production generated by the photovoltaic system.

The direct solar radiation reaches the maximum value in the 128 study days, on 10.05.2021, with the value of 2658 (j / cm2). On 29.05.2021, the day when the highest energy production was registered, the direct solar radiation has the value of 2641 (j / cm^2). Analyzing these values it can be concluded that direct solar radiation can influence the production of electricity.

Analyzing the values of wind speed from the 128 study days, the maximum value of 8.7 (m / s) was recorded on 18.05.2021. On 29.05.2021 the wind speed has a value of (4.5 m / s), analyzing the two values, it can be concluded that wind speed can be one of the factors that does not influence the production of electricity.

To obtain more concrete results, the study can be extended during the summer months, to observe the production of electricity, when the intensity of sunlight is higher, the day is longer, compared to the night and the sky is predominantly clear.

These results can be used when implementing a photovoltaic system, to predict its efficiency.

In the calculation of the amortization period, the electricity produced in the months February and March was taken into account, and the meteorological conditions were unfavorable to the production.

In order to obtain more concrete data for the amortization period, the research can be extended over a period of 6 months or even 12 months.

In determining the amortization period, the green certificates obtained according to the production of electricity delivered in the network. The research can be extended to account for each 1 MWh delivered in the network and two certificates can be obtained, each with a value of 123,17 lei, according to the national course BNR.

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