INFLUENCE OF TILT ANGLE ON PV ELECTRICITY GENERATION IN TARGU JIU AREA. PART 2 - RESULTS AND DISCUSSION

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ABSTRACT: *The experimental facility used for studying the influence of the tilt angle on electricity generation is presented. The methodology used and the results of measurements carried out for two years are highlighted.*

KEY WORDS: PV panel, tilt angle.

1. INTRODUCTION

For solar installations, the optimal angle of inclination is an important parameter that affects the overall energy efficiency of the entire system. The optimal tilt angle is influenced by different factors, such as location latitude, index clarity, air pollution, and the distribution of sunny days representing the climate.

Roof solar photovoltaic (PV) installations are becoming increasingly numerous and will develop further with deboning of the energy sector [1]. A parameter of particular importance for the installation of fixed panels is the tilt angle, as the power produced by the PV panel increases with the increase of the surface exposed to direct sunlight.

Another issue of concern is whether panels with mono or bi-axial solar tracking devices, which regulate the position of the solar panel, tracking the apparent sunshine during the day, receive more incident radiation than the optimally inclined panels.

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The project's goal was to increase the performance in scientific investigation activity in order to streamline current processes from energy industry based on fossil fuels and to promote renewable energy production and better use of waste - components with major impact on the environment Gorj county and South-West Oltenia.

2. PV SOLAR SYSTEM FEATURES

The regional research center for sustainable energy technologies consists of four laboratories, the Laboratory of Applied Research for Renewable Energy being one of them. In this laboratory, the conversion of solar energy into electricity, depending on climatic parameters, features of solar panels, solar panels orientation, reciprocal shading etc, can be studied.

The PV solar system has the following characteristics:

- The solar system is a standalone one, in the presence of grid and it will produce electricity mainly for the building

consumption. When the photovoltaic system will not provide the whole electricity demand, the gap will be provided by the grid via the existing main connection.

- The overproduction of electricity will be stored in gel batteries and it is delivered on demand via an inverter of 400 V. It is also possible to deliver the electricity on the grid.
- The photovoltaic system is fully automated and constantly electronically monitored.
- The installed capacity is of 12 kW, divided in four modules of PV panels of 3 kW each – fig.1.
- The photovoltaic panels are mounted on solar trackers with biaxial orientation.

Fig.1. PV solar system

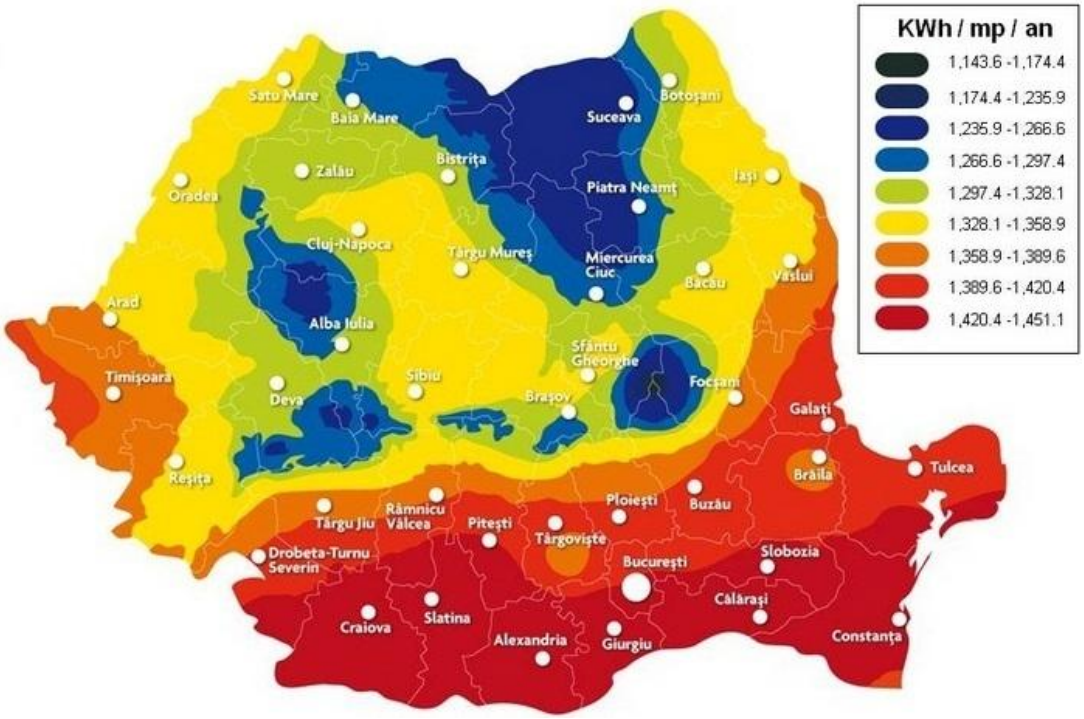


Fig.2. Solar irradiance map of Romania [2]

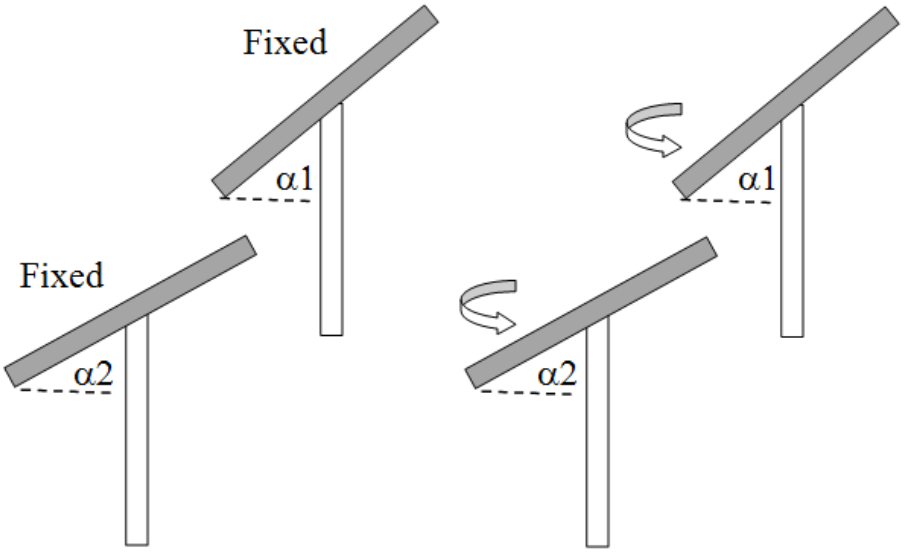


Fig.3. Positions of the trackers

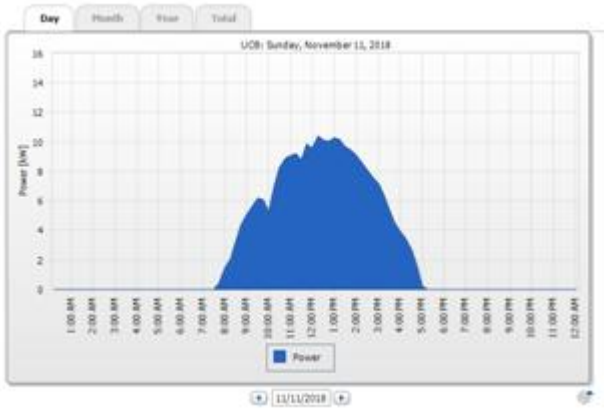
The analysis was performed for Targu Jiu, which is located in a good area of solar irradiance, respectively 1358,9 .. 1389,6 kWh/sqm/year – fig.2.

The latitude of Targu Jiu is 45 N, and according to [1], the optimal tilt angle should be also 45°.

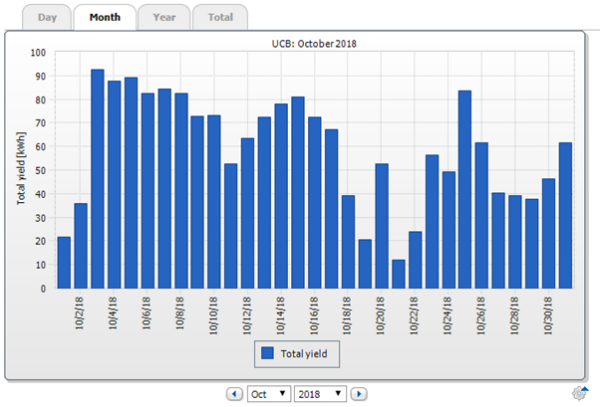
In order to determine the optimal tilt angle, the suggested methodology is the following:

- two panels will remain fixed, at different tilt angles, α1, α2.
- the other two panels will be inclined with the same tilt angles but they should follow the sun position from east to west – fig. 3
- the power generated by each panel should be measured and recorded

The monitoring system may store and integrate the measured parameters and to display them as tables or charts – fig. 4.



a



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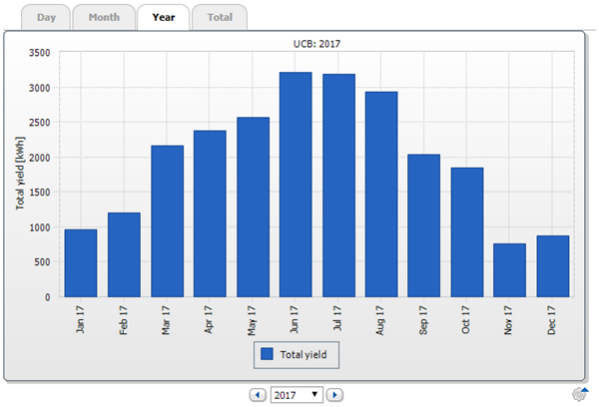

c

Fig. 4. Generated energy.
a – daily, b – monthly, c - yearly

3. RESULTS

The results are shown in tables 1 (for the fixed panels) and in table 2 (for mono-axial tracker) and in fig. 5.

Table 1. Electricity generated by the fixed panels

Tilt angle	25	35	45	60
Jan	2,323	2,583	**2,783**	**2,956**
Feb	3,126	3,348	**3,490**	**3,545**
Mar	3,977	**4,091**	**4,114**	3,976
Apr	**4,291**	**4,253**	4,128	3,787
May	**4,958**	4,808	4,563	4,033
Jun	**5,271**	5,055	4,748	4,123
Jul	**5,491**	5,291	4,989	4,356
Aug	**5,318**	**5,231**	5,032	4,539
Sep	**4,132**	**4,185**	**4,148**	3,924
Oct	3,230	3,408	**3,506**	**3,498**
Nov	2,221	2,422	**2,566**	**2,664**
Dec	1,805	1,997	**2,141**	**2,260**

Table 2. Electricity generated by the panels mounted on mono-axial trackers

Tilt angle	25	35	45	60
Jan	2,531	2,866	3,131	**3,382**
Feb	3,422	3,750	3,986	**4,152**
Mar	4,471	4,762	4,941	**4,989**
Apr	4,918	5,102	**5,173**	5,065
May	5,825	**5,966**	**5,976**	5,746
Jun	6,404	**6,569**	**6,589**	6,346
Jul	6,723	6,939	**6,998**	6,788
Aug	6,319	6,576	**6,681**	6,548
Sep	4,651	4,890	**5,016**	4,987
Oct	3,532	3,818	4,011	**4,117**
Nov	2,403	2,669	2,869	**3,035**
Dec	1,907	2,135	2,312	**2,470**

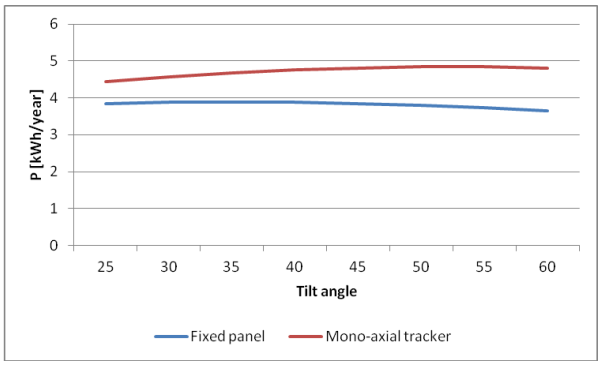

Fig. 5. Electricity generation

4. CONCLUSION

The optimal angle varies throughout the year, depending on the position of the sun.
The best results for fixed photovoltaic panels are obtained if they are south faced at an optimal angle depending on season. In winter months the tilt angle must be 45-60^{o} and in summer below 25 ^{o}.
The electricity generated by the panels mounted on mono-axial trackers is larger, and the optimal tilt angle is around 45 ^{o}.
The study must be extended to get the optimum value of the tilt angle.

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