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THE DESIGN OF A PHOTOVOLTAIC PANELS SYSTEM CONNECTED TO AN IRRIGATION SYSTEM

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Abstract: *The design and modelling of an off-grid photovoltaic panel system for the power supply was chosen. The general objective of this paper is to design and model a system concept of photovoltaic panels, as well as an irrigation system. The second objective is to connect an irrigation system to the photovoltaic panel system. The connection of the irrigation system is made with a cable containing three conductors for connecting the motor to electricity. The motor is connected to the water pump by an elastic coupling through which it exerts the rotational movement of the pump shaft.*

Key words: *design, calculation, photovoltaic panels, irrigation system.*

1. INTRODUCTION

Solar energy can be used directly to produce electricity for heating or even for cooling. Solar energy can be used in various ways. For example, plants convert sunlight into chemical energy through photosynthesis. Instead, we use this energy by eating plants or burning wood. The term "solar energy" means the "transformation of sunlight into thermal or electrical energy for use" [1].

The photovoltaic module represents the smallest photoelectric installation, which is obtained by interconnecting solar cells in series and / or in parallel, these being encapsulated in order to obtain a higher mechanical resistance and to protect the cells from the action of the environment.

2. THE STATE OF THE ART

The solar energy can be used to:

- generate electricity through solar cells (photovoltaic), generate electricity through solar thermal power plants, heat buildings by heat pumps, heat buildings and produce hot water through solar thermal panels [2] The two types of solar energy we use are solar thermal and photovoltaic.

The direct transformation of solar radiation into electricity with the help of solar cells is called photovoltaic conversion.

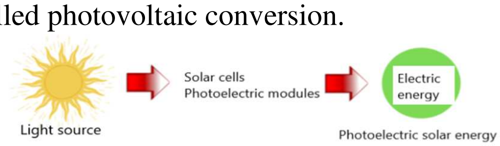

Fig. 1. Conversion of solar energy into photoelectric conversion

The photovoltaic cell is represented by an electronic device, which aims to generate pairs of electrons and free gaps through the process of light absorption, the device being composed of semiconductor materials. Within the cell, the charge carriers are separated by a potential

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barrier, where internal discontinuities drive electron in the opposite direction to the gaps. [3]

Fig. 2. The photovoltaic cell [2]

An assembly of photovoltaic panels, electrically connected to each other, forms a system of photovoltaic panels. The photovoltaic matrix is one that generates current continuously, being powered by sunlight. It is necessary to place these systems on stable structures, able to support the matrix ans resistant to less favorable weather conditions.

The components of a photovoltaic system are represented below.

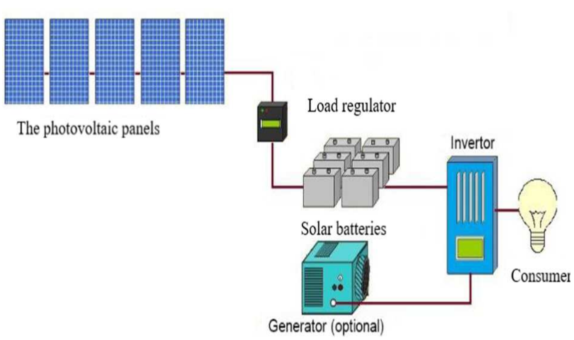


Fig. 3. The components of a photovoltaic system [2]

3. THE CONCEPT OF A PHOTOVOLTAIC IRRIGATION SYSTEM

To design the photovoltaic irrigation system, several aspects of major importance were taken into account.

Mainly, since the photovoltaic system benefits from several four batteries connected in parallel position it will be possible to use a large amount of energy which is stored for the continuous operation (in hours) of the irrigation system for a long period of time and to irrigate a large area of land. Although the design and shape of the photovoltaic assembly ranks last in the hierarchy of answers, a good design still offers increased confidence to potential consumers.[2]

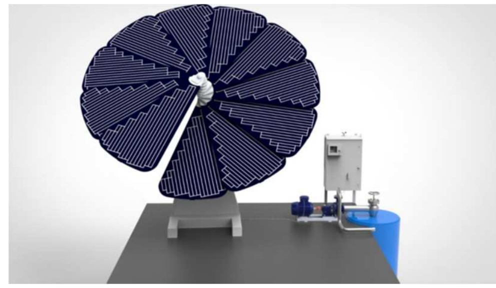


Fig. 4. The concept of a photovoltaic irrigation system

3.1 Checking the energy potential

Following the introduction of parameters related to the total power of photovoltaic panels, storage capacity of batteries, daily consumption expressed in watt hours but also the type of photovoltaic system, in our case being a two-axis solar tracking system, in the Radauti, Suceava County we obtained a result of the power absorbed during a year which is shown in the Figure 5. This was calculated with *electricalc* soft.

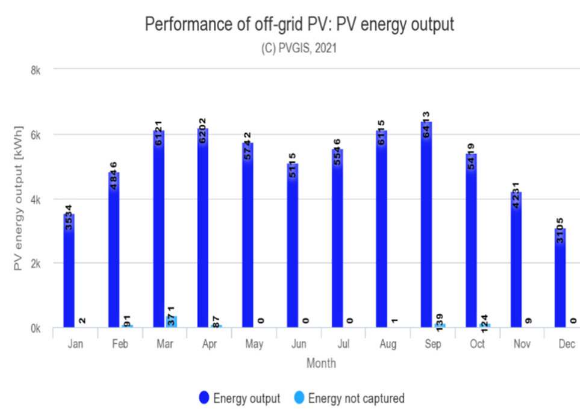


Fig. 5. The power absorbed during a year [3]

3.2 The components of the system

A list of components is shown in Table 1, as follows:

Table 1

The compounds of photovoltaic irrigator system

Name	No. of Pieces
Photovoltaic panel	12
Light sensor	1
Motor	1

Panel's support	1
East-west axle motor	1
Stand	1
Cooling fan	2
Battery	4
Battery support	1
Sun tracking system	1
Weather station	1
Irrigator system	1
Electric motor	1
Electric system (Mppt)	1
Flexible coupling	1
Water pump	1
Suction pipe	1
The well	1
Discharge line	1
North-South axle motor	1

The photovoltaic panel was designed in Solid works and the result is showed in Figure 6. For the main assembly, 12 flower mounted panels are used on an axis that has a rotating movement, to close and open the assembly during the night, or in adverse weather conditions.

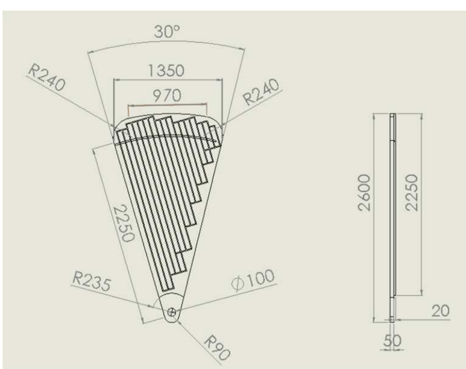


Fig. 6. The Solid works model

The fixed part of the photovoltaic system is made up of the stand and its attachment is made in 4 points located on the support in front of the stand.

At the same time, inside the stand is one of the electrical systems (Mppt) and the batteries and on the other hand, the sun tracking system.

At the base of the stand are located several 4 batteries (12V). If the batteries are connected in parallel, the voltage remains the same, but the amperage increases, respectively the amount of electricity multiplies by the number of batteries. In this case, a capacity of 880 Ah is reached. The parallel connection of the batteries is achieved by interconnecting the terminals so that the polarities are identical: positive to positive (+), negative to negative (-). Usually, the positive terminal is red, and the negative terminal is black.

Fig. 7 The Mppt presentation

The Mppt (Maximum power point tracking) is a DC converter that optimizes the path of electricity between photovoltaic panels and batteries. The energy of the photovoltaic panels is introduced through the charging controller in the batteries for charging them.

The Mppt also includes a 3500 W inverter, which converts direct current into alternating current to power the single-phase electric motor. Through the display and the buttons, it can see the condition of the batteries, their voltage, the power produces by the photovoltaic panels and the power consumed by electricity consumers.

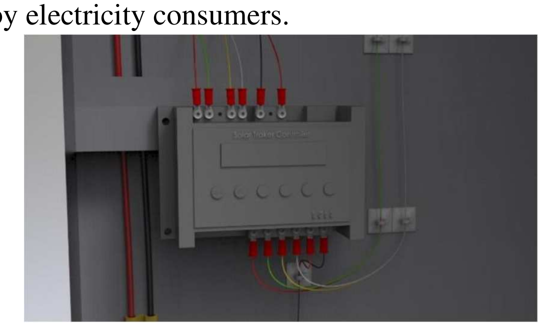


Fig. 8 The tracking sun system

The two-axis sun tracking technology using the sensor, shown in Figure 28, tracks the altitude angle and azimuthal angle of the sun, which in turn are constantly changing. The device is designed to track the sun from sunrise to sunset. This gives a higher capacity and efficiency of the photovoltaic system, compared to a fixed photovoltaic system or one with a single axis for tracking the azimuth or height of the horizon.

The controller is powered by a 12 V power supply. The connection is made through the lower side of the device, through two red and black conductors. Also, at the bottom are positioned the outputs through which the stepper motors are controlled. The red-green conductors represent the motor connection for the East-West axis, and yellow white for the North-South axis.

4. THE IRRIGATION SYSTEM CONCEPT

To achieve the concept of the photovoltaic irrigation system, we chose the drip irrigation. It is composed by a single-phase asynchronous motor, which operates at 220 V, with a power of 1.5 kW, powered by the inverter of the photovoltaic system. The motor is connected to the water pump by an elastic coupling.

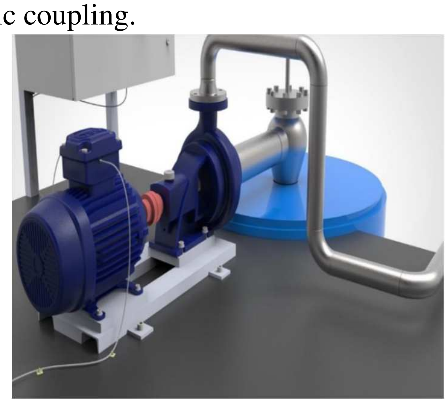


Fig. 9 The pump, electric motor, and the sensor

The connection for the irrigated area will be made with the help of solenoid valves corresponding to each area. With the help of solenoid valves, the connection is made between the system pipes and the surfaces to be irrigated. Subsequently, each connection between the valve and the central system will correspond to a specific area to be irrigated.

The correct operation of the irrigation system is due to the soil moisture sensor that is set from the control button. Being an electronic sensor, it displays the soil moisture level.

5. CALCULATION OF THE ENERGY STORAGE CAPACITY

According to [4] the battery capacity calculation:

$$P = V \times C = 12V \times 220\ Ah = 2640Wh \quad (1)$$

Where P is electric power, V is the voltage and C is the battery capacity.

The capacity of the batteries is:

$$P = V \times 4C = 10560\ Wh \quad (2)$$

The number of panels is:

$$Np = Pi \div Pp = 3000 \div 250 = 12 \quad (3)$$

where Pi is installed power and Pp is the power of a panel.

The total area is calculating as follows:

$$Ta = Pa \times Np = 21.36\text{m}^2 \quad (4)$$

Where Ta is total area, Pa is panel area and Np is total number of panels

<u>Calculation of photovoltaic generator characteristics</u>

The installed voltage of the photovoltaic generator is obtained using the following formula:

$$Ug = Np \div s \times Up = 72V \quad (5)$$

The generator current is obtained by multiplying the current generated by a photovoltaic panel with the number of strings:

$$Ig = 2 \times 8.73 = 17.46\text{m}^2 \quad (6)$$

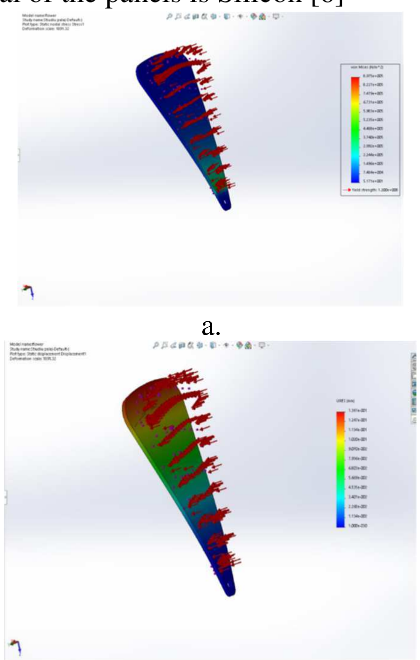
<u>Choosing the charge controller</u>

The role of the charge controllers is to control the charging of solar batteries. When choosing the right regulator is important to verifying the following:

- the nominal voltage of the regulator (must be less than equal to the nominal voltage of the photovoltaic assembly
- the input current must be greater than or equal to the maximum load current on which the assembly can flow.[5]

5.1 Performing the simulation

In the following is presented the resistance simulation of the panel. The material of the panels is Silicon [6]



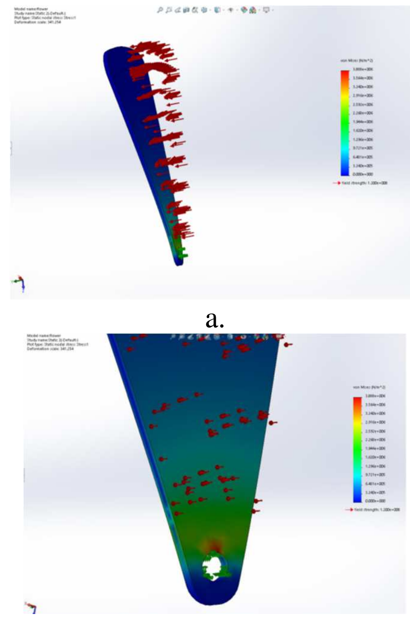
a.

b.

Fig. 10. The first static study

During the simulation, the bottom of the panel was fixed, and a force of 100 N was applied, which was distributed over the entire surface of the panel to check its resistance in adverse weather conditions.

In the area where the panel is attached to the support there is a small stress that can be seen in red color, negligible that does not affect the integrity of the assembly.



a.

b.

Fig. 11. The second static study

In both cases of stress testing the panels withstood and there were no major deformations.

6. CONCLUSION

This paper was proposed to design and model a system of photovoltaic panels in an irrigation network, to streamline the irrigation process through full automation, using the two-axis tracking system, similar to others already on the market. Based on the chosen construction variant, a petal-shaped photovoltaic panel was modeled. The 12 component photovoltaic panels of the final assembly, forming a flower, give it a pleasant and innovative design, and at the same time it is practical, as it is easier to rotate after the sun.

The advantages of this concept are strong wind resistance, innovative design, space for batteries and electrical installation. Therefore, the proposed concept of the photovoltaic irrigation system can be considered as being applied in the agricultural field being a very useful concept, both in terms of efficiency and efficiency, this being based on the calculations and simulations performed in this paper. The advantage of the photovoltaic panel system compared to petrol or diesel pumps, is that it does not require maintenance which consists of checking fuel, powering, starting or stopping the pump.

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Proiectarea unui sistem de panouri fotovoltaice conectate la un sistem de irigare

Rezumat: S-a ales proiectarea și modelarea unui sistem de panouri fotovoltaice pentru alimentarea cu energie a unui sistem automat de irigare. Obiectivul general al acestei lucrări este de a proiecta și modela un concept de sistem al panourilor fotovoltaice, precum și un sistem de irigare. Al doilea obiectiv este conectarea unui sistem de irigare la sistemul de panouri fotovoltaice. Conectarea sistemului de irigare se face cu un cablu care conține trei conductoare pentru conectarea motorului la electricitate. Motorul este conectat la pompa de apă printr-un cuplaj elastic prin care exercită mișcarea de rotație a arborelui pompei.

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