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MOBILE SYSTEM FOR THE PRODUCTION OF ELECTRICITY FROM ALTERNATIVE SOURCES (SOLAR + WIND)

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Abstract: The paper presents a mobile system for the production of electricity from alternative sources (solar + wind) which is intended for use in any isolated place, where there is no possibility to connect to an electricity grid, to ensure the electricity needed by various consumers in agricultural applications and agricultural crop monitoring, remote transmission and management services. At the same time, this mobile system, which is an ecological and economical electricity generator, can be used in the following locations without electricity: holiday homes, cottages, sheep farms, farms, greenhouses, caravans, bee trailers, boarding houses, monasteries, etc. The results of the research allow useful recommendations for farmers who want to use alternative energy sources in isolated farms, to reduce dependence on volatile and uncertain fossil fuel markets, especially oil and gas ones.
Keywords: mobile system, renewable energy, agricultural crop management

INTRODUCTION

A number of studies have been made so far on the development and promotion of energy obtained from renewable energy sources because they contribute to environmental protection, security of energy supply and independence from rising energy prices, thus solving current global problems: energy crisis and environmental impact (Comşa, M. L. 2015; Duhaneanu, M. et. al, 2015; Ilie, A. B. 2012).

The use of hybrid systems (solar + wind) contributes to reducing energy dependence, reducing losses through transmission and transformation, the lack of gaseous and liquid pollutants and to the low price of primary energy (Gheorghe, M. et. al, 2018).

Romania has temperate continental climate, with a high energy potential of energy resources for alternative energy supply (solar + wind) of isolated areas where there is no possibility to connect to a grid (Marcu, C. et. al, 2015). At the same time, it is in the 3rd group being characterized by relatively high intensities of solar radiation, with fluctuations in a wide range, but not extreme (annual maximum of 1600 kWh/m^2 in Dobrogea to 1250 kWh/m^2 in the north of the country) (Purece C., 2020).

The European Commission's Research Centre has developed software called the "Photovoltaic Geographical Information System (PVGIS)" which is used as a tool to assess the performance of photovoltaic technology in geographical regions and to provide interactive access to data, maps and tools for other research and education institutes, decision makers, PV professionals and system owners, as well as the general public (Baghdadi, A. et. al, 2010).

In this paper, the PVGIS application (http://re.jrc.ec.europa.eu/pvgis/apps4/) was used to estimate solar energy from an agricultural farm located in Fundeni, Călărași County, which does not have access to classical electricity.

Wind energy is one of the safest methods of producing electricity from renewable sources, the resources involved in air movements being considerable.

According to the National Institute of Statistics (INS), the production from wind power plants was 4125.7 million kWh in the first eight months of 2021 (http://www.insse.ro/cms).

The electricity produced by the turbine over a period of time depends on its constructive characteristics and the wind potential of the area where the turbine is installed, and the latest generation wind turbines have an efficiency of up to 98% (https://www.buletinulagir.agir.ro/).

A wind turbine with a vertical axis of 2kW (https://www.rolix.ro/proiecte_cercetare/inma–1.htm) was used to estimate the wind energy production by collecting the low intensity wind existing at low altitude in the Fundeni location.

MATERIALS AND METHODS

The experimental researches regarding the location, efficiency and behavior in operation of a mobile system for the production of electricity from alternative sources (solar + wind), which was developed by INMA Bucharest and ROLIX IMPEX SERIES SRL, were carried out in an agricultural farm in Fundeni locality, Călăraşi county.

Figure 1. Mobile system for the production of electricity from alternative sources (solar + wind) for agricultural applications and monitoring, tele–transmission and crop management services

The mobile electricity generation system (Figure 1) is intended for use in any isolated place, where there is no possibility to connect to an electricity grid, to ensure the electricity needed by various consumers in agricultural applications (Marin E. et. al, 2019).

The mobile system for producing electricity from alternative sources (solar + wind) consists of a photovoltaic trailer (Figure 2) equipped with a system for folding/unfolding photovoltaic panels and a wind turbine with a vertical axis (Figure 3) to ensure electricity in the field where there is no possibility to connect to an electricity grid for agricultural crops monitoring and management in order to transmit accurate information, in real time, to farmers to improve agricultural management.

Figure 2. Trailer for transporting mobile electricity production system + photovoltaic installation

Figure 3. Vertical axis wind turbine

RESULTS

The efficiency of the LG Neon R LG360Q1C–A5 photovoltaic panels used depends on the temperature, the level of solar radiation – received from the Sun converted by the panel into electricity with an efficiency of max. 20%, the rest being transformed into heat.

The operating temperature is due to the radiation to which the ambient temperature is added; when the module receives solar radiation, it heats to a temperature above ambient level.

At high temperatures, the efficiency of the panel decreases and production decreases; the support installation of the modules will ensure a good ventilation, obviously – retaining as little heat as possible.

The manufacturer of the photovoltaic panel specifies the NOCT (Nominal Operating Cell Temperature) parameter: Irradiance kW/m^2, ambient temperature 20°C, wind speed 1 m/s, and the temperature from which the efficiency starts to decrease is 45°C.

The main characteristics of the LG Neon R LG360Q1C–A5 photovoltaic panel are the following:

- Maximum Power(Pmax), W: 271
- MPP Voltage (Vmpp), V: 36.4
- MPP Current (Impp), A: 7.45
- Open Circuit Voltage (Voc), V: 40.2
- Short Circuit Current (Isc), A: 8.69

The warranty of the manufacturers of crystalline modules does not allow a degradation of the output power performance by more than 10% for a period of 10 years and by 20% for a period of 25 years.

Table 1 presents estimates of solar energy production obtained by means of the mobile system for electricity production from alternative sources (solar).

Table 1. Estimates of solar energy production

	Average monthly electricity production from the given system [kWh]	Average monthly sum of global irradiation per square meter received by the modules of the given system [kWh/m^2]	Standard deviation of the monthly electricity production due to year–to–year variation [kWh]
June	316.4	189.2	18.8
July	343.04	207.6	22.5
August	333.75	201.3	17.3

The estimates were made taking into account the following data:

- estimated temperature losses: 8.8% (using local ambient temperature);
- estimated loss caused by angular reflection effects: 2.8%;
- other losses (cables, inverter etc.): 14.0%;
- combined system losses: 23.8%

Starting from the average speeds measured in Fundeni location, Călăraşi County, a series of approximate calculations of the powers and quantities of electricity produced by the wind turbine with a vertical axis of 2kW were performed, depending on the electrical load available to the user.

The maximum power simultaneously absorbed is the sum of the powers of the electrical receivers (a surface solar pump with controller and two LED projectors) that can operate simultaneously at a given time: 1100 W.

The daily energy requirement W_z was calculated by relation (1):

$$W_z = \sum_{i=1}^{n} P_n \times t_n, \left[{}^{Wh}/_{day}\right] = 1000 + 200 = 1200 \left[{}^{Wh}/_{day}\right] \quad (1)$$

where:

– P_n represents the installed power of an electrical receiver;

– t_n represents the operating time of that receiver in a day.

The average required electric power will be given by relation (2):

$$P = \frac{W_z}{24} = \frac{1200}{24} = 50[W] \quad (2)$$

The amount of daily electricity that the wind generator has to produce, taking into account the efficiency of the inverter (η_i=80% ÷ 90%) was calculated by relation (3)

$$W_G = \frac{W_z}{\eta_i} = \frac{1200}{0,85} = 1411,76\left[{}^{Wh}/_{zi}\right] = 1,412\left[{}^{kWh}/_{zi}\right] \quad (3)$$

Taking into account the average wind speed v=9.14 m/s, the electric power that the wind turbine can generate can be determined by relation (4):

$$P_e = 0,5 \times \rho \times v^3 \times S_{ref} \times C_p [kW] \quad (4)$$

where:

– ρ represents the density of the air $\rho = 1.2255$ kg/m^3

– S_{ref} represents the area described by the turbine rotor calculated by relation (5):

$$S_{ref} = \pi \times R^2 = 3,14 \times 1^2 = 3,14\ [m^2] \quad (5)$$

where:

– R represents the radius of the wind turbine rotor;

– C_p represents the power coefficient calculated by relation (6):

$$C_p = \eta_m \times \eta_e \times \eta_a = 0,95 \times 0,97 \times 0,593 = 0,546 \quad (6)$$

where:

– η_m represents the efficiency of the mechanical transmission; it has a value of 0.95;

– η_e represents the efficiency of the electrical components; it has a value of 0.97;

– η_a represents the aerodynamic efficiency and has the maximum theoretical value established by Betz; it has the value 0.593.

The results for the electric power that the vertical axis wind turbine can generate are presented in table 2.

Table 2. The electric power that the vertical axis wind turbine can generate

Test no.	Average wind speed, m/s	Electric power, kW
1	14.0	2.851
2	12.0	1.795
3	8.0	0.532
4	9.0	0.757
5	7.0	0.356
Average	10.0	1.258

This calculation demonstrates that the wind speed in this area is sufficient to provide the necessary electrical power produced by the vertical axis wind turbine.

CONCLUSIONS

The research results allow useful recommendations for farmers who want to produce electricity from alternative sources in isolated places, where there is no possibility to connect to an electricity grid, to ensure the electricity needed by various consumers in agricultural applications and agricultural crops monitoring, tele–transmission and management services.

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