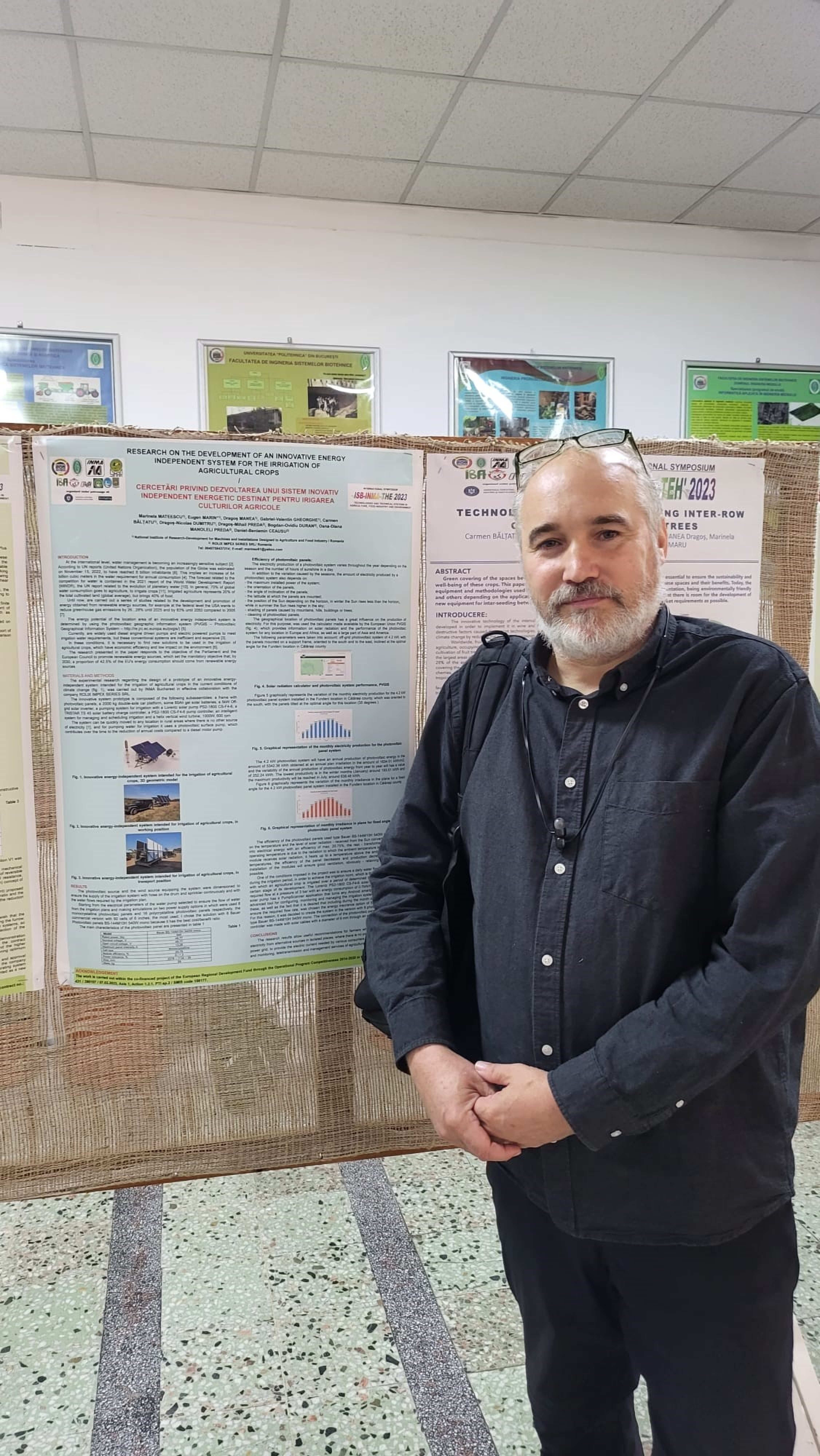

UNIVERSITATEA "POLITEHNICA" DIN BUCUREŞTI
FACULTATEA DE INGINERIA SISTEMELOR BIOTEHNICE
RESEARCH ON THE DEVELOPMENT OF AN INNOVATIVE ENERGY INDEPENDENT SYSTEM FOR THE IRRIGATION OF AGRICULTURAL CROPS
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CERCETĂRI PRIVIND DEZVOLTAREA UNUI SISTEM INOVATIV INDEPENDENT ENERGETIC DESTINAT PENTRU IRIGAREA CULTURILOR AGRICOLE
ISB-INMA-THE 2023
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TECHNOLOGIES AND TECHNICAL SYSTEMS IN AGRICULTURE, FOOD INDUSTRY AND ENVIRONMENT

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INTRODUCTION

At the international level, water management is becoming an increasingly sensitive subject [2]. According to UN reports (United Nations Organization), the population of the Globe was estimated on November 15, 2022, to have reached 8 billion inhabitants [8]. This implies an increase of 64 billion cubic meters in the water requirement for annual consumption [4]. The forecast related to the competition for water is contained in the 2021 report of the World Water Development Report (WWDR), the UN report related to the evolution of planetary water [10]. In general, 70% of global water consumption goes to agriculture, to irrigate crops [11]. Irrigated agriculture represents 20% of the total cultivated land (global average), but brings 40% of food.

Until now, are carried out a series of studies related to the development and promotion of energy obtained from renewable energy sources, for example at the federal level the USA wants to reduce greenhouse gas emissions by 26...28% until 2025 and by 83% until 2050 compared to 2005 [7].

The energy potential of the location area of an innovative energy independent system is determined by using the photovoltaic geographic information system (PVGIS – Photovoltaic Geographical Information System – http://re.jrc.ec.europa.eu/pvgis/) [5].

Currently, are widely used diesel engine driven pumps and electric powered pumps to meet irrigation water requirements, but these conventional systems are inefficient and expensive [3].

In these conditions, it is necessary to find new solutions to be used in the irrigation of agricultural crops, which have economic efficiency and low impact on the environment [6].

The research presented in the paper responds to the objective of the Parliament and the European Council to promote renewable energy sources, which set the mandatory objective that, by 2030, a proportion of 42.5% of the EU's energy consumption should come from renewable energy sources.

MATERIALS AND METHODS

The experimental research regarding the design of a prototype of an innovative energy-independent system intended for the irrigation of agricultural crops in the current conditions of climate change (fig. 1), was carried out by INMA Bucharest in effective collaboration with the company ROLIX IMPEX SERIES SRL.

The innovative system prototype is composed of the following subassemblies: a frame with photovoltaic panels, a 2000 kg double-axle car platform, some 85Ah gel solar batteries, a 5kW Off-grid solar inverter, a pumping system for irrigation with a Lorentz solar pump PS2-1800 CS-F4-6, a TRISTAR TS 45 solar battery charge controller, a PS2-1800 CS-F4-6 pump controller, an intelligent system for managing and scheduling irrigation and a helix vertical wind turbine, 1000W, 600 rpm

The system can be quickly moved to any location in rural areas where there is no other source of electricity [1], and for pumping water for irrigation it uses a photovoltaic surface pump, which contributes over the time to the reduction of annual costs compared to a diesel motor pump.

Fig. 1. Innovative energy-independent system intended for the irrigation of agricultural crops, 3D geometric model

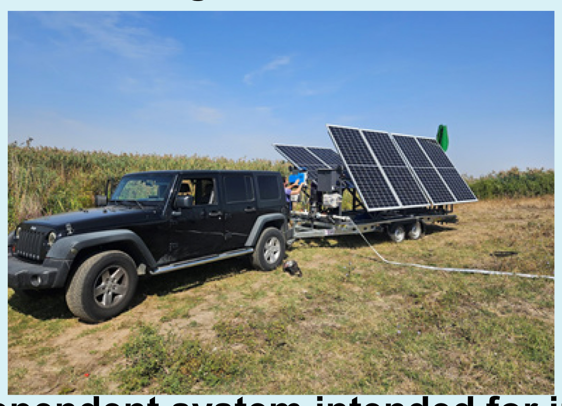

Fig. 2. Innovative energy-independent system intended for irrigation of agricultural crops, in working position

Fig. 3. Innovative energy-independent system intended for irrigation of agricultural crops, in transport position

RESULTS

The photovoltaic source and the wind source equipping the system were dimensioned to ensure the supply of the irrigation system with hose on the drum and sprinkler continuously and with the water flows required by the irrigation plan.

Starting from the electrical parameters of the water pump selected to ensure the flow of water from the irrigation plans and making simulations on two power supply options in which were used 8 monocrystalline photovoltaic panels and 16 polycrystalline photovoltaic panels respectively, the commercial version with 60 cells of 6 inches, the most used; I chose the solution with 8 Bauer Photovoltaic panels BS-144M10H 540W mono because it has the best cost/benefit ratio.

The main characteristics of the photovoltaic panel are presented in table 1

Table 1

Model	Bauer BS-144M10H 540W mono
Rated power, Wp	540
Nominal voltage, V	49,77
Open circuit voltage, V	49,77
Maximum panel intensity, A	13,28
Cell type	Monocrystalline
Module efficiency, %	20,75
Power tolerance, %	0 / + 3
Size, mm	2279 × 1134 × 35
Mass, kg	29

Efficiency of photovoltaic panels:

The electricity production of a photovoltaic system varies throughout the year depending on the season and the number of hours of sunshine in a day.

In addition to the variation caused by the seasons, the amount of electricity produced by a photovoltaic system also depends on:
- the maximum installed power of the system;
- the orientation of the panels;
- the angle of inclination of the panels;
- the latitude at which the panels are mounted;
- the position of the Sun depending on the horizon, in winter the Sun rises less than the horizon, while in summer the Sun rises higher in the sky;
- shading of panels caused by mountains, hills, buildings or trees;
- cleaning of photovoltaic panels.

The geographical location of photovoltaic panels has a great influence on the production of electricity. For this purpose, was used the calculator made available by the European Union PVGIS (fig. 4), which provides information on solar radiation and the performance of the photovoltaic system for any location in Europe and Africa, as well as a large part of Asia and America.

The following parameters were taken into account: off-grid photovoltaic system of 4.2 kW, with the panels mounted on a support frame, oriented to the south and to the east, inclined at the optimal angle for the Fundeni location in Călărași county.

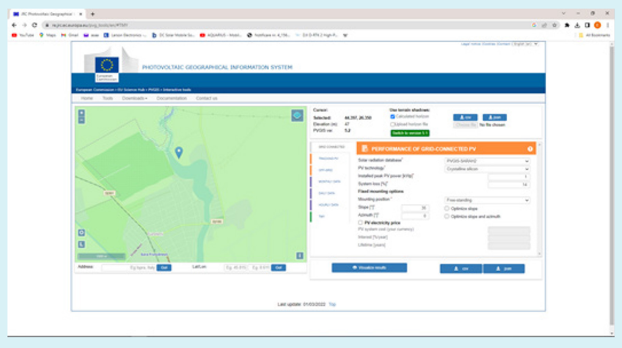

Fig. 4. Solar radiation calculator and photovoltaic system performance, PVGIS

Figure 5 graphically represents the variation of the monthly electricity production for the 4.2 kW photovoltaic panel system installed in the Fundeni location in Călărași county, which was oriented to the south, with the panels tilted at the optimal angle for this location (35 degrees).

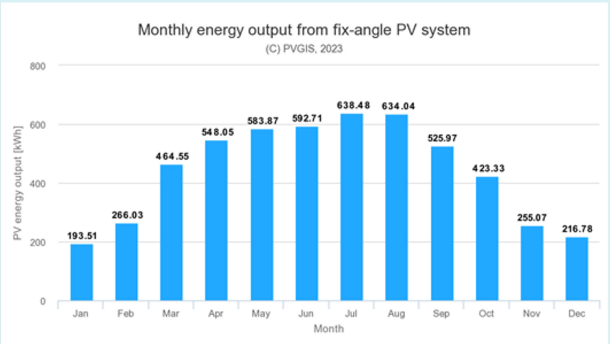

Fig. 5. Graphical representation of the monthly electricity production for the photovoltaic panel system

The 4.2 kW photovoltaic system will have an annual production of photovoltaic energy in the amount of 5342.36 kWh obtained at an annual plan irradiation in the amount of 1634.01 kWh/m2, and the variability of the annual production of photovoltaic energy from year to year will has a value of 252.24 kWh. The lowest productivity is in the winter months (January) around 193.51 kWh and the maximum productivity will be reached in July, around 638.48 kWh.

Figure 6 graphically represents the variation of the monthly irradiance in the plane for a fixed angle for the 4.2 kW photovoltaic panel system installed in the Fundeni location in Călărași county.

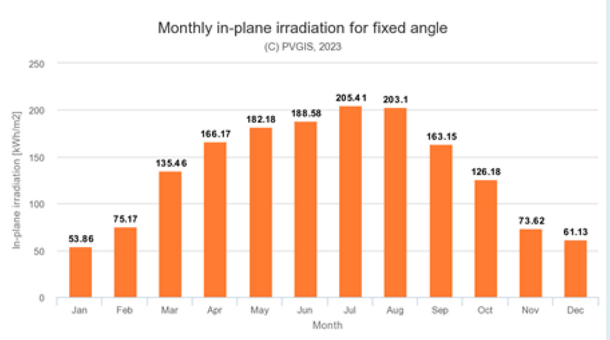

Fig. 6. Graphical representation of monthly irradiance in plane for fixed angle for photovoltaic panel system

The efficiency of the photovoltaic panels used type Bauer BS-144M10H 540W mono depends on the temperature and the level of solar radiation - received from the Sun converted by the panel into electrical energy with an efficiency of max. 20.75%, the rest - 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 up to a temperature above the ambient level. At high temperatures, the efficiency of the panel decreases and production decreases; the support installation of the modules will ensure good ventilation, obviously - retaining as little heat as possible.

One of the conditions imposed in the project was to ensure a daily water flow of at least 4 m3/h during the irrigation period, in order to achieve the irrigation norm, which is the total amount of water with which an agricultural crop is irrigated over a period of determined time, corresponding to a certain stage of its development. The Lorentz PS2-1800 CS-F4-6 solar pump can achieve the required flow at a pressure of 3 bar with an energy consumption of 0.7kW/h. At the same time, the solar pump has a PumpScanner application that turns any Android smartphone or tablet into an advanced tool for configuring, monitoring and managing the irrigation system. Taking into account these, as well as the fact that it is desired that including during the month of April the system can ensure the required flow rate, was chosen the energy insurance option of 5342.36 kWh per year. For this reason, it was decided to create the system in the version with 8 photovoltaic panels of the type Bauer BS-144M10H 540W mono. The connection of the photovoltaic panels to the solar pump controller was made with solar cables with a diameter of 6 mm through an electrical panel.

CONCLUSIONS

The research results allow useful recommendations for farmers who want the production of electricity from alternative sources in isolated places, where there is no possibility of connecting to a power grid, to provide the electric current needed by various consumers in agricultural applications and monitoring, teletransmission and management services of agricultural crops.

ACKNOWLEDGEMENT

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