Forecasting the Generation of Electricity From a Hybrid System

Evgeniya Petkova Vasileva, Ivelina Filcheva Takeva-Beberova

***Abstract* — The article predicts the generation of electricity from a wind-photovoltaic system (hybrid system) to supply a consumer. The geographical location of the user is a remote and hard-to-reach area, which is a reason to build an electricity transmission network. The designed hybrid system is modeled in a Matlab Simulink environment, which proves the generation of the required power according to the known load schedule for a period of one year.**

***Keywords* — hybrid system, photovoltaic modules, wind turbine, performance, load schedule.**

I. INTRODUCTION

Generating electricity from a hybrid system made up of photovoltaic panels and a wind turbine is a process that uses the energy from the sun and wind to generate electricity. This type of electricity generation is a clean and fast-growing method of power generation that poses no threat to the environment and produces no harmful emissions. In addition, solar-wind plants are sustainable and can be used to generate electricity throughout the year.

As a result, more countries and companies are investing in solar and wind power as part of their efforts to reduce greenhouse gas emissions and shift to more sustainable methods of generating electricity.

Solar energy auditing is a process that uses the energy of the sun to generate electricity. This process usually involves the use of solar panels that convert the light and heat of the sun into electrical energy. The way they are connected provides the required power.

Data on average annual sunshine and average annual solar radiation in Bulgaria are used. Other factors that have the greatest influence on the amount of electricity produced are the inclination and orientation of the solar module [1].

The most important factors affecting the amount of electricity produced are the tilt and orientation of the solar module. These factors should not be considered as insignificant because these factors are taken into account when installing the PV panels. They determine how much electricity the PV installation will produce. These parameters vary depending on the latitude.

The spectral composition of sunlight (waves) and the intensity of each frequency band are necessary for the optimal choice of solar panels. It is equally important to study the transparency of the atmosphere with respect to sunlight [2].

Atmospheric transparency with respect to sunlight and changes in the amount of solar radiation reaching green areas are equally important.

Solar energy varies with different inclinations of the sun's rays. Provided that the sun's rays are directed at an angle other than 900, then the sun's rays pass through a wider atmosphere than if the sun's rays fall directly on the PV panel (i.e. the sun's rays fall at right angles to the surface of the PV panel).

Another important component of solar diagnostics is the determination of the ratio between direct and diffuse sunlight incident on a geographical area.

As a first step, solar energy can be used to optimize monitoring through Solar Tracking Systems.

The modules are mounted on fixed or rotating structures (platforms).In mid-latitude areas, smaller platforms such as 10 to 20 m2 are used. By manually changing the tilt of the PV modules depending on the season, the average annual PV module output can be increased within 4 to 10 %.

Efficiency can be increased in systems with daily sun tracking (east to south and then west). In many regions of Bulgaria efficiency can be increased up to 30% in this way.

The use of additional flat plate systems to concentrate solar energy can increase efficiency. The efficiency of conventional solar panels more than doubles.

The solar potential study involves the analysis of input data on solar radiation in each area, as well as an assessment of the feasibility of using solar energy for electricity generation. This may include measurements of the strength of solar radiation, analysis of climatic conditions and calculations of the possible costs and benefits of installing solar panels. Studying solar potential is an important part of planning and installing solar systems and can help determine the most appropriate locations and technologies for harnessing solar energy.

Wind potential analysis is based on measurements of wind parameters made with special instruments called anemometers. Average wind speeds are recorded over a certain time interval (5 minutes). A sample of the overall statistics gives an overall picture of the wind parameters in the study area. These data are used to determine the parameters of the theoretical Weibull distribution [3].

Wind power plants (WPPs) are divided into three groups depending on the field of application: stand-alone, for co-operation with other sources of electricity and grid-connected. In this paper, the wind turbine is considered in common with a photovoltaic system.

Under relatively constant conditions, the useful power obtained from the air flow can be described by Eq. [4]:

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$$P = \frac{1}{2}\rho\pi R^2 v^2 C_p; \qquad (1)$$

where ρ is the air density 1.225, kg/m³; R - radius of the area traversed by the feathers, m; ν - air velocity, m; C_p - efficiency of the generator drive.

The power of the transformed energy can also be contorted by varying the angle of the wind turbine blades.

II. Identification of the Object Under Study

The object of the study is a single-family house located in a villa area, Sliven district, located 4 km from the meteorological station.

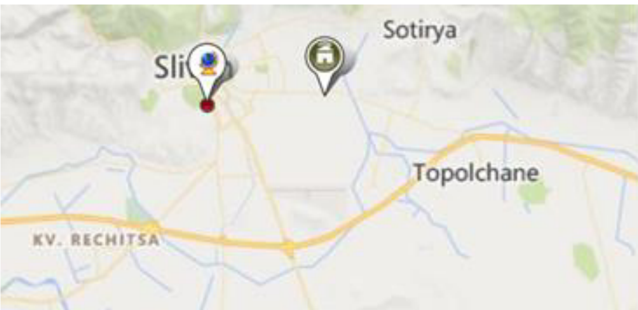
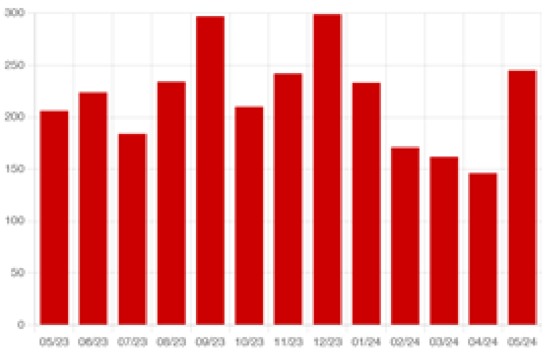
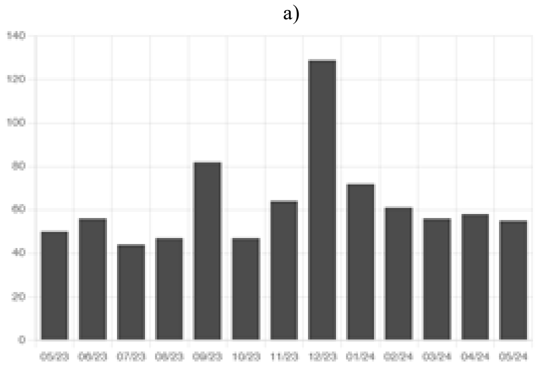


Fig. 1 Geographical location of the study site

To visualize the electricity consumed, a line graph is used that shows the amount of electricity used in a specific time period. The time period is placed on the X-axis and the amount of energy on the Y-axis. By this method it is possible to observe how the electricity consumption changes over different time periods. The load schedule for a period of one year (May 2023 to May 2024) is shown in Figure 2.



a)



b)

Fig. 2 Load schedule of the investigated user: a) day energy consumed; b) night energy consumed

To provide power to the site, renewables are required to provide around 30 kWh of electricity per day.

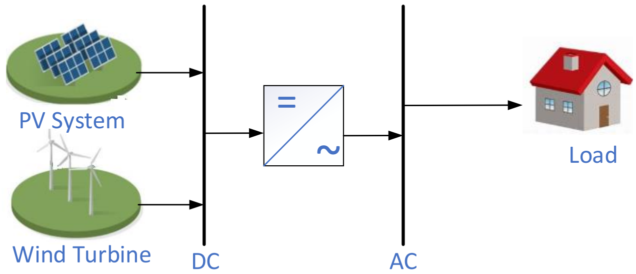


Fig. 3. Hybrid user power system

III. Hybrid System Design

The photovoltaic part of the hybrid system has the following elements:

- Photovoltaic modules ITS EcoFocus 250Wp, polycrystalline type;
- networked three-phase solar inverter AFORE 20 KW BNT020KTL - WI-FI, 2 MPPT, DC SWITCH, LCD;
- DC fuse: the current in the DC panel/circuit cannot exceed 30 A.
- AC fuse: for inverter Afore BTN020KTL has a rated current of 40 A.
- LPS: lightning protection;

Figure 4 shows the solar radiation values for the study area. The data were obtained from NASA satellites.

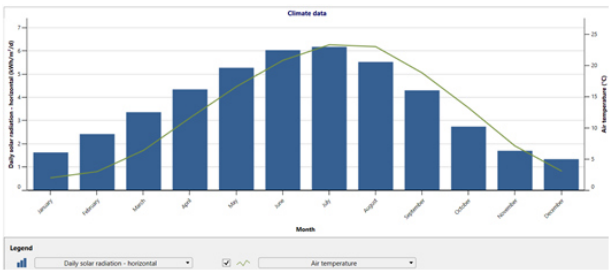


Fig. 4. Solar radiation readings characteristic of the studied location

The photovoltaic system was modelled in Matlab Simulink environment and the following results were obtained:

- The power ($P_{gen,PV}$) generated by the PV system is:

$$P_{gen,PV} = P_m . N \approx 15\ kW,$$

where P_m - power of one photovoltaic module, Wp;
N - number of modules connected in series in a string.

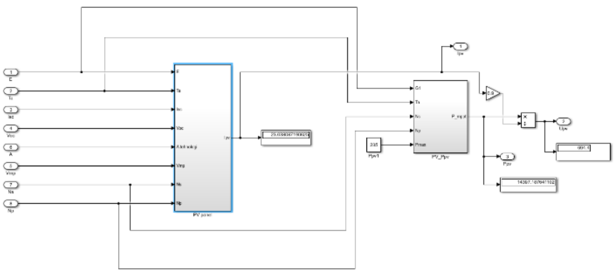


Fig. 5. PV system model

Figure 6 shows the values describing the wind speed for the study area. The data were obtained from the NASA database.

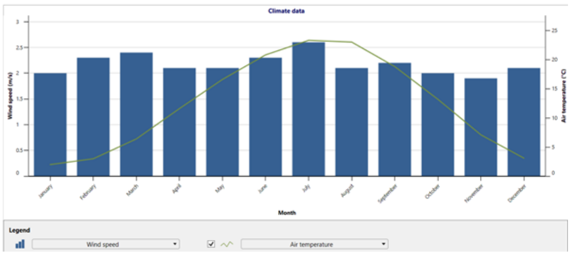


Fig. 6. Wind speed readings for Sliven district

A wind generator model Condor Air 20 is used to supplement and provide the required electricity.

Modelling the power output in a Matlab Simulink environment (Fig. 7):

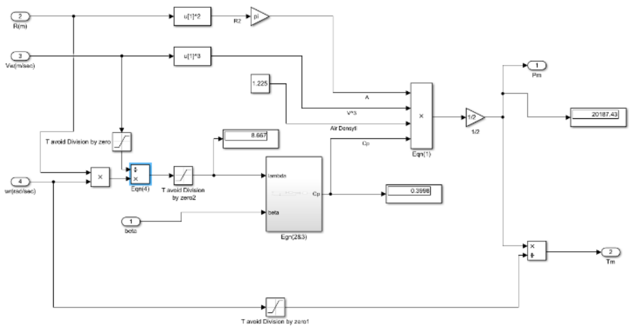


Fig. 7. Wind generator model Condor Air 20 in Matlab Simulink environment

- The wind power generation system modelled in this way provides a power output of 20 kW:

$$P_{gen,WT} \approx 20187.43W \approx 20.2kW$$

IV. Conclusion

For the site under consideration, a power supply of 30 kW/h per day is required. The required power will be provided as follows: from the photovoltaic plant - 15 kW and from the wind generator - 20,2kW. The proposed configuration covers the need according to the known commodity schedule.

The hybrid system so designed and modelled will provide power to the user under consideration. In order to guarantee the autonomy of the investigated object it is necessary to add rechargeable batteries to the structural scheme of the hybrid system. They will provide the necessary power in poor meteorological conditions and in the dark part of the day.

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