A statistically analysis to determine the use of renewable sources for campus lighting, case study of technical faculty of Kosova

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ABSTRACT

Considering the ever-increasing demand for electricity and the current crisis in this sector, various ways of generating electricity have been studied. Most of them are based on hybrid technologies as a solution to replace the relevant resources during the absence. In Kosova, as an economically poor country, such technologies are rarely used. Public lighting in some countries is still considered unaffordable due to high cost. This study further demonstrates an environmentally friendly option for power generation using hybrid PV and Wind systems. The current study presents the study that was carried out on the campus of the technical faculty in Prishitna. The analysis has been done analytically, which has resulted in the need for 6 hybrid lighting systems to achieve a coverage of the lighting needs, which so far lacks lighting in this part of the campus. A total of 461,448 kWh can be generated during the year from the wind turbine system and 796.11 kWh from the solar photovoltaic system. Considering that we have an ever-decreasing cost of such devices and from the analysis done it results that these systems are cost effective and ideal solutions for such cases and similar needs which are vital needs today.

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1. INTRODUCTION

Energy is a vital resource whose importance is growing every day with the increasing demand for energy which is constantly growing [1]. Good and sustainable energy supply is also very important including all energy consuming sectors as well as the construction sector [2]. Renewable energy sources present a great potential that can be exploited in this regard [3]. Renewable energy sources if combined to form a hybrid system offer greater opportunities for energy benefits [4]. Among these systems, the most suitable and favorable are the use of hybrid systems of solar energy and wind energy [5]. Considering the use of a combined system as well as individual systems during their use comes to encounter obstacles that affect the reduction of energy received from the system [6]. Combined solar and wind systems utilize solar panels and wind generators to generate energy [7]. These systems are seen as adequate systems to meet energy demand especially in the public lighting sector [8]. Small energy systems for meeting energy needs from renewable energy sources are becoming more and more in demand [9]. The use of such hybrid systems requires the planning, design and selection of adequate technologies to meet the energy requirements of the system [10].

A hybrid system is analyzed by presenting the technical and economic analysis of the hybrid system as shown in [11]. The solar energy potential and the wind potential for the analyzed site are shown in detail. After the presentation of the study methodology, the results achieved regarding the system needed and its cost are presented [12]. The work in [13] presents the energy analysis of a hybrid solar/wind system which is expected to be connected to the power grid. The following shows the construction of the system and its architecture. After the construction of the system, the power achieved by the solar and wind energy is calculated and presented, thus presenting how much energy is produced by the system. The work in [14] presents the design of a hybrid system for power generation. The paper explains the design method as well as the components used in a hybrid system. The work in [15] presents the design, testing and simulation of a hybrid system. The design of the system, the type of technologies selected and their simulation depending on the climatic conditions to which the system will be subject are shown in detail. The work in [16] presents a simulation of a hybrid wind/solar system using MATLAB software. After describing the system, the model is built and the system's simulation is simulated. A solar/wind system is presented to cover the lighting requirements as shown in [17]. The model used is constructed in the paper and its results are simulated.

This paper presents the analysis of a hybrid solar/wind system to cover the needs for public lighting for some faculties. The paper will present the analyzed system and the capacity generated by this system to cover the needs for public lighting. The work itself represents innovation in this field as well as in the way it was analyzed in our country and especially in the specific country where the analysis was carried out, taking into account that such analyzes have not been carried out in our country so far. Thus, creating an example of similar analyzes that can be performed for other locations with different climatic conditions.

2. PROCEDURE SPECIFICALLY DESIGNED

2.1. System description

The hybrid solar/wind system will be used to cover the energy requirements for public lighting of the technical faculty campus. This space of the campus is used by three technical faculties, that of construction, mechanics and the faculty of electrical engineering. The space that will be illuminated includes the space of the campus in which the students of these three faculties move. The analyzed system contains six solar panels and six wind generators. The solar panels used are 100 W each and are monocrystalline [18]. While wind generators are horizontal and with a capacity of 300 W each [19]. The described system is used for lighting the stairs of technical faculties. The structure of the system used is shown in Figure 1 in which the elements as well as the technologies used can be seen.

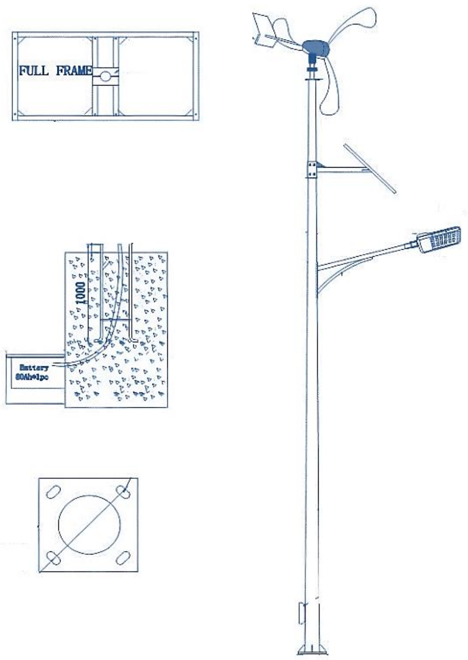

Figure 1. System structure

Based on the figure shown, it can be seen that the lighting will be covered by solar panels and the wind system consisting of horizontal generators, while the photovoltaic panels are monocrystalline. Where the cross-section and the elements that make up the system are shown in detail. Each lighting pole will have a solar panel and a wind generator. Figure 2 shows the location where campus lighting will be located.

Figure 2. Place where the project will be implemented

Taking into account the needs for lighting in this part of the campus is vital, the analysis in question has been done. The figure shows the place where the public lighting will be placed to cover the lighting in the part of the campus frequented by the students of the technical faculties. Thus, presenting the location of the installation of the hybrid systems that will illuminate this part of the campus.

2.2. Meteorological data analysis

For the most accurate presentation of the results, all the components that affect the performance of the system have been analyzed. In this study, data from one-year field measurements were taken. The measurements include temperature measurement, air pressure, solar radiation and wind speed. Figure 3 shows the solar radiation which is taken at the analyzed site for every hour.

The Figure 3 shown the solar radiation for different time intervals within the day, for the whole months of the year, as well as the total energy which is obtained from solar energy in the analyzed place. Very great importance during the use of solar panels should be paid to the angle of placement of the solar photovoltaic panel and the parameters of the environment to which the solar panel will be subject. The average values of solar radiation for the analyzed location are shown in Figure 4.

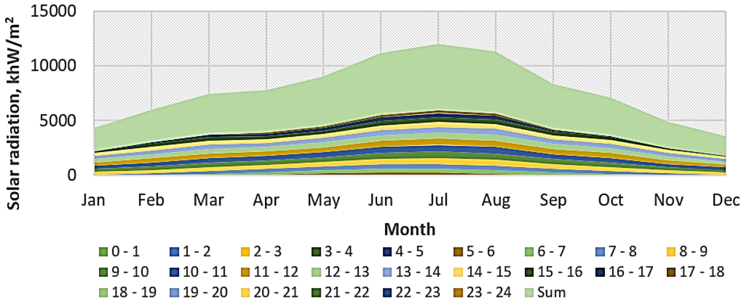

Figure 3. Solar radiation in specified location

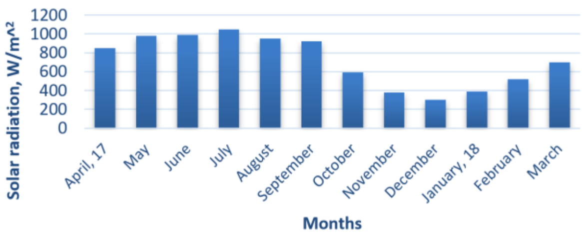

Figure 4. Average solar radiation for specified location

From the Figure 4 it can be seen that there is a high potential of solar energy which can be used to cover public lighting for the analyzed space. The months with the highest radiation are the summer months, while the lowest in the winter. The month with the highest radiation is July with 1050 W/m^2, while the month with the lowest radiation is December with 390 W/m^2. Table 1 presents the characteristics for the analyzed location.

Table 1. Terrain data's

Air temperature	Optimum tilt of PV modules	Terrain elevation
11.9 °C	34°	622 m

The Table 1 shows the altitude of the analyzed location, the optimal angle of placement of the solar panels and the average ambient temperature to which the solar panels will be subjected. These components in particular have been treated because they affect the performance of the system and thus also the energy that can be taken in general. Among the components that must be considered during such systems is also wind speed. Figure 5 shows the ambient temperature for the analyzed location.

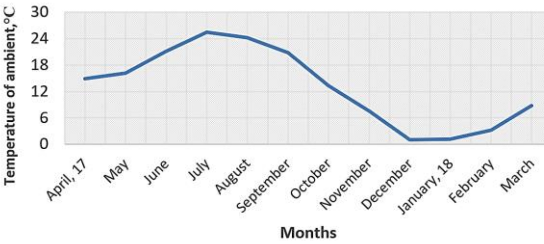

Figure 5. Average temperature of air in specified location

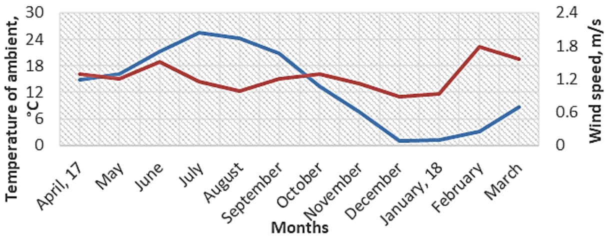

Figure 6. Average wind speed in specified location

Based on the fact that the analyzed location is characterized by continental climatic conditions, the air temperature has lower values during the winter months and higher during the summer months. The highest ambient temperature is reached in July with 25 ℃, while the lowest in January with 0.5 ℃. Temperature values are important especially for photovoltaic panels whose performance is affected by temperature. Figure 6 shows the average wind speed.

The wind speed in the analyzed place varies during the months of the year but takes a greater value during winter and early spring. We have the highest wind speed during the month of February with 1.9 m/s, while the lowest in December with 0.5 m/s. The wind speed as a component must be analyzed since it affects the energy production of the wind turbines used in this hybrid system.

3. METHOD

The energy produced by the hybrid solar/wind system is very important to know how much we can meet the requirements of this energy produced. There is no connection between solar and wind energy but their combination affects each other [20]. The power gained from a combined P_C system is [21]:

$$P_C = P_S + P_W \tag{1}$$

where P_w is the total wind turbine power (W), P_s is the total solar power (W).
The power generated by P_W ; wind energy is [22]:

$$P_W = \frac{1}{2} \cdot \rho \cdot A \cdot w^3 \tag{2}$$

where: P_w is wind power, ρ is air density in kg/m^3, A is swept area in m^2 and w is wind speed in m/s.
Air density is calculated by the formula [23]:

$$\rho = \frac{p}{R \cdot T} \tag{3}$$

where R [J/kg·K] is the specific gas constant for dry air, and T [K] is the absolute temperature.
The power generated by monocrystalline photovoltaic panels is [24]:

$$P_{theoretical} = P_{peak} \cdot \frac{G}{1000} \tag{4}$$

where $P_{theoretical}$ is theoretical power given by the module [W], P_{peak} is peak power of the solar modules [W], and G is direct solar irradiance [W/m^2].

The utilization rate of photovoltaic panels as one of the main factors of their performance is calculated by the formula:

$$P_{max} = V_{oc} \cdot I_{sc} \cdot FF \tag{5}$$

$$\eta = \frac{V_{oc} \cdot I_{sc} \cdot FF}{P_{in}} \tag{6}$$

Where V_{oc} is the open-circuit voltage, I_{sc} is the short-circuit current, FF is the fill factor, Pin is the input power [W], and η is the efficiency [25].

4. RESULTS AND DISCUSSION

From the realized measurements as well as the use of the respective equations, the power during each month has been calculated, which can be which can be stored in batteries from a wind turbine. Figure 7 shows the power generated during the months of the year for the analyzed site. The power generated is not uniform and mainly favors the winter months. The greatest power is obtained during the months of March and April with about 5 kW, while the lowest is in August with 1 kW. This happens because in the period of greater production there is a greater wind speed and not very high temperatures that have a negative impact on the performance of the photovoltaic panels. Figure 8 shows the power generated by the photovoltaic system from solar energy.

The Figure 8 shows a high potential of solar energy that can be used in the analyzed place but having a low efficiency of the photovoltaic panel affects the minimization of the total power that can be used for lighting by this hybrid system. The specific power reaches the highest values in July with 900 W/m^2 while the lowest in December with 295 W/m^2. Figure 9 shows the energy generated over the months by the solar system.

The energy generated during summer is highest in the month of July with 140 kWh, while the lowest is in December with 40 kWh of generated energy. During the summer season, the intensity of radiation is maximum and the wind speed decreases significantly. Thus, the battery further assists the supporting role of the solar and wind system. During the night, according to the temperature drop, the wind speed increases and thus the system uses the energy generated by the turbine while only when there are defects and the turbine cannot operate or on quiet nights without wind, the energy accumulated in the battery is used.

Figure 7. Power generated from wind turbines

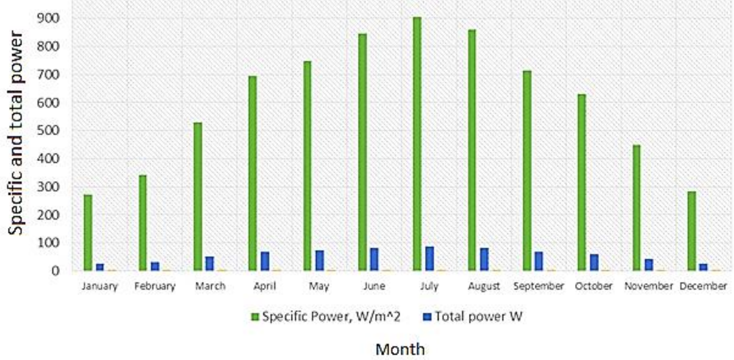

Figure 8. Specific power and total of power generated

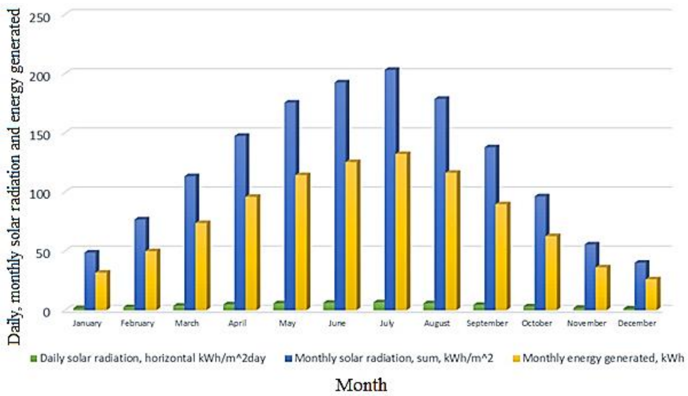

Figure 9. Daily, monthly solar radiation and monthly energy generated from solar panels

5. CONCLUSION

In this paper, the hybrid solar/wind system is examined, which enables an uninterrupted supply of lighting for a part of the campus of the technical faculties in Prishitna, Kosova. The results obtained from our study show that we have the potential to develop hybrid systems in the country under study. Further considering the fact that such technologies do not have a high-cost price we can say that they will be cost flexible. Knowing that we have a worldwide energy crisis and knowing that these systems are capable of operating autonomously, they are favored. From the figures presented, it can be seen that the wind power increases during the winter season in order to go in line with the energy demand taking into account the length of the day. Therefore, since the day is shorter, lighting is required for a longer duration. In addition to the benefits in terms of environment and service for the students attending that part, here they will be able to perform measurements and experiments by the students that influence the realization of the practical part. A total of 461,448 kWh can be generated during the year from the own wind turbine system and 796.11 kWh from the solar photovoltaic system. From the monthly distribution we notice that when wind energy increases, solar energy decreases and vice versa so that the lighting system meets the lighting requirements. The largest production of power from the wind turbines is made during the months of March and April with about 5 kW, while the lowest during August with about 1 kW. While the lowest energy generated by photovoltaic panels is in the month of December with about 35 kWh of intergenerational energy, the highest is during the month of May with 125 kWh of energy produced. The presented analysis has been analyzed in detail by analyzing all the elements that affect the hybrid system. It is preferred that, except in this case, such projects are added, knowing that Kosova faces numerous shortages of energy, namely public lighting in the capital.

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