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Oil type transformers, Testing of transformers, Commissioning of transformers, Type of testing.

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Analysis of Wind Data and Calculation of Energy Yield Potential

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Abstract. Wind energy has a relatively strong potential for electricity generation in various parts of Europe and it has increasingly taken its place in the energy mix in recent years. Kosovo has limited sources of renewable energy and its energy production sector is based on fossil fuels. This may come from the policies used so far in subsidizing such resources. Such a situation emphasizes the importance of active research and efficient use of renewable energy potential. According to the analysis of meteorological data for Kosovo, it can be concluded that the place with high potential is Kaçandoll. Due to the shared terrain and the allowed capacity, it can be considered as Kaçandolli 1 and 2. The measurements provided are measurements from the virtual meter. In both terrains we have measurements at the same height therefore the comparison and calculation of performance will be easier. Information on wind speed interpolation at central altitude and power turns at each wind farm location are also presented. Since the difference in wind speed is quite large versus a change in altitude that is not very large, then analyzes are made regarding terrain characteristics including terrain relief features.

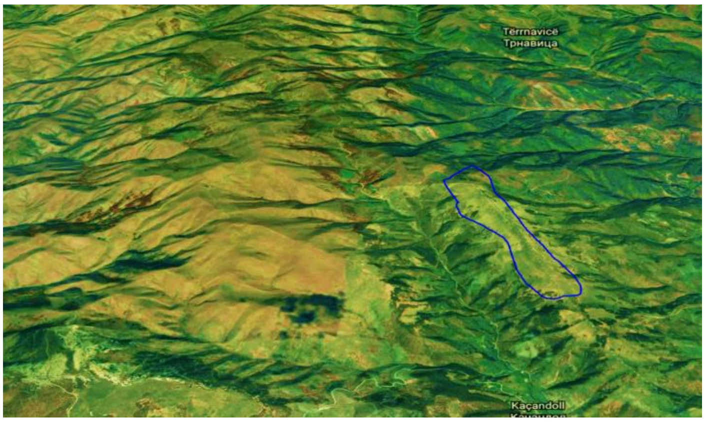
Keywords: wind turbines, wind energy, Kaçandoll, wind speed, energy efficiency

Introduction

Because of the harmful consequences of pollution from the emissions of various gases, renewable energy sources increasingly gain in importance. The wind is a natural phenomenon related to the movement of air passes caused primarily by differential solar heating of the earth's surface [1,11]. The European Union (EU) has agreed to supply 20 percent of its total energy demand from renewable sources by 2020. In two years (2008 and 2009), more than 24,000 MW of new power capacity based on wind energy was installed in the EU countries [1]. Nowadays, wind energy, as an alternative clean sustainable energy source, has been recognized as one of the fastest developing renewable energy source technologies. Wind power generation has made a remarkable contribution to daily life across the globe and has grown rapidly over the past 20 years [6]. As a renewable energy source with the highest growth rate in the last two decades, wind energy is considered a very important resource of electricity production in the future. The forecasts for the development of wind energy are highly optimistic and state that this type of energy will be important in the future [2]. It is also important that the small wind systems also have potential as distributed energy resources. Distributed energy resources refer to a variety of small, modular power-generating technologies that can be combined to improve the operation of the electricity delivery system [3]. Air density, and hence power in the wind, depends on atmospheric pressure as well as temperature. Since air pressure is a function of altitude, it is useful to have a correction factor to help estimate wind power at sites above sea level [4]. The primary meteorological factor in evaluating a prospective wind turbine site is the mean wind speed. Another important parameter is the anticipated extreme wind speed [5]. Wind power plants generate electricity when the wind is blowing, and the plant output depends on the wind speed. Wind speeds cannot be predicted with high accuracy over daily periods, and the wind often fluctuates from minute to minute and hour to an hour [7]. In fact, the wind also varies every second due to turbulence caused by land features, thermal sources, and specific weather conditions. It also blows more strongly higher above the ground than closer to it, due to surface friction [12]. Total energy production and capacity factor are fundamental aspects of a wind power project. To determine the optimum energy output, it is essential to select the right turbine design for a location [8]. Wind turbine operation is dependent on wind speeds to generate power [9]. Sustainability evaluation of wind resources can be performed using different approaches that are complementary between each other: thermo-economic analysis (energy and/or exergy calculations), life cycle assessment (which is a multicriteria product-oriented analysis), emerge approach (a holistic approach donor side oriented). These different assessment approaches were compared one by one by Kharrazi et al. (2014) and/or combined (Duan et al. (2011)) [10]. Annual energy produced is typically calculated referring to the annual mean wind speed of the site. Unfortunately, the annual average wind speed varies significantly [13]. Operation of the individual wind turbines may be adversely impacted by the turbulent wakes from other upwind turbines, with the magnitude of the impact depending largely on the turbines' respective rotor sizes and distance between one another, as well as on the overall shape of the wind farm and turbine spacing therein [14]. Wind shear is the variation of wind speed with elevation. It is important to understand because it directly impacts the power available at different wind turbine hub heights and strongly influences the cyclic loading on the turbine blades [18]. Based on the analysis done, we can assess precisely whether these two countries have the potential to contribute to the local energy production.

2. Site description and data for Kaçandoll

Kaçandoll mountain site is in a complex mountainous region, shown in figure below. Although the slopes of the terrain were high, no cliffs were observed. Turbines are planned on the plateau of mountain ridge running northwest-southeast direction. Site elevations range from 960 m to 1090 m from sea level. The site consists of agricultural land, short shrubs, and forest areas. Most of the wooded areas are on the northern hillside of the site. Forest areas are showing similar characteristics of about 10 m height and closed formation. Windrose also is presented in figure 1.



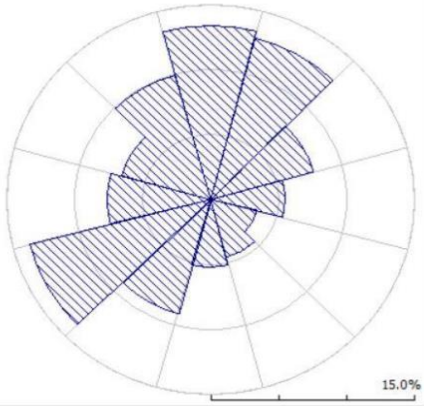


Fig. 1. Kaçandoll mountain and its wind rose

Main characteristics of the manufacturer, the capacity and the surface of the turbine are used to perform the calculations of the produced energy and the cut-in and cut-off speeds.

Tab. 1. Technical details for wind turbines in Kaçandoll

Location	**Wind turbines used in Kaçandoll**
Nominal power, MW	P_{nom}=3.4 MW
Swept area, m^2	13273 m^2

The way of their organization of the farm with 10 same wind turbines is further given by the figure 2.

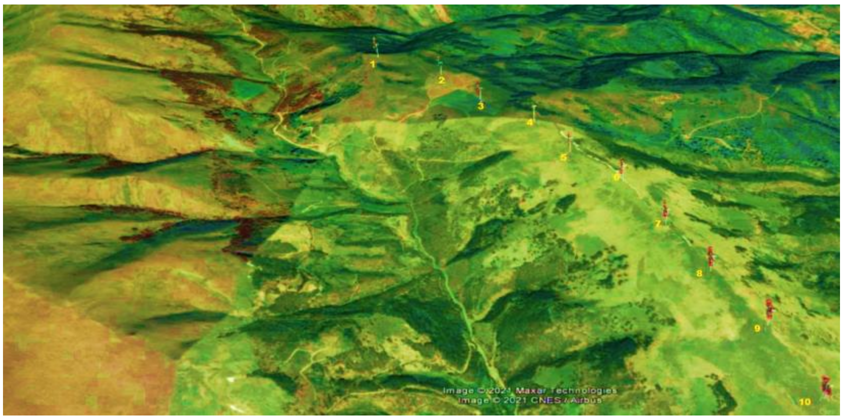


Fig. 2. Kaçandoll layout

Another important parameter is efficiency of energy converting or given from wind turbines. First, we start with Kaçandoll, where the average wind speed per year is 7.1 m/s, and capacity factor generated by WAsP is 47.145%.

Based on the installed capacity the efficiency is calculated as below [19]:

$$\eta = \frac{P_{real}}{P_{theoritically}} \tag{1}$$

The theoretical power of a wind turbine is calculated according to the following formula:

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

Then, the real power is described by:

$$P_{real} = C_P \cdot \frac{1}{2} \cdot \rho \cdot A \cdot w^3 \tag{3}$$

The probability of occurrence of speeds less than 3 m / s and more than 25 m / s is described by the following formulas [20]:

$$F(w_{\min}) = prob(w < w_{\min}) = 1 - \exp\left[-\frac{\pi}{4} \cdot \left(\frac{w_{\min}}{w_{average}}\right)^2\right]$$

$$\tau_{w>25m/s} = 8760 \frac{h}{vit} \cdot \exp\left[-\frac{\pi}{4} \cdot \left(\frac{w_{\max}}{w_{average}}\right)^2\right] \tag{4}$$

The annual energy is further calculated should also consider the efficiency of the turbines in the wind park:

$$Energy\ yield = Capacity\ factor \cdot P_w \cdot number\ of\ turbines \cdot number\ of\ hours\ during\ year \quad (5)$$

C_P- capacity factor in the targeted region, %

ρ – air density, kg/m^3

A – turbine area, m^2

w – wind speed, m/s

Measurements made for those different terrains, which are shown above, can be recalculated using probabilistic methods, so we can calculate how many hours during the year the wind speed will be below 3m/s, the speed which is considered as the average at which the wind turbines start moving, we will have:

This is described also by figure below:

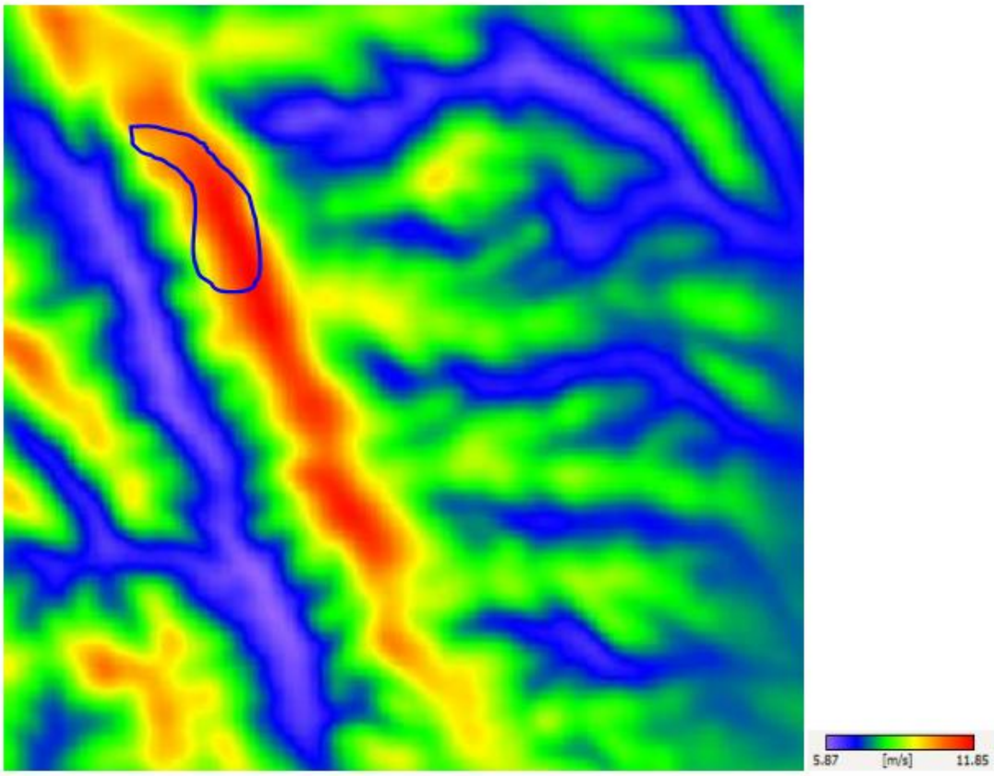


Fig. 3. Mean wind speed in Kaçandoll

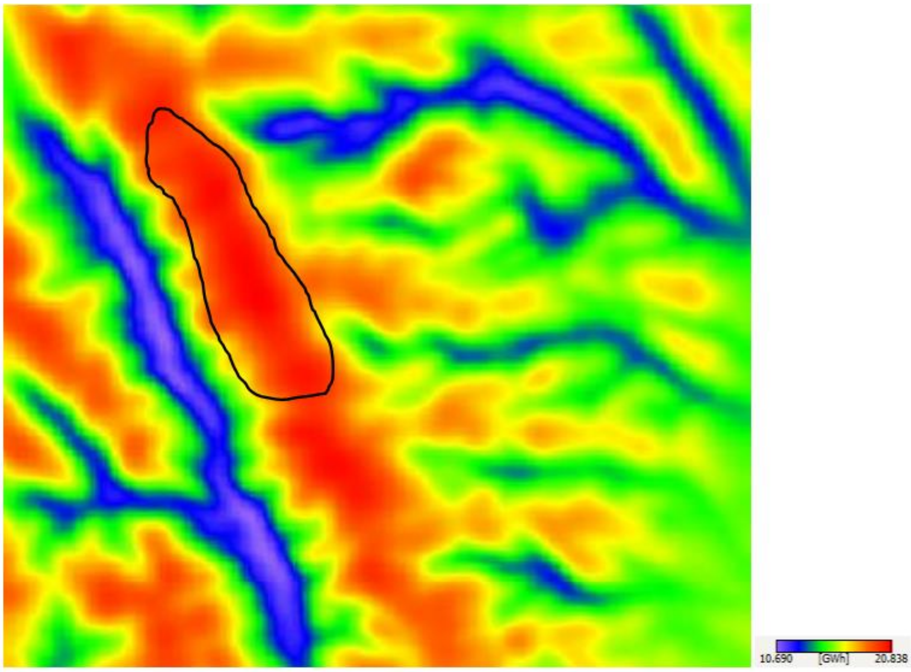


Fig. 4. Energy yield for Kaçandoll mountain, in GWh

From the presented figure we have a high potential of wind energy and this potential in terms of energy generated minimum capacity is 10.690 GWh at a maximum capacity of 20.838 GWh. The fact that we have some hours with speeds less than 3m/s shows that this country has a potential for development. Also, that we do not have many hours of extreme speeds, over 25 m/s shows that we have a stability in terms of speeds.

Conclusions

From the performed and presented analyzes we have a considerable energy potential. The measurements were taken by Vortex for which we thank them for the opportunity given to use this analysis in the framework of doctoral studies. From our analysis we have the results as follows, the potential power to be achieved is 1208.398kW. The efficiency achieved is 35.5%. The probability of hours of occurrence of cut-in speed, <3m/s is 1136.802 h/yr. On the other hand, the cut-off stop speed of 25m/s, has the probability of occurrence at 0.51975 h/yr. In these operating conditions, we will have a minimum annual production of 49932.117MWh during the year. It can be concluded that there is a significant capacity of wind energy in this country and that we have a significant probability of utilizing wind energy in this country. This will of course play a role in the CO_2 considered.

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