Wind Turbines Potential Energy Production in three Locations of Kosovo and its Impact on the Environment

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Abstract— In order to reduce high amount of pollution that Kosovo is facing, its options have to be considered. One of the solutions to reducing the amount of pollutions is using renewable energy resources. There has been quite a number of studies to find sustainable resources that Kosovo has in possession. It came up that, quite an amount of energy can be produced by some renewable resources available in some regions of Kosovo, especially by Wind Turbines that can be installed in a variety of locations, where NEK (NEK umwelttechnik) found the highest wind velocity.

Index Terms— Wind Turbines, Wind Velocity, Climate Change, Locations, Birds.

1 Introduction

KOSOVO has a condition by EU, as other Balkan countries, to produce 20% of the energy consumption using renewable resources until the year 2020. This condition, along with others has to be fulfilled to get the possibility to join EU. The energy scenario of Ministry of Energy and Mining was to achieve a target to produce this amount of energy up to 141 MW of energy, produced by Wind Turbines until 2020 and an amount of 300 MW of energy until 2025.

NEK umwelttechnik in 2010 made a report called Wind Resource Assessment, giving results about the wind velocity in different places and different heights of Kosovo. 10 locations have been chosen by them giving results on wind speed and its direction.

	Locations		
	Lipjan	Prishtina	Theranda
January 10	4.9	4.0	9.0
February 10	4.7	4.6	9.1
March 10	4.1	5.5	8.0
April 10	3.8	4.7	5.9
May 10	3.7	5.3	7.6
June 10	3.0	3.9	5.5
July 09	3.1	4.3	5.0
August 09	2.7	4.5	4.7
September 09	2.8	3.6	5.9
October 09	3.3	4.6	5.8
November 09	2.8	3.6	7.4
December 09	4.2	5.3	9.5

Table 1. Monthly Average wind velocity for three chosen locations given by NEK

Some calculations have been made by our side, only from three locations that have been chosen. Table 1 shows the monthly average wind velocity for these three locations.

2 Analyses of Energy Production using Wind Turbines

2.1 Mathematical Calculation in General

Wind turbines capacity varies from dozens kilowatts to few megawatts. The amount of energy that one turbine can produce is in function of the wind velocity and swept area of the turbine. Wind turbines convert kinetic energy of the wind into rotation kinetic energy of the turbine, from where it can be converted into electricity using a generator. Kinetic energy can be written:

$$E_k = \left(m \cdot v^2\right)/2 \quad (0)$$

Power of energy given by a wind turbine is written with the energy change or, which is actually the first derivate:

$$P = dE_k/dt = \left(d/dt\right)\left(m \cdot v^2/2\right) = \left(v^2/2\right) dm/dt \quad (2)$$

The mass flow formula can be written here as follows:

$$dm/dt = \rho \cdot A \cdot dx/dt \quad (3)$$

Where ρ is the density of air and A is the swept area of the turbine. From the derivative of x the velocity formula can be written:

$$dx/dt = v \quad (4)$$

Putting two last equations into equation (2) we get:

$$P = \rho \cdot A \cdot v^3/2 \quad (5)$$

The Betz Law has to be taken in consideration, which says that the maximum power efficiency of a turbine can be 59%. The wind turbine converts 70% of the Betz Limit into electricity. Good wind turbines generally vary between 35-45% range. The Betz factor is written with C_P. Adding Betz Law into equation (5), we get:

$$P = \left(\rho \cdot A \cdot v^3/2\right) \cdot C_p \quad (6)$$

Hence, the energy produced from a windmill depends on the air density (which is ρ =1.23 kg/m^3), swept area of the turbine, cubic velocity and Betz Law.

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2.2 Analyses of production capacity for Lipjan, Prishtina and Theranda Locations

A possible energy production will be calculated from one medium turbine in every three locations. Assumingly, a plan to install a wind turbine in this location is planned by our side. A calculation for the January will be done. Given data are: air density is ϱ = 1.23 kg/m3, wind speed v = 4.9 m/s, blade length l = 25 m and Betz factor Cp = 35%. Swept area of the turbine will be:

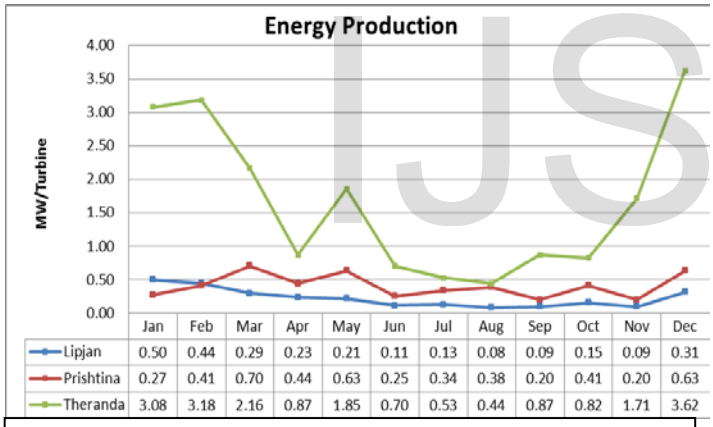
$$A = \pi \cdot r^2 = \pi \cdot l^2 = 3.14 \cdot 25^2 = 1962.5\, m^2$$

Hence, the power that can be produced by one 25m blade turbine rotor will be calculated, which is according to the equation (6):

$$P = \left(\rho \cdot A \cdot v^3/2\right) \cdot C_p = \left(1.23 \cdot 1962.5 \cdot 4.9^3/2\right) \cdot 0.35$$

$$= 49698\, kW = 0.49\, MW \approx 0.5\, MW$$

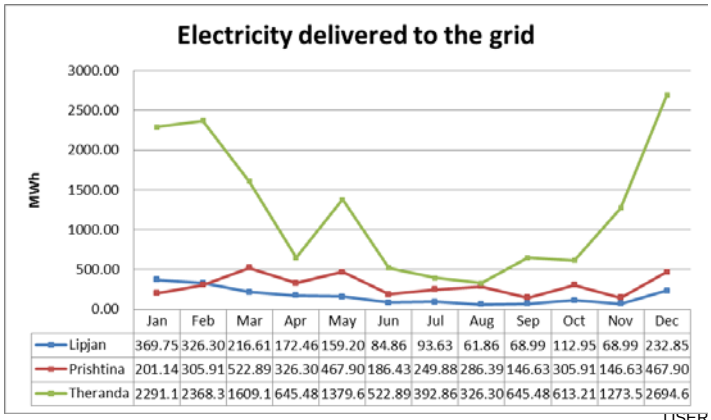
Possible power production by one 25m blade turbine rotor is somewhere 0.5 MW, which means 5 MW for 10 turbines installed. Installing larger turbines or higher number turbines, can provide different results. The possible energy production for every month from these three locations using above given turbines blade length, which gave the swept area of A = 1962.5 m2 is shown in table 2, together with a diagram showing changes during the months.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lipjan	0.50	0.44	0.29	0.23	0.21	0.11	0.13	0.08	0.09	0.15	0.09	0.31
Prishtina	0.27	0.41	0.70	0.44	0.63	0.25	0.34	0.38	0.20	0.41	0.20	0.63
Theranda	3.08	3.18	2.16	0.87	1.85	0.70	0.53	0.44	0.87	0.82	1.71	3.62

Table 2. Calculations of Energy production in three chosen locations with given data throughout the year

Using simple math, the energy delivered to the energy grid can be calculated by our side every month. Considering that turbines work 24 hours, capacity of energy delivered to the grid by each turbine installed would be as follows:



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lipjan	369.75	326.30	216.61	172.46	159.20	84.86	93.63	61.86	68.99	112.95	68.99	232.85
Prishtina	201.14	305.91	522.89	326.30	467.90	186.43	249.88	286.39	146.63	305.91	146.63	467.90
Theranda	2291.1	2368.3	1609.1	645.48	1379.6	522.89	392.86	326.30	645.48	613.21	1273.5	2694.6

Table 2. Energy delivered to the grid by each turbine in MWh

3 Wind Turbines and Environment

Indications throughout the recent years tend to show a negative impact of wind turbines in environment. This especially has to do with the location where wind farms are located, since in some cases, they can be danger to some kind of birds that fly near these locations at a certain height. Although the most common reason for birds mortality caused by wind turbines is location, the size of the turbine and the height of the tower also play a crucial role. Studies have shown that the larger the blades are and the higher the wind turbine tower is, the more dangerous it becomes to increasing bird mortality. This becomes a real problem, because larger wind turbines may provide more efficient energy generation.

3.1 Endangered Bird Species in Kosovo

There are hundreds of bird species that live in Kosovo. Some of them migrate during fall and some of them don't. In fact, the migration time is the most dangerous time for birds, since they fly in large groups, and in case they meet wind farms, the risk increases. Worldwidely, the most endangered species of birds from wind turbines are: birds of prey, eagles, vultures, harriers, etc. Some other endangered species are: hawks, kestrels, owls, etc.

In Kosovo, there is a number of bird species which are endangered, near-threatened or vulnerable. All species must be cared for, especially these ones. The species that may be threatened in Kosovo are:

- Vultures (Egyptian (already near-threatened), Cinereous (already near-threatened));
- Osprey;
- Eagles (Short-toed Snake, Lesser Spotted, Greater Spotted (vulnerable), Booted, Steppe, Imperial, Golden, Bonelli's, White-tailed, Eurasian Eagle-Owl);
- Harriers (Eurasian Marsh, Northern, Pallid, Montagu's);
- All kinds of birds of prey etc.

3.2 Solution(s)

Most birds live in mountains, near lakes or near places where water is easily available. When building wind farms, it is necessary to be careful about avoiding these locations as much as possible and choosing other locations which are less dangerous. And this is the number one solution. According to the most researchers, the No. 1 way to prevent bird deaths is to do a better job, choosing sites for wind energy development. Other solutions include Radars, which can be installed on each turbine. This way, turbines will slow down the speed when birds approach the endangered zone, and stop sweeping when they come to the red zone. Ultrasonic acoustic determent is also a solution to reducing bird deaths. The idea here is the ultrasonic boxes that emit high frequency sounds between 10 and 100 kHz, so birds will avoid that area. List of solutions continues, as one can be more effective than another. It is important to know that, none of the solutions until now stops bird deaths at all, they only reduce them. The technology at this point has to improve furthermore!

4 CONCLUSION

One of the best solutions among other renewables are Wind Turbines. And NEK has proven that there are at least 10 locations that Wind Turbines can be installed and give a satisfied amount of energy production, from which three have been studied on this paper. On these locations, hundreds, maybe thousands of MW using only Wind Turbines as renewables could be produced.

Even Wind Turbines have their impact on environment. Especially when it comes to endangering birds and bats. So, when installing the wind turbines, it is important to be very careful when choosing the location and equip the Wind Turbines with necessary tools to prevent and reduce the number of birds injured or killed. As none of the tools totally prevents birds' mortality, the technology related to preventing birds' mortality by Wind Turbines is still upgrading.

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