Int. J. of Thermal & Environmental Engineering
Volume 2, No. 2 (2011) 61-67

Analyzing Wind Data of the First Wind Farm in Kosovo

Bedri Dragusha[a,]*, Blerim Rexha[b], Ilir Limani[b]

[a] *Faculty of Mechanical Engineering, Kodra e Diellit pn., 10000 Prishtine, Republic of Kosovo*

[b] *Faculty of Electrical and Computer Engineering, Kodra e Diellit pn., 10000 Prishtine, Republic of Kosovo*

Abstract

In this paper are analyzed the wind data of the first wind farm in Kosovo. The wind farm is very small, consisting of three generators, each of 450 kW capacities. The wind farm has successfully passed the testing period as foreseen by law. The wind farm is located near to Prishtina region, but due to privacy agreement the exact location is not cited in this paper. Wind data for the Prishtina region captured by the Kosovo Hydro Meteorological Institute show that this region is very poor in wind. In contrary the measured wind speed at the installed site gives very promising wind data. Environmental impact (local and global), come from the use of energy, limiting the resources and increases their cost, making it more important to find and use a "clean" energy system, which increases the diversity of generation capacities and increases the security of supply. The energy generated by the wind farm is rather small that Kosovo cannot fulfill the famous 20-20-20 requirement from European Union directive. More work toward fulfilling this directive need to be done. The need of clean energy will be a global challenge of 21st century.

Keywords: *Energy, Wind Turbines, Wind Generators, European Directive, Clean Environmental,* CO_2

1. Introduction

Electricity plays a very important rule in daily life and economic development of a country. The main priority of electricity generation from renewable resources respectively from wind turbines is protection the environment by cast of CO_2 in the atmosphere. New energy policies of the EU also oblige Kosovo to fulfill its directives. Kosovo uses the feed-in tariff schema for supporting the Renewable Energy Sources (RES) [1]. Energy policy, until now, almost has exclude using wind as a source for production of electricity in many south-east European countries. Justifications for this attitude have been based on three main factors:

- There is no enough Wind in the territory of Kosovo.
- The contribution expected from wind, as additional electricity for the national electricity balance, there would be considerable.
- Cost of electricity production from wind would be higher than that produced by existing generating units, especially those of coal power plant.

Wind energy potential based on initial early studies and according to the data of hydro meteorological institute, Kosovo does not have enough wind speed for this kind of energy [2]. Therefore, based on this it would be necessary in Kosovo to make a feasibility study of wind and generation of wind maps in order to achieve a final conclusion on the possibility of using of this renewable energy and identifying the best spots in the country. Despite inadequate (weakness) of non existence of a specific study in this field, private investors have started to build the first capacity of generation. So, the first wind generators are in use for electricity generation, where the first concrete results are expected to provide electricity directly from this generation, and thus confirming the existence of sufficient wind for these turbines.

2. Wind energy

Exploitation of wind energy (as a renewable source of clean energy) is realized by eolic engine. The technology involves the capture of wind energy (air movement) through a turbine with a sheet, placed on a shaft that rotates, setting in motion electric generator. Wind eolic engine often known by the name as Wind Turbine and perceived as an aggregator of full turbine-generator that converts kinetic energy to electricity, mechanical, that is preferable to form energy supply of any customer.

* Corresponding author. Tel.: +377 (0) 44 174155
E-mail: bedridragusha@gmail.com
© 2010 International Association for Sharing Knowledge and Sustainability
DOI:10.5383/ijtee.02.02.001

In the world, wind energy during last 25 years took a great development and is now a potential source, usable and of great interest. In Europe, as a result of increased demand for additional resources of clean energy, supported by technical and scientific progress, it is foreseen that in 2030 to reach ~700 TWh/year. To achieve these targets four thematic areas have been identified [7]:

1. Wind conditions
2. Wind turbine Technology
3. Wind energy integration
4. Offshore deployment and integration

European Commission, based on studies made by member of EU countries, expressed more favorable optimistic about the use of wind energy for electricity generation, after the cost / price of electricity produced by wind energy will be lower, by increasing costs / prices of conventional and nuclear sources as well as other types of renewable resources.

Production of electricity from wind in wind farm represents the interests not only in terms of using the advantages of its economic and ecological, but also the social benefits that are achieved by applying the concept "Energy from local resources, that recommended by international institutions: EnergyChartTreaty (ECT) and WorldEnergyCouncil (WEC). Park of wind generators will consist of 9 wind generators. Generators will be placed on the distance between pillars of 160 meters. Wind Power JSC at the beginning of the project will install 3 wind generators with a capacity of 450 kW (total capacity 1.35MW) [3].

3. Wind data

3.1. Monthly and annually average wind data

Average monthly and annual wind velocity [in m/sec] data, as measured by Hydro Meteorological Institute of Kosovo (HMIK) are presented in Table 1 [2].

In the Table 2 are given average monthly and annual wind velocity [in m/sec] data, according to the database from RETScreen for Prishtina measured at 10 m height from the ground.

Table 1: Measured wind data by HMIK

Year	Month												Average annual
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2001	2.3	1.3	2.6	1.5	1.6	0.9	1.2	1.5	1.6	0.8	1.9	2.2	1.616
2002	1.6	1.2	3.0	1.8	1.3	1.6	1.5	1.7	1.6	1.4	1.6	1.4	1.641
2003	1.3	1.0	1.0	4.7	1.6	0.7	1.0	1.4	2.1	1.8	2.3	1.7	1.716
2004	1.8	1.7	1.9	1.5	1.5	1.1	1.0	1.2	1.2	1.0	1.3	1.5	1.391
2005	0.8	1.4	1.4	1.8	1.6	1.2	1.0	1.2	1.0	1.1	1.3	1.4	1.266
2006	1.2	1.2	2.0	1.2	1.5	0.9	1.4	1.0	1.0	1.3	0.9	2.2	1.316
2007	1.6	1.7	2.4	1.3	1.5	1.3	1.4	1.3	1.9	1.2	1.2	1.1	1.491
2008	0.8	1.9	1.9	1.6	1.0	1.1	1.7	1.1	1.0	0.8	1.2	2.5	1.38
Average 2001-2008	1.43	1.43	2.03	1.93	1.45	1.10	1.28	1.30	1.43	1.18	1.46	1.75	1.48

Table 2: Average monthly and annual wind velocity for Prishtina region

Month												Average annual
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
3.6	3.1	3.6	3.1	2.6	2.6	2.6	2.6	2.6	2.6	3.1	3.1	2.9

Table 3: RETScreen data for Prishtina region

Month	Air temperature [°C]	Relative humidity [%]	Atmospheric pressure [kPa]	Wind speed [m/s]	Measured at high [m]
I	-1.1	80.5%	95.4	3.6	10.0
II	1.7	73.5%	95.1	3.1	10.0
III	6.1	67.0%	94.9	3.6	10.0
IV	10.0	64.0%	94.6	3.1	10.0
V	15.0	65.0%	94.9	2.6	10.0
VI	18.3	64.0%	94.8	2.6	10.0
VII	20.6	59.5%	95.0	2.6	10.0
VIII	20.0	59.5%	95.0	2.6	10.0
IX	16.7	65.5%	95.2	2.6	10.0
X	11.7	71.0%	95.2	2.6	10.0
XI	4.4	80.5%	95.2	3.1	10.0
XII	0.6	82.5%	95.1	3.1	10.0
Average annual	10.4	69.4%	95.0	2.9	10.0

Meteorological data from RETScreen that are relevant for Prishtina region are presented in Table 3. Comparing the data from Table 1 and Table 3 (i.e. data from Hydro Meteorological Institute of Kosovo and data from international databases RETScreen) appears to have discrepancies. This probably due to the fact that is used different databases in each case [2]. It is important to note that in the case of wind energy one cannot be based in those

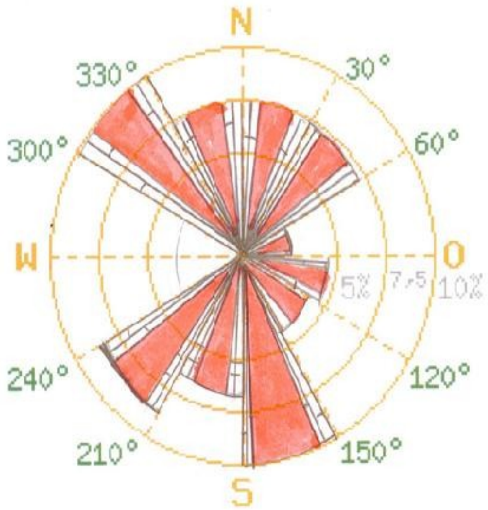

Figure 1: Prishtina windrosse

3.2. Wind, power and energy relation

It is therefore necessary to measure the wind data ate the exact location where wind generators are going to be installed. Height above sea at location where are put the wind turbines is 950 m while that of the Pristina is 545 m [2]. Exact location will be kept anonym due to privacy agreement with Implementation Company. In the Figure 2 is presented the installed wind generator near Prishtina region. Based on measurements and calculations made

data (i.e. data from Table 2 and Table 3), because they underestimate the real energy that can be generate by wind in this location. This is because there is altitude difference about 460-470 meters between the location of the measurement point and the Pristina location.
Based on the data from Table 3 and knowing the direction of the wind one can build the "Windrosse" for Prishtina region, as is presented in Figure 1.

above has become possible to build graphics, as presented in Figure 3 and Figure 4 for wind velocity measured at 10 m high and interpolated wind velocity at high of 32 m.

Figure 2: View of the installed wind generator

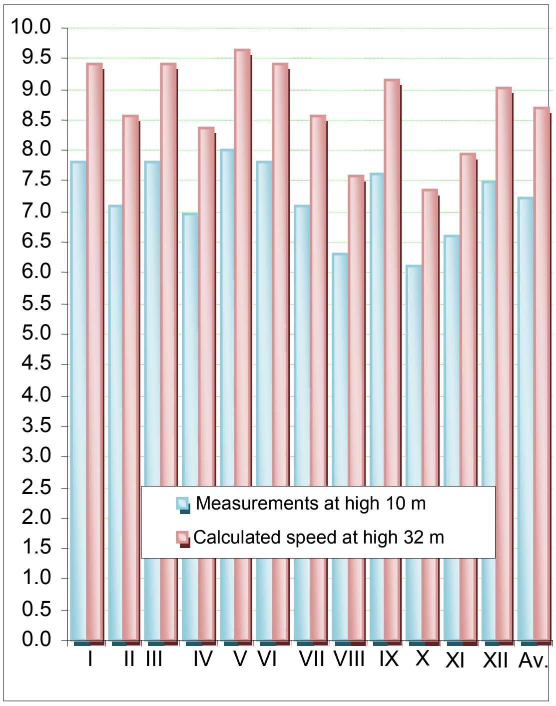

Figure 3: Velocity at high 10m and 32m

At this site are installed three generators, each of 450 kW capacities and have the following characteristics:

- pillar with height = 32.7 meters,
- number of wheel = 3 meters,
- wheel length = 17 meters,

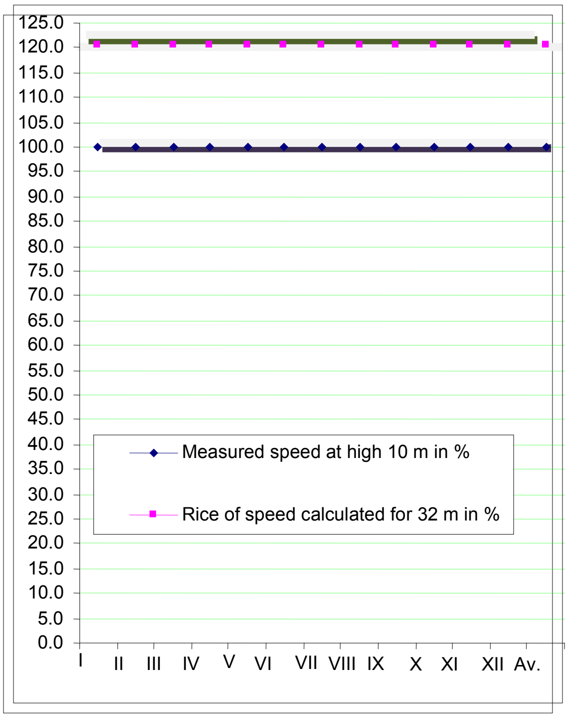

Figure 4: Velocity in % at high 10m and 32m

- wheel diameter d= 35 meters,
- plant height = 53 meters,

Thus in total, the first wind farm in Kosovo has 3 x 450 [kW] = 1350[kW] capacity.

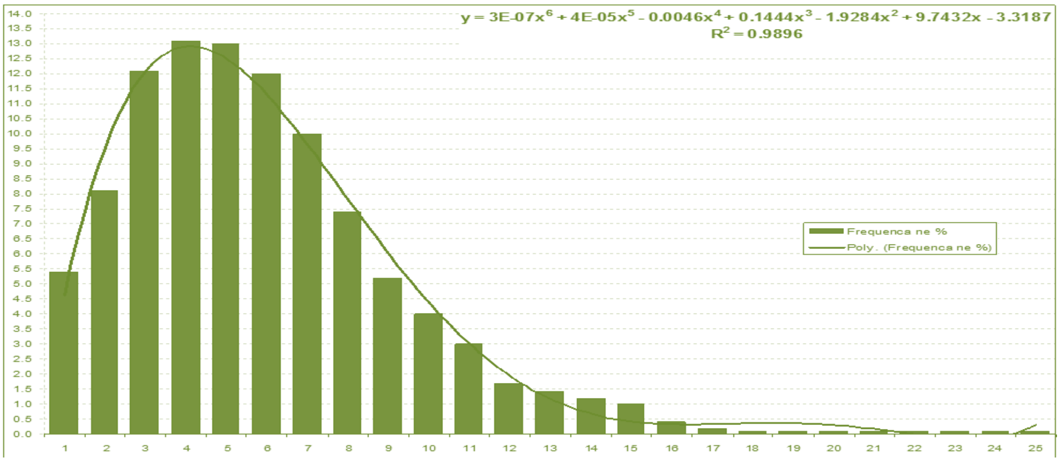

Figure 5: Distribution (in %) of velocity (m / sec) according to Weillbull

Graph of Weibull Distribution which graphically represents the relation between wind speed (m/s) and percentage (%) of time in which the wind speed will be achieved is presented in Figure 5 [8].

In the Figure 6 is presented the relation between wind velocity, generator capacity and energy for one of the installed generator, as given by the generator manufacturer.

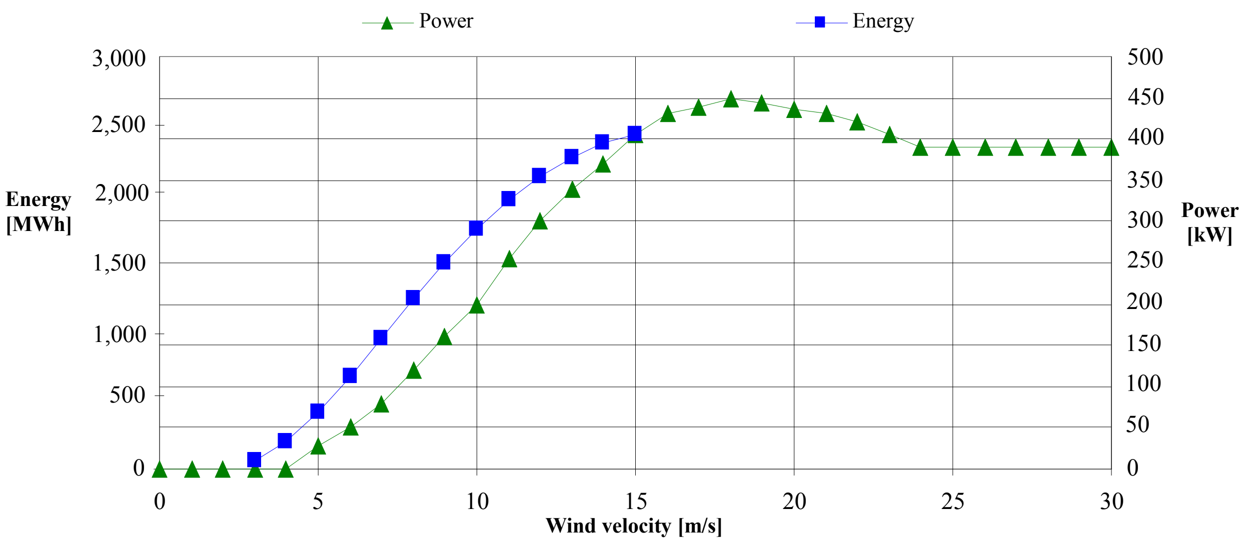

Figure 6: Relation between wind velocity, power and energy

In Figure 7 is presented the power curve vs. wind velocity. These data are taken one of the three installed generator, during the test period phase.

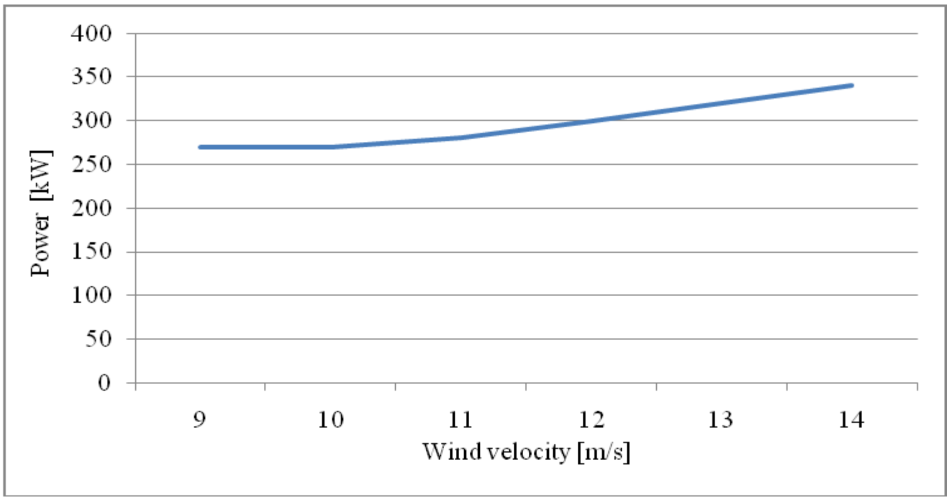

Figure 7: Relation between velocity and power capacity for one installed generator

4. Evolution of wind gradient

4.1. Interpolation of wind velocity

This evolution will help to assess the wind speed at the high of generators gondola compared with the high at which wind measurement are made. In the municipality at region in which the wind mills are installed the most frequent winds are northern and rare south-west, while the largest average wind speed is 2.2 m/s. From measurements made in this site the wind speed is approximately about 6.0 m/s.

Table 4: Measured wind speed (m/s) high measurement 10 m

Month												Year Average
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
7.8	7.1	7.8	6.95	8.0	7.8	7.1	6.3	7.6	6.1	6.6	7.5	7.22

The measurements of wind speed are made at 10m high; it is requested to be corrected/correlated for high of the axis of generator. The technical data of generators turns out that this axis is located approximately at 32m high from the ground. Correlation is made with formula (1)[6]:

$$v(h) = v_{10} \cdot \left(\frac{h}{h_{10}} \right)^{a} \qquad (1)$$

Where:

v(h) -velocity of the wind at height h, for our case at high 32m

v_{10} –velocity of the wind at height, h_{10}=10m

a – the Hellman exponent, for our case is a=0.16

Calculated of wind velocity at height h=32m is given in Table 5.

Table 5: Wind velocity at height 32m

Month												Year Average
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
9.40	8.55	9.40	8.37	9.64	9.40	8.55	7.59	9.15	7.35	7.95	9.03	8.70

4.2. Wind power density

The power curve depends on wind density. Wind power density is calculated in different form.
Expression for determination of wind power density is:

$$WPD = \frac{1}{2} \rho \cdot v^3 \qquad (2)$$

Method:

1) ρ = 1.225 kg/m3 (constant value based on Atmosphere, at sea level)
2) ρ = 1.225 - (1.194 * 10-4) * z (z=the location's elevation above sea level in m.)
3) If it is known pressure and temperature data:
   ρ = p / RT (kg/m^3)
   where p - air pressure (in units of Pascals or Newtons/m^2)
   R -the specific gas constant (287 J kg^{-1} $Kelvin^{-1}$)
   T -air temperature in degrees Kelvin
4) If it is temperature data but not pressure data
   ρ = (p_o / RT) * exp(-g*z/RT) (kg/m^3)
   where p_o -atmospheric pressure (101,325 Pascals)
   g -the gravitational constant (9.8 m/s^2); and
   z -the region's elevation above sea level (in meters)

In the equation (2) is made the assumption that the wind blew with velocity *v* all the time, but in the reality winds varying. The Wind Power Density will be calculated with equation:

$$WPD = 0.5 \cdot \frac{1}{n} \cdot \sum_{j=1}^{n} \left(\rho_j \cdot v_j^3 \right) \qquad (3)$$

Where:
n -is the number of wind velocity readings
ρ_j –readings of the air density
v_j –reading of the wind velocity

5. Calculation of Installed Power and Energy Capacity

5.1. Calculation of installed power capacity

Based on the installed capacity the efficiency is calculated as below:

$$\eta = \frac{P}{P_r \cdot 8760} = \frac{3303000}{3 \cdot 450 \cdot 8760} = 27.9\% \qquad (4)$$

Where:
P – Used power
P_r – Real Power
As can be seen the rate of efficiency is 27.9%.
Wind power is calculated in [W] [4],[9]:

$$P_w = \frac{1}{2} \rho \cdot A \cdot v^3 \qquad (5)$$

The wind power for one square meter can be calculated as follows:

$$P_w = 0.2 \cdot v^3 \qquad (6)$$

Where:
ρ –density of air at 15°C 1.225 [kg/m^3]
A -surface in quadrate meter [m^2]
v -wind velocity [m/s]

5.2. Calculation of installed energy capacity

Based on the wind data, from testing period of the wind farm and using the formulas from (1) to (6) one can calculate the annual energy delivered to Kosovo energy grid. This energy amount is about to be as 3300 MWh. In the Figure 8 is presented the amount of the energy in monthly basis delivered to Kosovo energy grid.

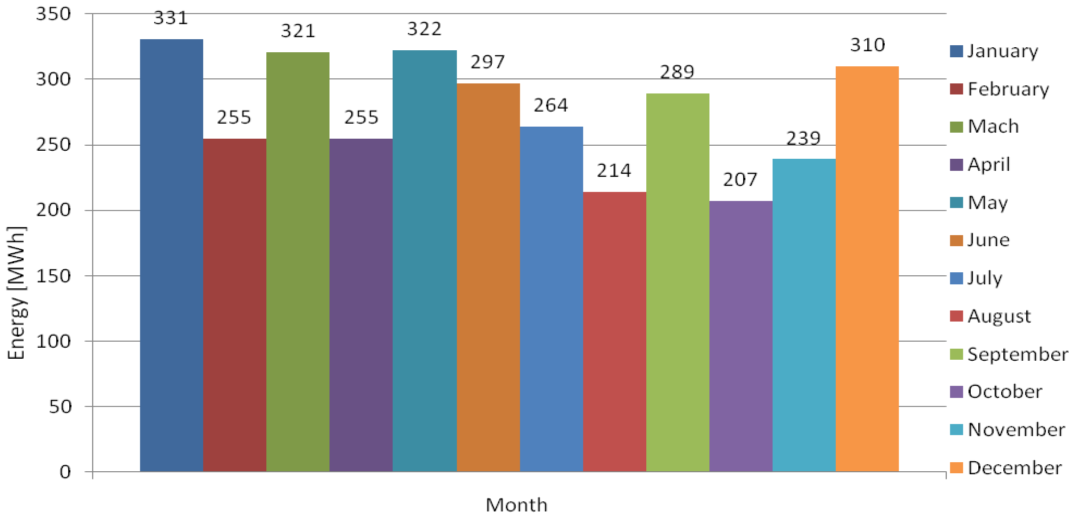

Figure 8: Monthly energy delivered to grid

6. Conclusion

In this paper are analyzed wind data in the Prishtina region. Taking in consideration the fact that data from the Hydro Meteorological Institute of Kosovo were in very contrast with real measured wind data at preferred location the early result are very promising. These three installed win generators build the first wind farm in Kosovo, thus brings us as a first country in the region with green energy generation. The usage of wind for generation of electricity is one possibility in this region to increase the security supply of electricity. Kosovo still needs its own wind map in order to maximize the wind potentials. It is possible to conclude that using wind energy helps to keep low value of CO_2 in Kosovo where 98% of electricity generation is from coal and only about 2% water energy.

References

[1] B. Rexha, B. Dragusha & I. Limani, Feed-in Tariff Kosovo, Proceedings of the 5th IASME/WSEAS International Conference on Energy & Environment (EE ‘10), University of Cambridge, UK, February 23-25, 2010.

[2] Instituti Hidrometeorologjik i Kosovës, Prishtine, 2009.

[3] B. Dragusha, B. Rexha & I. Limani, The use of wind generators in Kosovo, Proceeding of the 7th WSEAS International Conference on Recent Advances in Environment Ecosystems and Development (EED ’09), Puerto De La Cruz, Tenerife, Canary Islands, Spain, December 14-16, 2009 (pp142-146).

[4] Shu-Chen Wang, Pei-Hwa Huang, Chi-Jui Wu, Study on Fuzzy Models of Wind Turbine Power Curve, IASME/WSEAS International Conference on Energy & Environmental Systems, Chalkida, Greece, May 8-10, 2006 (pp33-37).

[5] J. Bilbao, E. Bravo, O. Garcia, C. Varela, M. Rodriguez, P. Gonzalez, A. Olazaga, “Noise Map of Wind Farms” 4th IASME/WSEAS International Conference on Energy, Environment, Ecosystems and Sustainable Development (EEESD'08) Algarve, Portugal, June 11-13, 2008 (pp86-89).

[6] European Wind Energy Association, Wind for electricity generations practical action, 2009.

[7] European Wind Energy Association (EWEA), Wind Energy- The Facts, London 2009.

[8] Gary L. Johnson, Wind Energy Systems, Electronic Edition, Manhatan, KS, October 2006.

[9] Thomas Ackermann, Wind Power in Power Systems, Royal Institute of Technology Stockholm, Sweden, 2005.