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A NEW METHOD OF DETERMINING THE PARAMETERS FOR ESTABLISHING THE INSTALLATION POSITION OF SMALL WIND TURBINES

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Abstract: *Many producers have been developing in the last years products for the implementation of small power wind turbines, both for the urban environment and for remote consumers (houses, vacation houses, ships, etc.). These inventions are not based on a very good wind potential, but more on choosing the most appropriate type of wind turbine and on adapting the components as much as possible (blades, generator, number of poles). Further on we will deal with the determination of the air currents through a simple and low-cost method, in order to determine the placement location in the urban area of one or more small wind turbines.*
Key words: *SWT (Small Wind Turbine), urban area, air currents*

1. INTRODUCTION

A potential user of an energetic system using a renewable energy source must have data which lead to the insurance of the efficiency of the investment. In view of this, we need to have an estimation of the energetic potential than a certain location has, so that an estimative calculus of the annual energy production can be made.

In order for the design, the production, installation and maintenance of wind turbines to treat the security aspects and the ones concerned with quality and reliability insurance in the same way, normatives with technical character have been put together. They can be used by designers and producing firms, ensuring an attestation of the product's quality. However, there does not exist yet a research methodology of the aspects which can certify the opportunity of installing a small power wind turbine in the urban environment.

2. THE INTEGRATION OF A SWT IN THE URBAN ENVIRONMENT

Wind energy in an urban environment cannot be treated in the same way as in an open space because buildings act like obstacles which influence the wind's direction. The wind's speed is usually smaller due to the increased roughness determined by the buildings. However, local circulation fluxes are formed, with flurries and more powerful and frequent turbulences. In these cases we also have a convective system of air circulation at low heights and a width which varies according to the obstacles in the area (Gipe, 2009).

However in the last period we can notice a sharp increase of the number of wind turbines of up to 20 kW which are being set up in the urban area in order to compensate for a part of the consumption of electricity of companies or house owners. Although, in order to install them it is necessary to determine the aerodynamics of the possible location, so that in the next steps an efficient decision is made.

In view of this, it would be necessary to do measurements of the wind parameters in several possible locations, on a long period of time (at least one year), but this would lead to big expenses, in some cases bigger than the cost of the wind turbine, (fig. 1).

3. MEASUREMENTS OF AIR CURRENTS

In order to make the best decision concerning the place where a SWT can be installed in the urban area and the height at which the rotor can be installed without too high costs, we suggest in this paper that the measurements of the wind's speed, its direction, density and height measured by installing an anemometric pole should be replaced with a balloon filled with helium, which moves the measurement sensors in different vertical and horizontal locations. This creates the possibility of obtaining sections of the wind currents similar to the ones obtained through the LIDAR method, but with much lower costs.

Thus we can determine the speed of the wind at different heights through the simple lifting of the sensors in a controlled manner and through the processing of the data thus stocked or sent by wireless. We can draw a map of the air currents and after these repeated measurements, during a month for example, we can draw the conclusion on the characteristics and the installation position of a SWT. We can thus ensure the installation of the turbine's rotor in a favorable air current, which can ensure as high an efficiency as possible. This is important, as we are talking about small offers of potential.

The calculus for the turbine is usually done for the normal operating system, system at which the functional performances are optimal. A calculus of the power at the turbine's hub can be made (Bej A., 2003):

$$P_{sh} = C_{Psh} \cdot \rho \cdot \frac{v^3}{2} \cdot \frac{\pi D^2}{4} \cdot \left(1 - \frac{d^2}{D^2}\right) \qquad (1)$$

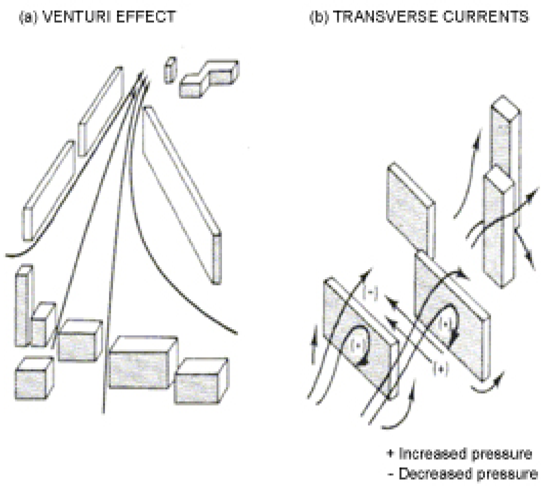

Fig. 1. Wind circulation in area with buildings (www.unc.edu/courses/2008ss2/geog/111/001/NCSy)

where:

C_{Psh} - the turbine's power coefficient
ρ [kg/m^3] - air density
v [m/s] - wind speed
D [m] - peripheral diameter of the rotor
d [m] - the diameter of the turbine's hub

The distribution of the speed of the wind is important for choosing (designing) the SWT, as it decides the tasks which the wind turbine has to take. In the case when it is installed in the urban area, they are included in the designing classes III – IV, using the IEC 61400-2/2006 classification (IEC 61400-2/2006). This means that in the designing calculus for the wind speed at the level of the ax of the rotor V_{hub} we can use the Rayleigh probable cumulative distribution (Gyulai, 2004):

$$P_R(V_{hub}) = 1 - \exp\left[-\pi\left(\frac{V_{hub}}{2V_{ave}}\right)^2\right] \qquad (2)$$

The vertical profile of the wind can be designed by taking into account that speed is a function depending on the height z at which the measurements are made and on the of roughness the soil. Thus we can use the formula:

$$V(z) = V_{hub} \cdot \left(\frac{z}{z_{hub}}\right)^{\alpha} \qquad (3)$$

Where the exponent of the power factor α can be considered as being: α= 0.2.

The profile of the wind thus determined represents the average of the wind which passes through the rotor. In all the cases when the degree at which the air flows is less than 8° compared to the horizontal plane, it will be regarded as constant on height and will not influence the designing calculus.

In order to describe a model of normal turbulence we consider a 10 minutes average of the deviation of the wind's speed, direction and random rotation. For a random wind flow, which introduces a variable speed, we have:

The standard value of the wind deviation on a longitudinal plane (Cano et al., 2009):

$$\sigma_1 = I_{15} \cdot \left(\frac{15 + a \cdot V_{hub}}{a+1}\right) \qquad (4)$$

The characteristic value of the turbulence I_{15} is in this case:

I_{15}[-] = 0.18, and the slope parameter is: a [-] = 2.

The value of the spectral density function can be approximated with:

$$S_1(f) = 0.05 \cdot \sigma_1^2 \cdot \left(\frac{\Lambda_1}{V_{hub}}\right)^{-\frac{2}{3}} \cdot f^{-\frac{5}{3}} \quad [\mathrm{m}^2/\mathrm{s}] \qquad (5)$$

Where the scale parameters of the turbulence are:

$\Lambda_1 = 0.7\, z_{hub}$ [m] , for $z_{hub} < 30$ m
$\Lambda_1 = 21$ m , for $z_{hub} \geq 30$ m

We take this into consideration when choosing or designing a SWT for the urban area, depending on the results of the measurements made and the extreme wind conditions which can appear. These conditions include the peak values of the wind's speed, in extremely difficult weather conditions, with very fast changes in the intensity and direction of the wind.

Thus you can determine more accurately the available potential of the location and then, considering the financial aspects, the type of wind turbine and the sizes of the turbine's rotor.

The measurements can be made with a weather station which has independent measurement sensors and which can send the data in real time or can save it. An example of such a station is IROX Pro X.

In the case of SWT installed in the urban area, the speed fluctuations of the wind are much bigger and they must be known in order to do the resistance calculations. We must consider that in the case of SWT installed in the urban area we also have additional requests which are transmitted to the buildings, as well as the problems related to aesthetics and the noise made by the turbine.

It should be noted that these are the facts relating to building-mounted, grid connected micro-wind systems less than 2kW only and the findings cannot and should not be generalized to larger scale or freestanding wind (Brown et al., 2009).

Wind speed and power curve data available to predict performance is not very accurate and requires significant adjustment to generate predictions for energy production.

4. CONCLUSION

The proposed method for doing the measurements can be applied at low costs in the case of an intention to set up a SWT in the urban area or in the case of locations which are known as having small wind power potential.

More investigations would be needed in order to focus on the measurements of the SWT's and their components.

The actual measurement procedures should be more reliable. An important way for research is opened.

In order to achieve an even higher efficiency one must choose depending on the present conditions a wind turbine which has a power curve as close as possible to the measured conditions.

5. ACKNOWLEDGEMENTS

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