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SUITABILITY OF WIND POTENTIAL IN SOME AREAS OF CENTRAL MOLDAVIAN PLATEAU

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Key words: wind potential, Central Moldavian Plateau, Huntsberger relation, statistic methods

Abstract. In the contemporary period, the most important element in sustaining and developing the society, under all its aspects, is represented by energy. Due to the fact that in society consumption is increasing, the actual preoccupation is to reduce the energy consumption and also to find clean, alternative sources to produce energy. The theme of this article is directed towards the concepts of increased availability and energetic independency and concerns estimations over the wind potential in certain areas of Central Moldavian Plateau. For this purpose there were analyzed genetic factors of the wind in the analyzed area and those parameters of wind speed, useful to the justification of the wind potential study. The obtained results confirm the fact that in Central Moldavian Plateau, in many areas, especially those of high altitude, are favorable conditions to use wind energy. Along with the remoteness from the Eastern Carpathians and the proximity of the Black Sea, the conditions become more and more favorable. Unfortunately, the lack of meteorological stations on the top of hills (besides the Barnova station, situated in the woods). Increased wind speed in the meaning of what was stated, was approved only on high valleys and upper terraces in the main valleys, especially on the Prut.

Introduction

The speed of wind is determined by general circulation of atmosphere and active surface characteristics, especially landscape. The major landscape from the studied are and of the surrounding areas, as well as in local landscape, influences the speed of wind especially by altitude, but also by the position on tops, slopes or valleys, morphology, the presence of localities, woods etc.

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The suitability of wind potential in this area was confirmed by numerous studies which individualized among areas with favorable wind potential, the tops of high mountains, especially those from the Eastern Carpathians and the Curvature Carpathians, Moldavian Plateau, Baragan, Dobrogea and Western Plains. Among these, the most favorable conditions are gathered in Dobrogea and Barlad Plateau. The suitability of the studied area for using electric energy is confirmed by using, in the past, widely, in this area, of windmills (Patrichi, Gugiuman, 1983)

Studies about wind energy potential in Romania, made by meteorologists and climatologists, most of them from the Meteorological Institute, belong to several stages. The first, including 7 and 8 decades of the last century, which correspond to the plenary development stage of Romanian climatology, and studies respond mostly to general goals regarding the knowledge of some applied climatology aspects and some hypothetical intentions of recovery. Studies are about wind characteristics in several areas (Patrichi et al, 1965; Patrichi, 1971 etc), the most important being those of national level (Cristodor et al, 1966; Stoenescu et al, 1967; Ţîştea et al 1976; Neacşa, 1979 etc). The second stage, the 9th decade of the last century was the result of an acute requirement, Romania, in the conditions of an oversized and intensive industry, could no longer ensure the necessary of energy from own conventional sources, and the financial resources for importation were nonexistent. We mention for this period fundamental research studies concerning the wind characteristics (Bâzâc, 1984; Voicu, 1984; Voicu et al, 1984; Frimescu et al etc), or for different regions (Bordei-Ion et al, 1984 etc). It are remarkable the studies of the team from Pângăraţi Resort, approaching methodological issues and analysis of the wind potential in Moldavia (Apăvăloae et al, 1985, a şi b; Apostol et al, 1985; Apăvăloae et al 1986). The last stage, from 1990 until today is characterized by some value synthesis regarding the wind characteristics in Romania (Soare, 2008), in different regions of the country, but especially by studies of the wind potential in Romania (Ţuinea et al, 1992), Moldavia, (Rusan, 2010) and other regions (Apostol, 2004).

The studied area includes several representative areas from the Central Moldavian Plateau: the Western high area, by analyzing the data from the meteorological station Plopana; the valleys from the western plateau; with general orientation north-west – south-east and west-east, represented by Negresti station; the main valleys, wider, from the center of the area are represented by the Vaslui meteorological station and Prut's Passage, by the Huşi meteorological station. The location of the national meteorological network, does not have unfortunately, presently any top station in Moldavia, until the altitude of 1900 m (Barnova station not being representative for analyzing the wind potential, being situated in the woods). Therefore the areas with the biggest wind energy from Central Moldavian

Plateau are not covered in our analysis, the nonexistent background data for wind energy in these areas being private so inaccessible.

For analyzing the limits of the studies areas and landscape conditions with influence over the wind energy were used bibliographic database. (Băcăuanu et al, 1980; Patriche, 2005 etc).

An important characteristic of the speed of wind is **average energetic speed**, which represents summing the speeds of active wind, which is >3m/s. to be able to correlate it with the power of wind turbines, the energetic speed must be used on stages of value. From most of the works on this regard, we can conclude that the efficiency of wind turbines, namely that their productivity depends on the speed and duration of the wind, but mostly on the presence, even in moderated values, of higher classes of wind, boosted values and location suitability.

1. ***Data and methods***

Hereinafter, we will analyze the suitability for using wind energy in the mentioned areas from the Central Moldavian Plateau, by specific ways of approach. The old climatic data prior 1972 are accessible in climatic yearbooks, but unfortunately for a more thorough study of the wind, after 1972, there are restrictions in the climatic background data in the national meteorological network, the climatic data being accessible only partially and only from the stations in the international flux.

The background data used in this article is represented by series of 11 years for 3 stations (Plopana, Vaslui, Husi) and a series of 8 years for the Negresti meteorological station. The period for which the study was made is 1965-1975, respectively 1965-1972 and was chosen this period because of the fact that after 1960 the stations suffered changes of the observation program and in some cases of location (tab.1). The periods of observation are representative as number of years for this parameter of the wind, speed (Kostin, Pokrovskaia, 1964).

Tab. 1. Altitude and average wind speed for used meteorological stations

Station	**Altitude (m)**	**Medium speed (m/s)**
Plopana	230	4.9
Negresti	134	4.2
Vaslui	117	3.3
Husi	98	3.8

The authors of the previous studies used, generally, classical methods, comparative studies, using determination formulas of kinetic energy, but most

often using values of the average speed of the wind, annual, monthly and mostly monthly and annual for observation hours.

For processing the data, along classical methods of exposure of data graphical with the help of Excel program, there were used statistical methods by which it was synthesized the situation of wind frequency with certain speeds at the 4 meteorological stations.

To express the distribution of frequencies of quantitative variables – wind speeds, were used the statistic class by which it is revealed a subdivision of the variation field of the variable (wind speed), having as characteristics the inferior limit, respectively the superior limit. Grouping in classes of frequencies, is extremely important because it depends the rightness of the subsequent developments and exactness of the obtained results. To obtain these we used *Huntsberger relation*, with the formula for calculating $k = 1 + 3.332 * \log(n)$ where k = the number of classes, and n = the total number of values from the series. To establish the class limits, the most used progressions are arithmetic, geometric and squared progression. In this case was used arithmetic progression. Once the number of classes was found, it was calculated the size of the interval by the relation of H. D. Sturges, $l = \frac{x_{\max} - x_{\min}}{1 + 3{,}332 \log n}$. It resulted 10 classes of frequencies, with a size of the interval of 0.66, between the absolute minimal value and the absolute maximal value, the differences and amplitudes being constant.

2. Results

2.1 Suitability at a annual level

In the next section it will be presented the results obtained from the study of these characteristics of the wind in some regions from the Central Moldavian Plateau. It were presented the linear trends for the 4 studied stations, from west to east Plopana, Negresti, Vaslui and Husi (fig.1,2). The decreasing of the average wind speeds in the studied area happen from west to east, once the decreased altitude, with one exception, Husi station, were it is registered a slightly elevated speed from the Vaslui station.

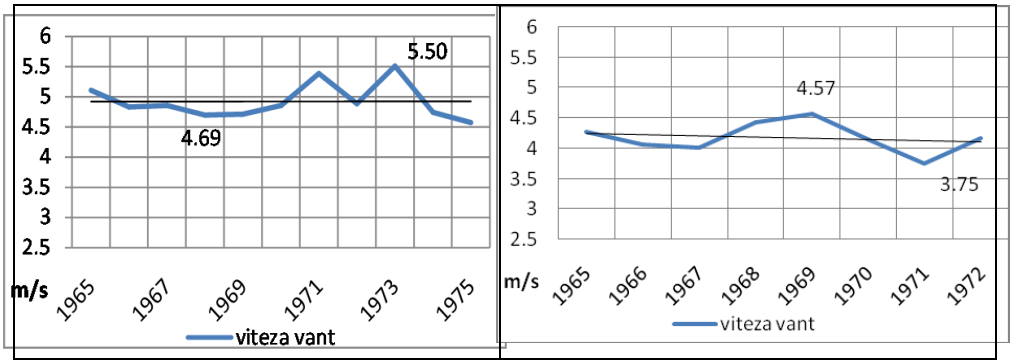

Fig.1. Linear trend of the wind speed at Plopana (left)and Negresti (right), (1965-1975)

Although the altitude values decrease from west to east and the Huși station is located at the lowest altitude, here, because of channeling the air masses on the Prut's Passage, the tendency of the wind speed is to increase, compared with the other 3 stations where it is registered a stationary or declining (Negrești and Vaslui).

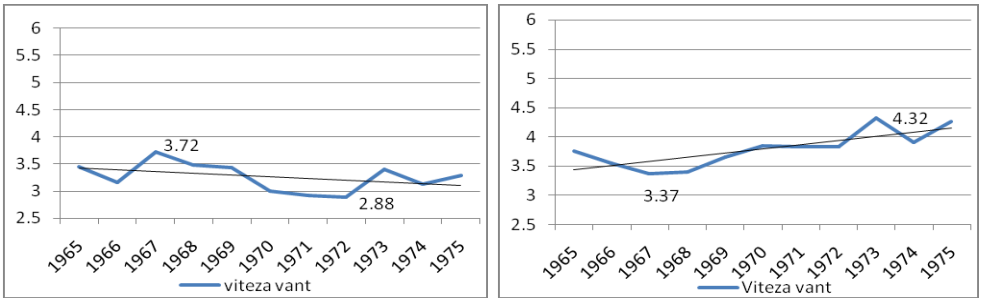

Fig. 2. Linear trend of the wind speed at Vaslui station (1965-1975) (left)Linear trend of the wind speed at Huși station (1965-1975) (right)

To establish the link between altitude and wind speed values it was calculated the coefficient of correlation. It is known that the speed of wind increases directly proportionally with altitude, therefore was analyzed in comparison, at the 4 stations the average wind speeds, correlated to the altitude of the location (fig. 3).

As you can see in fig.3, the average speed of the wind increases proportionally with altitude, exception being the Husi station where it is registered a higher value, which is observed in the coefficient R^2.

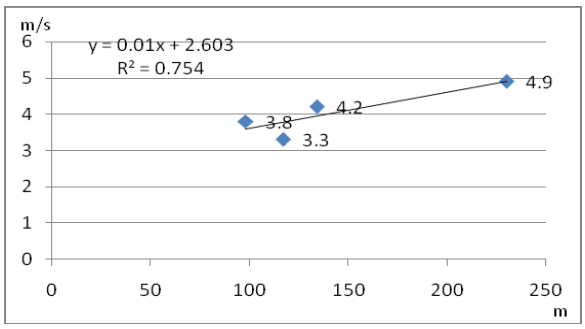

Fig.3. Altitude - wind speed correlation for used stations (1965-1975)

The closer to 1 is the value of the correlation coefficient R^2, the stronger the correlation between the two elements is. The value of R^2 which characterizes the correlation between the 4 stations is 0,754 and when R^2 is between 0,75 and 1, it presents a strong correlation, so this case presents a valid correlation, according to the idea of increasing the speed of wind in relation to altitude. Further it was realized the effective study of the suitability of energetic wind potential in the areas of the four stations from the Central Moldavian Plateau. It were analyzed frequencies classes of wind speed to determine the suitability of energetic wind potential, on the base of the number of frequent cases in the region of Plopana station. During the studied period, at the Plopana station the average speed is maintained constant, it are not registered but two major oscillations in the years 1971 and 1973 (Fig.1).

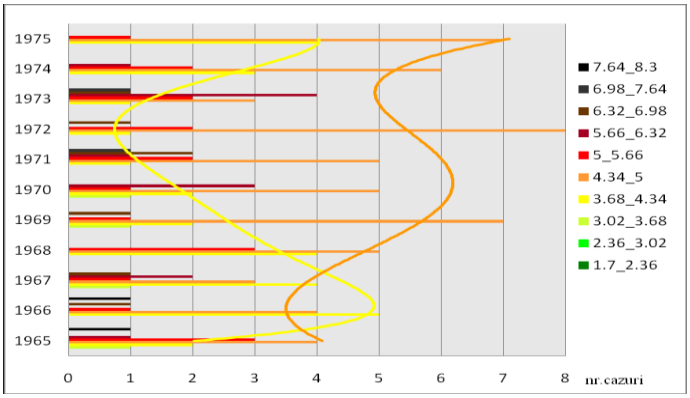

Fig. 4. Annual frequency of wind speed values at Plopana station (1965-1975)

The decreased variability and major values of the wind speed are the main characteristics of high wind performance, and at Plopana was registered the highest

values of average wind speed as well as a small oscillation over the years. In 1972 was the maximum number of cases for the value class of 4.34 - 5 m/s, which represents the year with the highest potential, with average speeds of the wind until 5m/s. The highest frequency was registered for the values class of 4.34 and 5 m/s, with a multiannual average of 5,2 cases, followed by the values class 3.68-4.34. according to these values and considering that over the years, according to the polynomial trend, the main values classes succeed, at Plopana station was registered a high potential of producing wind energy, the multiannual average speed being 4,9 m/s.

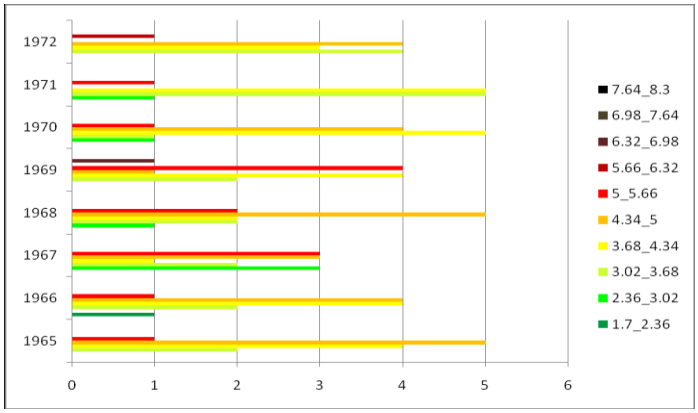

Fig.5. Annual frequency of wind speed values at Negrești station (1965-1972)

For Negresti station, the speed of wind had an uneven character, with a general trend similar to that of Plopana station, but with a smaller number of cases, so a more pronounced variability, which decreases the wind performance. (Fig. 5).

Analyzing the value class of the speed of wind, we observe that it mainly fits in the value classes of 3.68-4.34m/s and 4.34 - 5 m/s. Even though it presents the same main value classes as in Plopana, the suitability is decreased because the wind speed presented a higher variability (more classes, but with smaller values) being a negative aspect for producing wind energy. According to the distribution of the speed and variability of the wind at an annual level, Negresti station presents a good energetic potential, inferior to that of Plopana station with a multiannual average of 4,2 m/s.

Frequency classes for Vaslui station present much smaller speeds of the wind comparative to the two stations presented previously (fig.6). The most frequent cases are those with speed between 2.36 – 3.02m/s and 3.02 - 3.68m/s. The maximum frequency is of the class of value between 2.36 and 3.02m/s, with a value of the multiannual average speed of 3,3 m/s, a speed for which wind turbines

of wide usage are not sufficient. Being given the small values of the wind speed the energetic wind potential is low, recommended for this area is the usage of wind turbines of low power, maximum 500W, which was the cut-in speed of 2/2m/s, being used only for domestic usage and in on-grid system.

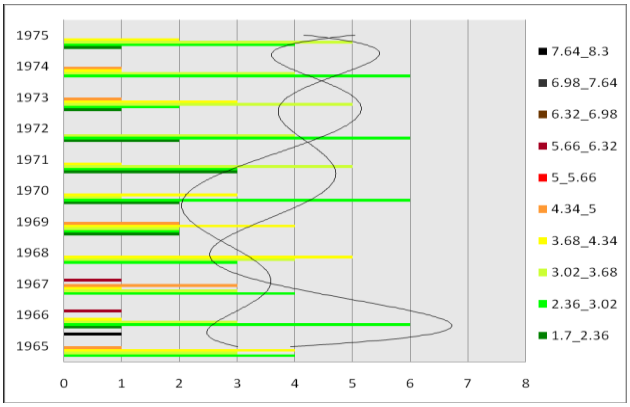

Fig. 6. Annual frequency of wind speed values at Vaslui station (1965-1975)

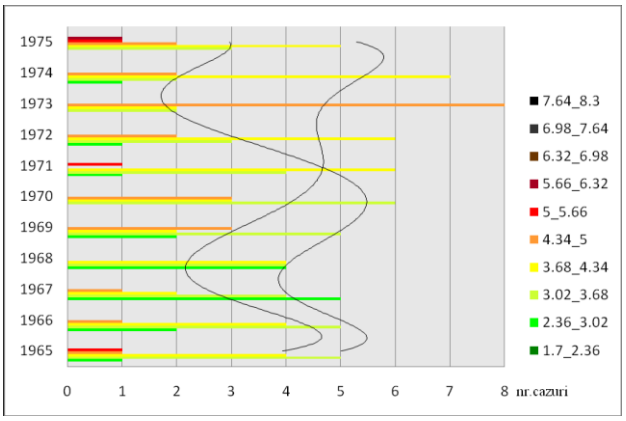

Fig.7. Annual frequency of wind speed values at Huşi station (1965-1975)

At Husi station (fig.7) the speed of wind registers an increase towards the final of the decade, an increase that is sustained both from a linear trend (fig.2) as well as from a trend of the frequency of the values classes. The main classes are with values between 3,02-3,68m/s and 3,68-4,34m/s. In the first part of the decade is prevalent the class of values between 3,02-3,68m/s which has a decreasing trend and in the second part of the decade prevalent is the values class 3,68-4,34 m/s which presents an increasing trend. The energetic potential of Husi station is

average but increasing because of the speed of wind which has a positive trend and can be valued due to the minimal registered speed of 3 m/s – necessary for triggering the wind turbine, the multiannual average speed being 3,8 m/s. The wind turbines which are according to the registered speed at Husi station, are those of maximum 5 Kw, which can produce at a speed of minimum 3 m/s aprox. 2000Kwh/year.

2.2 The suitability at a monthly level

One aspect of a major importance of the suitability is the evolution at the monthly level, because over the year the wind regime varies. The trend of the wind speed is similar for all four stations, with a minimum in the warm season and a maximum in the cold season (fig. 8).

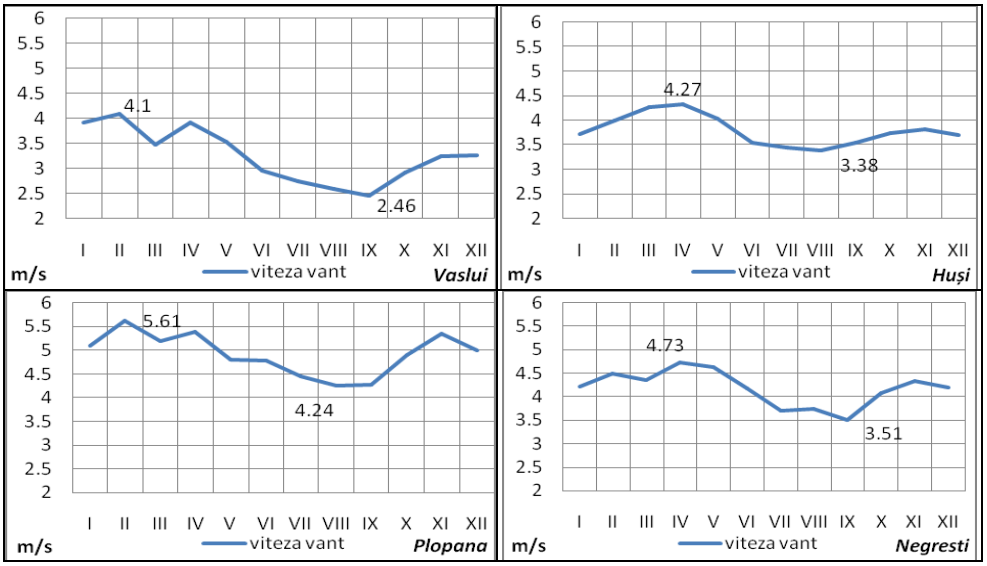

Fig.8. Monthly average wind speed for all stations (1965-1975)

In the area of study the maximum suitability was in the months February (Plopana and Vaslui) and April (Negrești and Huși). At Plopana and Vaslui was registered a second top in April. In June-September in all four stations was registered the lowest potential for developing wind energy, being frequent the atmospheric calm because of the typical baric conditions for the warm season.

Results

According to the study made it results that the energetic wind potential in Central Moldavian Plateau is the highest as the altitude is bigger, so at Plopana station, which is at the highest altitude of the four stations, it was registered the highest speeds of the wind, with a high variability, so a favorable energetic potential, well defined. In the areas of Negreşti and Huşi stations, the energetic wind potential is reduced, but enough for wind turbines up to 5 Kw. A wind turbine of 5 Kw, has the cut-in speed 3 m/s and can produce up to 2000 kw annually, which represents efficiency energetically speaking. For Vaslui, the wind energetic potential is very reduced, the average annual wind speed is very reduced, around 2.5m/s, situation in which the wind energy cannot be harnessed without wind turbines of domestic usage, of maximum 0.5 Kw, in on-grid systems, simultaneously with the electric network already existent, as well as in case of any types of usage of electric energy.

At a monthly level, at all stations it is observed, according to linear graphics, between June and September, the period with wind potential is reduced, thus at Vaslui station, due to this long unfavorable period, the energetic wind potential per year is low, and the investment in a wind system does not present trust, because the performance is very low.

In the areas studied within the Central Moldavian Plateau, according to the values of the wind speed, because of the altitude, but also because of local factors, the highest potential is registered at Plopana station, followed by Negresti, Husi, and at Vaslui station is the lowest energetic wind potential.

Following the analysis, at Central Moldavian Plateau can be said that it exists real possibilities of efficient usage of wind energy, present research, through a different methodology, confirming previous studies results.

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