WIND ENERGY POTENTIAL IN THE EAST OF ROMANIA

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Key words: wind energy, aggregate, pilot poll, Romania.

Le potentiel énergétique éolien de l'est de la Roumanie. Dans le texte sont analysées la fréquence et la vitesse du vent, ce qui met en évidence le potentiel énergétique éolien de l'est de la Roumanie. Les plus hautes vitesses moyennes du vent (> 7 m/s) sont enregistrées à Sulina, au-dessus des eaux territoriales, sur la plate-forme continentale de la mer Noire, ainsi que dans les régions adjacentes. On peut y envisager d'installer des agrégats éoliens de différentes puissances qui produiraient d'énergie électrique toute l'année. La continuation des études systématiques théoriques est nécessaire pour le dépistage des aires avec grand potentiel énergétique éolien, des études techniques qui assureraient la fonctionnalité continuelle des agrégats éoliens et pratiques pour sa valorisation à divers buts: agriculture, irrigation, transport, etc. La documentation accumulée pour cet article nous autorise d'apprécier que toute contribution apportée sur le vent et ses éléments caractéristiques d'une certaine partie du pays est un support dans le but de l'usage du potentiel énergétique éolien de la Roumanie.

1. INTRODUCTION

The interest in using electric power as an unconventional energy source dates to mid-20th century when the intensive exploitation of conventional energy sources was considered to lead to their exhaustion. This made people worldwide seek productive and unpolluting alternative energy sources to replace the primary, conventional ones. Some of the unconventional energy sources, acting as substitutes for the conventional ones, are solar energy, geothermal energy, biogas, winds and wave power provided more performant technologies are used to capture, converse, produce and store this type of energy.

Of all these unconventional energy sources, wind power in wind blown (regardless of wind direction) proved to be the easiest to use.

Differences in temperature and air pressure lead to the formation of winds which blow from higher-to-lower pressure regions.

Wind energy, or the energy produced by the force of wind, has the widest development and use. Worldwide research shows it capable to provide five times more energy than is presently used. It would require 12.7% of land to be covered by parks with wind turbines.

Romania's wind energy potential is about 14,000 MW installed power and the technical capacity to produce 2,500 MW. Geographically speaking, the region with the highest wind energy potential is in the eastern part of the country, that is the Danube Delta, the Romanian Black Sea coast, the Dobrogea Plateau and the Moldavian Plateau, areas still insufficiently studied and exploited. According to the 2003 National Strategy for the Use of Energy Resources, this country's production capacities have been scheduled 120 MW by the end of 2010 and at 280 MW by 2015. An all-country analysis shows that the wind energy potential of Dobrogea region alone is of 2,000 MW installed power, that is more than two nuclear power plants the size of the Cernavodă one. This scenario is rather exaggerated, impossible to implement because there are no investments in this field.

In Romania, efforts to use the energy of wind began in 1962, when a map of major wind characteristics was drawn up (Patrichi, 1984), based on the meteorological measurements taken every hour over a ten-year period (1951–1960).

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In 2009, there are five wind-based electricity-producing centers: Tihuța (Bistrița-Năsăud) 250 kW/h, Ploieşti (Prahova) 660 kW/h, Baia 550 kW/h, Valea Nucarilor – Tulcea with three aggregates of 750 kW/h each, and Corbu (Constanța) 100 kW/h.

In 2005, the wind turbine at Tihuța produced 186 MWh, the equivalent of burning 23 tones of coal (Fig. 1).

Fig. 1 – The wind turbine in the Tihuța Pass, Bistrița-Năsăud County, Eastern Carpathians.

Summing up, we would say that wind power is a promising source of electricity for the coming years, because it is ecologically clean and in never-ending supply. This has prompted us to carry out climatic studies on the wind regime in the eastern part of Romania, that is the Moldavian Plateau, the Siret Corridor and the North-Dobrogea region.

2. WIND CHARACTERISTICS IN THE EASTERN REGIONS OF ROMANIA

Studies of the wind regime in Romania have been carried out in two distinct stages:

● before 1960, when observations were made at three hourly intervals, namely 8:00, 14:00 and 20:00 and never at night;

● after 1960, when the international system with four observation times: 1:00, 7:00, 13:00 and 19:00 was adopted as well as at fact that change previous conclusions.

2.1. Annual average wind direction frequency before 1960

The analysis is based on the data obtained by five stations before 1960 and in the 1965–2004 period: Botoşani and Iaşi stations are characteristic of the northern and central parts of the Moldavian Plateau, Bacău station is specific to the Siret Corridor, Galați station to the southern part of the Moldavian Plateau and the Danube Corridor, Sulina station to the Black Sea shore.

Wind frequency before 1960: the northern half of the Moldavian Plateau was governed by NW winds (Botoşani 23.6%, Iaşi 21.5%) and SE winds (Botoşani 18.7% and Iaşi 13%). In the Siret Corridor, which follows the Eastern Carpathian alignment, N winds prevailed (Bacău 19.4%), next in line (17.5%) coming the NW ones. The occurrence frequencies of S and SE winds are quite significant

(Bacău 13.6% and 13.4%, respectively). In the southern part of the Moldavian Plateau dominant winds blew from the NE (Galați 19.8%) and the N (Galați 16.1%), next coming the SW winds (Galați 14.7%) and the S winds (10%).

In this case, the annual average wind frequency along these main directions follows the direction of the Danube Corridor, but it obviously depends also on the dominant airflow forced by the continental air advection generated by the East-European Anticyclone and by the position of the weather station in the narrowest sector, between the Carpathian Curvature and the Măcin Mountains named *Carpathian Gateway* (Octavia Bogdan, 1980), through which winds reach the Romanian Plain.

Farther east, in the Danube Delta, winds are more intense, Sulina station records showing that NE and N winds (18.3% and 13.1%, respectively) have the highest frequencies, while NW and SE winds amount to 12.5% each, these directions being imposed by the Black Sea currents and by the orientation of the seashore. The most important wind directions depend on the alignment of the Carpathians, the Siret Corridor, or the Carpathian Curvature and the Black Sea shoreline. In contrast with the dominant annual average winds frequency is the frequency of atmospheric calm, which varies inversely proportional, decreasing from north to south and from south to east: Botoşani 28.2%, Iaşi 26.6%, Galați 14.1% and Sulina 11.7% as the influence of the mountains diminishes, or is completely absent (Sulina). In the northern half of the Moldavian Plateau and in the Siret Corridor (with variously-oriented sectors) wind frequency decreases, but the frequency of atmospheric calms increases.

2.2. Wind frequency over 1965–2004

Analysing statistical data from each station (Table 1) has yielded some important conclusions regarding wind frequency in the last four decades, when the weather stations were located on representative platforms and had four observation times in their schedule. We are referring to classical observations, not to the modern automated ones which are in operation since 2001. *The northern half of the Moldavian Plateau* is governed by NW winds (Botoşani 27.2%, Iaşi 20.5%), S–E winds (Botoşani 17.7%) and E winds (Iaşi 16.2%) (Figs 2, 3).

Table 1

Comparisons between annual average wind frequencies in the two study periods: 1941–1955 and 1965–2004.

Station	1941–1955		1965–2004	
	Dominant direction	Frequency (%)	Dominant direction	Frequency(%)
Botoşani	NW SE	23.6 18.7	NV SE	27.2 17.7
Iaşi	NW SE	21.5 13.0	NV E	20.5 16.2
Bacău	N NW	19.4 17.5	S N	21.4 16.5
Galați	NE N	19.8 16.1	N SV	22.4 15.6
Sulina	NE N	18.3 13.1	N S	18.9 17.6

Source: ANM Archive, Bucharest. Calculated percentages.

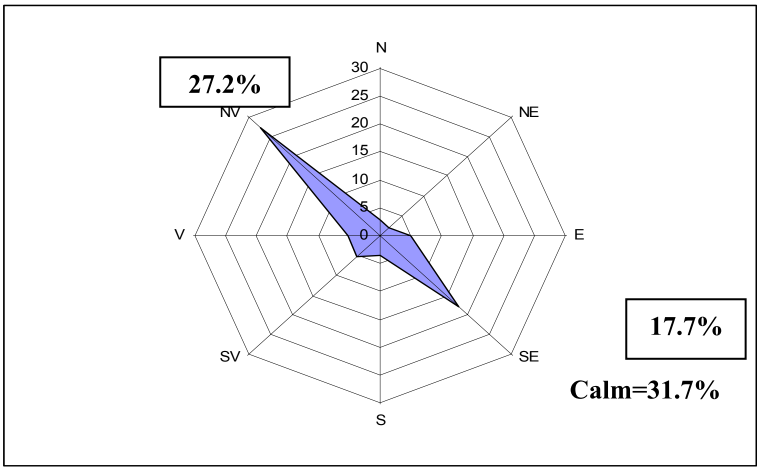

Fig. 2 – Average wind frequency – Botoșani.

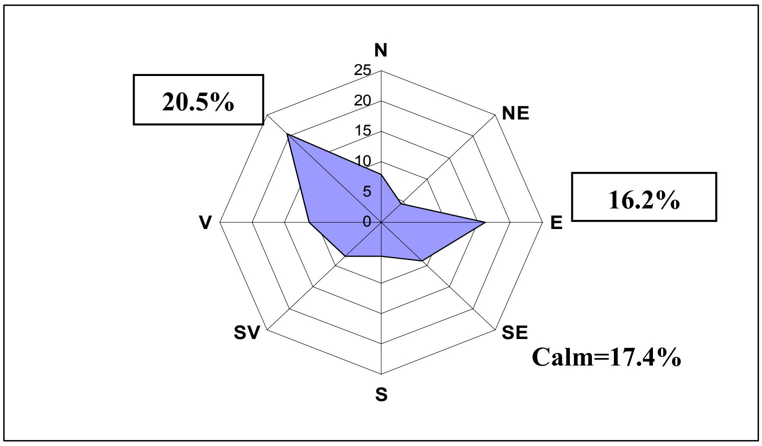

Fig. 3 – Average wind frequency – Iaşi.

The direction of the airflows is influenced by the Scandinavian Anticyclone, by the barrage of the Carpathians, by valley corridors and hillsides. Thus, the location of *Coasta Iaşilor* weather station on a E–W direction in a hilly zone at altitudes of over 400 meters, influences the second dominant wind direction, that from the east. Similarly, *Botoşani* weather station, situated close to the Sitna Valley, a tributary of the Bahlui, both NW–SE-oriented just like the hillsides, has influenced the second down-to-uphill dominant S–E direction.

In the Siret Corridor, in the Bistrița-Siret confluence sector, winds blow mainly from the south (Bacău 21.4%), and from the north (16.5%). In this case the influence of the valley corridor is quite obvious, forcing the airflows along it (Fig. 4).

In the southern half of Moldavia, where altitudes decrease from north to south under 100 m at Galați, N winds (22.4%), and S–W winds (15.6%) prevail (Fig. 5). These directions are determined firstly by the wide open plains crossed by the Prut Corridor from north to south, the Danube Corridor from south-west to north-east and by the Lower Siret Plain which has the same inclination eastwards with lowest altitudes in the east, at the mouth of the Siret River.

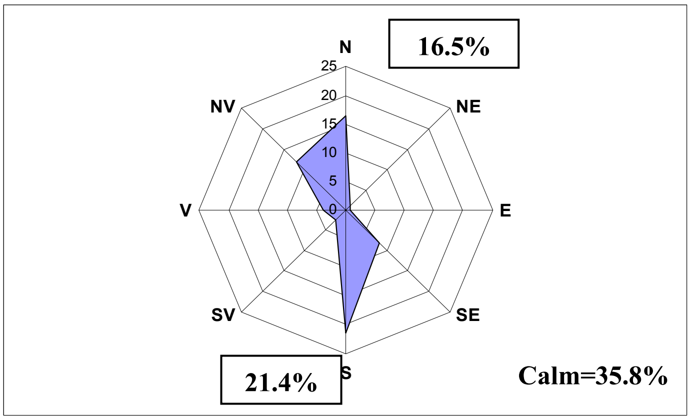

Fig. 4 – Average wind frequency – Bacău.

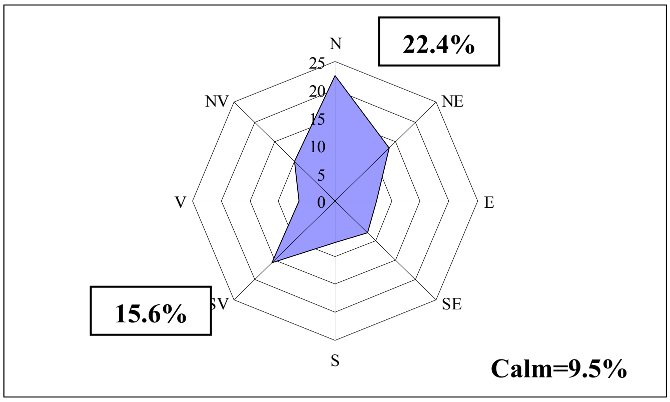

Fig. 5 – Average wind frequency – Galați.

On the northern Black Sea shores, at the mouth of the Danube's Sulina Arm, which continues 6 km into the continental shelf at the end of the limitrophe dam, winds blow mostly from the north (18.9%) and the south (17.6%) (Fig. 6), following the direction of the Black Sea shore in this sector, and of airflows governed by the East-European and Scandinavian anticyclones, and by the Black Sea coastal currents.

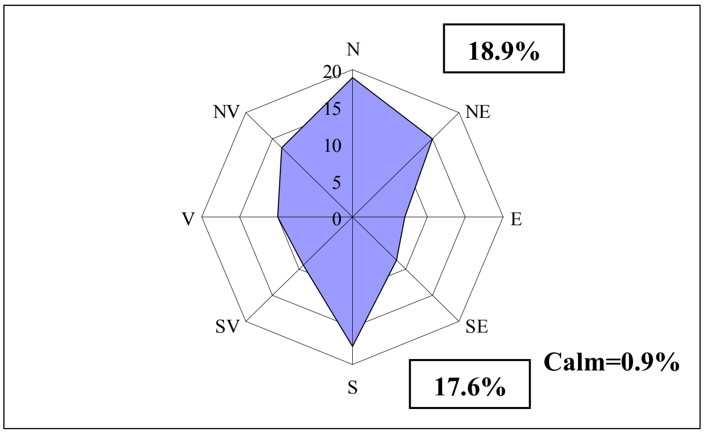

Fig. 6 – Average wind frequency – Sulina.

Summing up, we would say that the same wind directions appear to have prevailed both before and after 1960, some changes having occurred in the south of the region, at Galați and Sulina. Differences regard wind frequency, which either increased or decreased along the dominant directions.

Other important wind directions, but with lower annual frequencies (under 15%) are:

– in the northern half of the Moldavian Plateau, W and SW (about 5%) (Fig. 2);

– in the central part of the Moldavian Plateau, W (11%) and SE (9%), influenced by the Coasta Iaşilor Hills and the direction of the Bahlui Valley (C.2);

– in the Siret Corridor, NW (11.8%) and SE (8%) following the direction of the Bistrița Corridor (C.4);

– in the south of Moldavia, NE (13.4%) and NW (10%) influenced by the hillsides of the Bârlad Plateau;

– on the Black Sea continental shelf, at Sulina-dam, NE (15%) and NW (13.2%) winds have a higher frequency.

An important wind characteristic in the last four decades is the atmospheric calm, which has registered some changes from the previous period, although the general variation tendency in the area has remained the same, namely, a north-to-south decrease. The highest atmospheric calm value was registered at Bacău station (35.8%), in the Siret Corridor, due to the influence of the urban topoclimate (Fig. 4).

Apart from this Corridor, in the rest of the area between the Siret and Prut rivers, annual atmospheric calm average values were as follows: 31.7% at Botoşani (Fig. 2) in the northern half of the region; 17.4% at Iaşi (Fig. 3) in the center; and 9.5% at Galați (Fig. 5) stations in the south of the region. The highest wind frequency being on the Black Sea continental shelf at Sulina, atmospheric calm had the lowest annual value there (0.9%) (Fig. 6).

The frequency increase of atmospheric calm on land in this time period compared to the previous one is due to the topoclimatic conditions at night, when temperature inversions take place, characterized by great air stability, high humidity and atmospheric calm. These situations have been noted only by observations made at 1:00 a.m. and 7:00 a.m.

On the waters surface, devoid of any obstacles, there is higher wind frequency and diminished atmospheric calm (Sulina weather station records), which means high energy potential. Because of the vast water body, winds frequently blow from all directions, while in where water courses are bounded by the slopes of valley corridors, winds follow the direction of the valley and atmospheric calm increases due to the shelter provided by valleyside slopes. Whenever winds blow perpendicular to the corridor they have a high energy potential.

The highest monthly wind frequency averages at each weather stations *over the year* are as follows:

– *in the northern part of the Moldavian Plateau*, at Botoşani station NW winds account for the highest monthly averages throughout the studied regions, varying between 22% and 36%. Next come the SE winds with monthly averages of 10% to 20%. For three months / year (March, April, and October) frequencies exceed 20%;

– *in the central part of the Moldavian Plateau*, at Iaşi station, the highest monthly frequency have the NW winds (18–25%), with over 20% for eight months / year (December, January, February, March, April, June, July and August) both in the coldest winter months and in the warmest summer months. In winter-time (November–February) E winds (6–23%) represent more than 20%;

– *in the Siret Corridor*, at Bacău station, S winds are dominant at an annual average frequency of 8–23%, representing over 20% during the four winter months (November, December, January, and February). North winds (13.5–19.3%) have frequencies of over 17% in February, March, April, May, June and July;

– *in southern Moldavia*, at Galați station, dominant N winds have monthly average frequencies of 8 to 25%; here in all the months of the year, except for November, the monthly average of N winds exceeds 20%; second in line are the SW winds with average frequencies of 14 to 25%; these winds registered monthly averages above 20% in November, December, January, and February. In winter-time, there is the influence of Mediterranean cyclones with a backward evolution;

– *on the northern shores of the Black Sea* the dominant N wind direction has monthly frequencies of 14–22%; in January, February, March, August, October and December values average over 20%, with 14–25% for the S winds, which in April, May and June record over 20%.

Usually, at each weather station the first dominant wind direction has the highest average frequency in winter (Iaşi, Bacău, Galați, and Sulina); the second dominant direction has highest frequencies either in winter (Iaşi, and Galați), or in spring and summer (Botoşani, Bacău, and Sulina). The average monthly and annual wind frequencies by dominant directions *indicate external climatic influences determined by the main air pressure centers* as follows:

– the N and NE direction have continental influences determined by the East-European Anticyclone, especially in winter when it pumps in cold air;

– the NW direction present Scandinavian and Baltic influences, best felt in the northern part of the Moldavian Plateau (Botoşani), entailing cold air and precipitation in summer;

– the S, SE and SW directions indicate the influence of Mediterranean air pumped in by Mediterranean Cyclones and by Pontic Cyclones, either with a normal evolution or more often with backward evolution. They bring warmer air and humidity, often causing violent precipitation.

Monthly wind frequency *influences disproportionately the monthly average of atmospheric calm*.

The frequency of atmospheric calm over the year varies from one month to another, being the exact opposite of wind frequency. Looking only at the highest values from each station, regardless of month, we see the same N–S decrease trend in the highest monthly average values, just like before 1960: at Botoşani 36.7%, at Iaşi 22.6%, at Galați 13.1% and by only 1.1%. at Sulina.

North-to-south monthly average frequencies variations:

– in the northern part of the Moldavian Plateau and at Botoşani station where, apart from dominant winds no other winds have frequencies higher than 5%, atmospheric calm has the highest monthly averages in the Moldavian Plateau region. In the 12 months of the year, the frequency of atmospheric calm exceeds 24% regularly, and over 30% from July through to January;

– in the central Moldavian Plateau, at Iaşi station, where winds have slightly higher monthly average frequencies, atmospheric calm registers lower average values. In the 12 months of the year, the frequency of atmospheric calm is above 10% regularly and over 20% from July to September;

– in the southern part of Moldavia, at Galați station, where the monthly average wind frequency rises sharply, the atmospheric calm frequency is substantially reduced: 7–8% in the first part of the year, and above 10% from July to November;

– on the northern Black Sea coast, at Sulina dam, winds have the highest monthly average frequencies, regardless of direction. As a result, the lowest monthly atmospheric calm frequency averages below 1% in all the months of the year, exceeding 1% only in May, June and August.

In the Siret Corridor, at Bacău, frequencies of atmospheric calm and the monthly annual average frequencies are the highest throughout the study region, values exceeding 30% in all the months of the year and over 40% from June to October. The highest average atmospheric calm value in the whole of Moldavia region is registered here, with a peak in August of 50.3%, this high percentage making it easier for gases to accumulate in the air layers above the city almost all the year round.

This short presentation reveals that an annual maximum and minimum level of atmospheric calm is registered in the course of any regular year, with a maximum between July and October, which is the warm period of the year, and a minimum in winter and spring (November to May). The highest values occur either in August, September, October or November. This is the most uneventful time of the year marked by anticyclonic weather featuring great atmospheric stability and the absence, or very few precipitation.

2.3. Comparisons between the annual average wind frequencies in the analyzed periods

Although the two periods are not homogeneous as far as duration and observation times are concerned, yet we have tried to draw up a general picture of the differences between them.

Changing the observation methods and switching from the classical system of three observation times (8, 14, 20hrs) to four observation times (1, 7, 13, 19hrs) has modified *wind frequency data*.

These modifications must be considered from two points of view:

- *introducing the 1:00 am* observation time increased atmospheric calm, which completely agrees with the topographic and climatic features of the active surface at night, when the atmospheric calm reaches a 24h-peak.
- *A higher frequency of atmospheric calm* leads to a decrease of wind frequency, irrespective of its directions, sometimes only on particular directions, depending on the local geographical characteristics. Even the dominant directions may change, for instance, the frequency of the first two dominant winds (Table 1);
- *as far as the dominant directions* are concerned, it was only at Botoşani station that both directions remained the same in the second and the first period (NW and SE). At Iaşi, only the first dominant direction was the same in either period (NW), the second one changing from SE to S;
- at all the other stations the first two dominant wind directions from the first period changed.
- *at Bacău*, N and NW directions were replaced by S and N ones; here, too, the N wind, which had been the dominant one in the first period, fell to second place.

Important modifications occurred also in the annual average frequencies of the dominant wind directions. For example, at Botoşani station the annual average wind frequency of the NW direction (23.6%) increased in the second period to 27.2%, the SE direction decreasing from 18.7% in the first period to 17.7% in the second period.

2.4. Comparisons between the annual average of atmospheric calm frequencies in the study periods

Also in this case comparisons give a general image of the differences between the two periods, although they are not entirely relevant (Table 2).

A brief analysis of this table shows that only in *two cases, Botoşani and Bacău, the frequency of atmospheric calm has increased in the second period,* which was expected because of the introduction of 1:00 am observation time. In the other cases there is a noticeable decrease of 5 to 10% in atmospheric calm which seems abnormal. However, with the introduction of the 1:00 am observation time also the location of the weather stations was reconsidered, fact that modified both average wind frequencies in terms of direction, and of atmospheric calm.

The best example is Sulina weather station which was moved from the outskirts of the town and relocated at the end of the Sulina dam at a distance of about 6 km from the shoreline, so that the obstacle of a town environment before 1960 did no longer exist at the new location, were *winds are blowing permanently.*

Table 2

Comparisons between the annual average frequencies (%) of atmospheric calm in the years 1941–1955 and 1965–2004.

Period	Station				
	Botoşani	Iaşi	Bacău	Galaţi	Sulina
1941–1955	28.2	26.6	22.7	14.1	11.7
1965–2004	*31.7*	*17.4*	*35.8*	*9.5*	*0.9*
Δ Calm	+3.5	-9.2	+13.1	-4.6	-10.8

Source: ANM Archive, Bucharest. Calculated percentages.

Note: (+) and (-) indicate atmospheric calm increases and decreases, respectively in the second period, 1965–2004.

2.5. Wind speed between 1965 and 2004

We consider this 40-year period (1965–2004) long enough to be representative for the wind regime in the eastern regions of Romania. Changes in the observation schedule and in the reorganization of the weather stations are reflected also in the annual wind speed average. The highest annual average speed over 1965–2004 was in the NW direction, in the northern half of the Moldavian Plateau (Botoşani 5m/s and Iaşi 5 m/s) and in the N direction at all the other stations: Bacău 4.6 m/s, Galaţi 5.1 m/s and Sulina 7.9 m/s. These were dominant wind directions in all cases.

Ignoring direction, we see that *the highest annual average speed in the eastern regions of Romania increases from north to south, except for Bacău station where speed is the lowest* (Fig. 7).

Next are speeds varying between 3.7 m/s and 7.4 m/s, but it is only at Botoşani station that speed correspond to the second dominant wind direction (N). The second highest annual average wind speed increases from N to S throughout the study area: Botoşani 3.7 m/s; Iaşi 4.1 m/s; Bacău 4.5 m/s; Galaţi 4.9 m/s and Sulina 7.4 m /s (Tables 1–2, Fig.7).

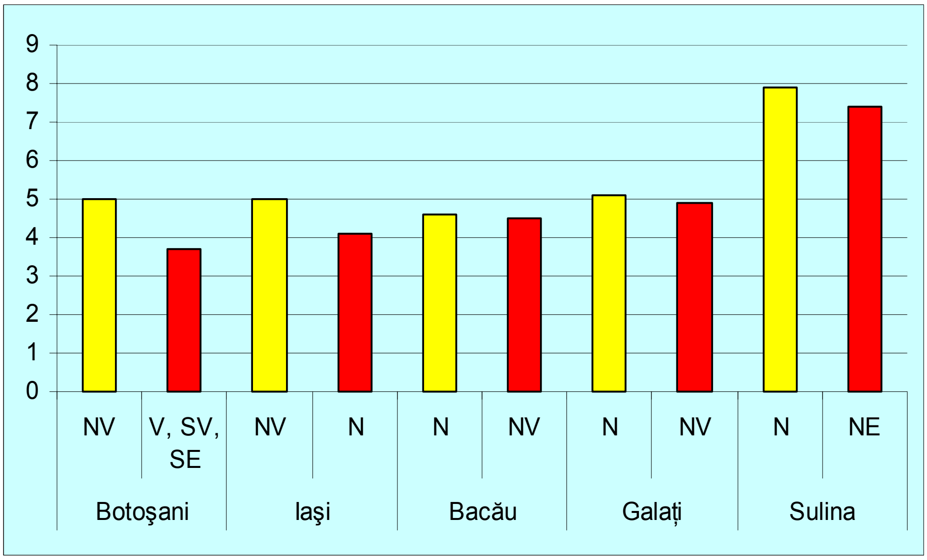

Fig. 7 – Highest annual average direction of wind speed (N to S) after 1960.

In order to have a clearer picture of wind power potential in the study region, we have analyzed the monthly and annual average wind speed values, regardless of direction. The wind speed regime over the year at each weather station is shown in Table 3, speed increasing from N to S: Botoşani 3.3 m/s, Iaşi 3.5 m/s, Galaţi 4.2 m/s and Sulina 6.2 m/s. The cause is the same: decreasing altitude and the orientation of summits and valley corridors in the same direction as the winds, the elimination of previous obstacles in the south of the region and the presence of large water bodies (Fig. 8). Bacău station is an exception, because, being located in the Siret Corridor with a shelter topoclimate, wind speed is more similar (3.3 m/s) to that registered at Botoşani station in the north of the Moldavian Plateau.

Table 3

Monthly and annual wind speed averages in the study area, regardless of wind direction (m/s) (1965–2004)

No.	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	An
1	Botoşani	3.3	3.4	3.6	*3.8*	3.4	3.1	2.9	2.9	3.0	3.1	3.0	3.4	3.3
2	Iaşi	3.5	3.9	4.0	*4.1*	3.8	3.2	2.8	3.0	3.1	3.5	3.6	3.4	3.5
3	Bacău	*3.5*	3.6	3.7	*3.8*	3.5	3.2	3.0	3.0	3.0	3.0	3.4	3.4	3.3
4	Galaţi	4.2	4.6	4.6	*4.7*	4.3	4.1	3.9	3.6	4.2	4.2	4.2	4.1	4.2
5	Sulina	6.8	6.7	6.7	6.5	5.8	5.7	5.3	5.2	6.0	6.3	6.7	*7.1*	6.2

Source: ANM Archive, Bucharest. Calculated averages.

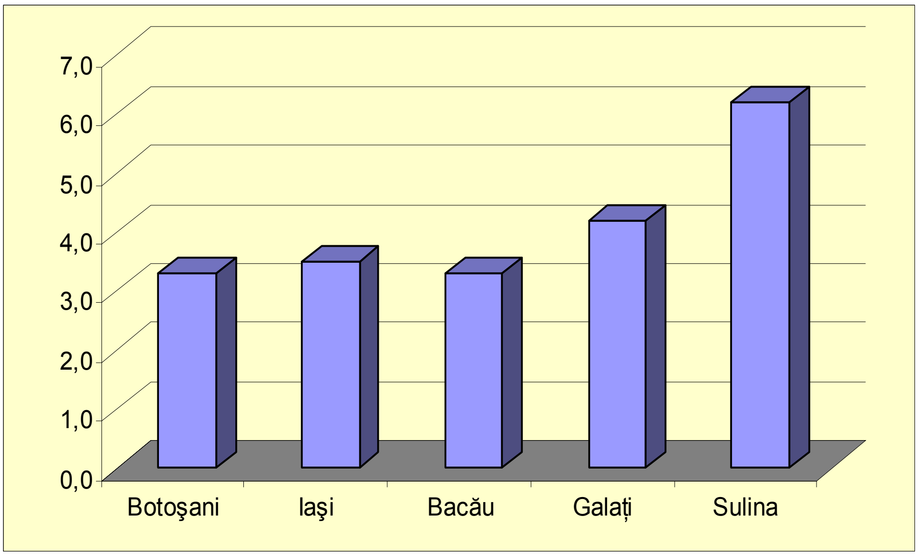

Fig. 8 – Annual average wind speed variation in the area, regardless of wind direction (1965–2004).

The annual average speed at all the stations *exceeds the 3m/s minimum threshold for a wind aggregate to function (Fig.8, Table 3). The highest annual average* wind speed (6.3 m/s) is registered at Sulina-dam. Although this value is recorded at only 3 meters above sea level, it is almost as high as that in the sub-alpine regions of the Carpathian Mountains (Bogdan, Mărculeţ, 2001–2002). *This shows a high wind energy potential that can be harnessed*. Furthermore, *in the fluvial-marine sector of the Danube* (downstream of Brăila port) where wind blows both along the river and in the *Siret* and *Prut* corridors, giant wind mills can be set up to take advantage of wind energy potential.

2.6. Average energy speed

For a wind aggregate to work, the wind should blow with at least 3m/s, on average, a speed capable to generate energy (the so-called energy speed). The notion of *energy speed* designates the *average speed obtained by summating active wind frequencies at speeds of 3m/s observation times,* *blowing every meter, referred to the number of possible cases over the year*. So, it is a question of hourly speeds necessary to keep the aggregate working continuously (Patrichi, 1983).

Our calculated annual frequency (Table 4) of active wind speeds (over 3 m/s) indicates a north-to-south frequency increase throughout the study region: 34.2% at Botoşani, 39.8% at Iaşi, 41.3% at Galați and 91.4% at Sulina stations.

Table 4

Frequencies of daily wind speeds (%) over 3.0 m/s (1999–2004).

Station		Months												
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Averages
Botoşani	%	37.7	**43.8**	43.0	35.0	40.9	39.5	31.1	18.9	21.2	29.6	33.8	36.0	34.2
Iaşi	%	37.6	46.2	**96.2**	42.2	34.4	38.9	19.9	15.1	17.2	24.2	65.8	39.8	39.8
Bacău	%	34.6	39.6	**51.6**	35.0	35.4	22,2	17.0	14.0	18.3	20.5	38.4	35.5	30.2
Galți	%	43.5	55.1	**58.1**	19.4	46.3	36.1	44.6	28.5	33.3	31.1	42.7	56.5	41.3
Sulina	%	89.8	88.1	95.2	91.7	87.6	92.8	85.5	88.5	95.0	93.0	93.3	**96.2**	91.4

Source: ANM Archive, Bucharest. Calculated averages.

We appreciate that winds can best spin aggregates on the seaside and in the Danube Delta (about 91% of the year), where speeds are the highest.

During the year, the highest monthly average wind speed is registered in the cold season, values differing from north to south: in the north of Moldavia, at Botoşani, the highest frequency occurs in February (43.8%); in central and southern Moldavia in March (Iaşi 96.2%, Bacău 51.6% and Galați 58.1%); and at Sulina, above territorial waters, in November (96.2%).

The value differences throughout Romania's eastern territory depend on the times of the year, when the general atmospheric circulation intensifies in February, in connection with the activity of the Polar Anticyclones and the East-European Anticyclone which come into contact with the Mediterranean and Pontic cyclones; in March-April with atmospheric disturbances generated by changes in the general atmospheric circulation from east in winter to west in summer; in November-December with the intensified activity of the Mediterranean and Pontic cyclones. At Sulina, active speed frequencies/year (over or equal to 3 m/s) exceed 80%; 90% in 7 months/year (March, April, June, September, October, November and December) and more than 95% in 3 months/year (March, September, and November). This is in accordance with the conclusions outlined in this paper.

Within 24 hours, the differences between active speeds in the day-time and at night are the result of air masses and active surfaces warming up and cooling down, respectively.

Thus, the highest active speed frequencies in the day-time usually occur between 10:00 a.m. and 7:00 p.m., when temperature convection stimulates the development of air currents both on the vertical and the horizontal. The lowest frequencies are registered at night, between 10:00 p.m. and 5:00 a.m. because morning cooling enhances temperature inversions stabilizing air temperature. It follows that daily active speed amplitudes are higher in summer and autumn than in winter.

Here are some conclusions of our analysis:

– The eastern part of Romania has an important wind energy potential which increases from west to east and from north to south;

– the highest average wind speeds (over 7m/s) registered at Sulina, above the territorial Black Sea waters, are similar to those in the Carpathian sub-alpine regions (1,800–2,000 m altitude);

– this distribution patterns are the result of the presence of *plains and low hills* (under 500 m), in Eastern and North-Eastern Europe, traversed in winter by N and NE winds, as well as of *the presence of the Black Sea* water-table, devoid of any obstacles, which allows for high winds to develop; the

Carpathian Mountains, which act as a barrage for winds to pass farther towards the west, and the bottleneck region, the so-called *Carpathian Gateway* (Bogdan, 1980b) *where air currents streamline into the narrow areas between the Carpathian Arc and the Măcin Mountains* to reach the Carpathian-Balkan Depression, and gathering speed on the way. Therefore wind speed is higher in the Lower Siret Plain and in the Bărăgan Plain than in the Moldavian Subcarpathian Hills, where they overlap the mountain-to-valley winds developing in the Carpathian valleys, particularly in the Bistriţa Valley (Mihăilescu 2001);

– the role of orographic barrage played by the Eastern Carpathians has a huge impact on the winds blowing in the eastern regions of Romania. N. Ion-Bordei, Ecaterina Ion-Bordei *et al.* (1984) have shown that this impact decreases with altitude, while the speed and frequency of the west winds increases above 3,000 m altitude.

And last, but not least, the data presented herein, as well as any further contributions to, or information on wind and its characteristic elements in a certain part of the country, will be of real help in substantiating research into the use of wind energy potential in Romania.

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