APPLYING GIS-TECHNOLOGIES METHODS TO WIND ENERGETIC RESOURCES MAPPING

TatianaConstantinova*, Galina Mleavaia*

*Institute of Ecology and Geography, Academy of Sciences of Moldova, *Chisinau*

Резюме: *В данной статье приводятся результаты исследования ветрового режима на территории Республики Молдова. С целью оценки ветроэнергетического потенциала при помощи современных ГИС-технологий осуществлено картирование основных характеристик и энергии ветра.*

Key words: *renewable energy sources, wind energy, wind's operation speed.*

Rezumat: *Acest articol prezintă rezultatele studiului regimului vântului pe teritoriul Republicii Moldova. În scopul evaluării potenţialului energiei eoliene cu ajutorul tehnologielor moderne SIG au fost cartografiete caracteristicile de bază şi a energiei eoliene.*

Cuvinte cheie: *surse de energie renovabilă, energia vântului, viteza de operare a vântului*

Introduction

During hundreds of year's man tried to benefit from wind power by building wind stations that execute various functions: windmills, water and oil pumps, power plants. Wind energetics started its active developing after the world-shaking oil crisis in 1973, because, first of all, wind is inexhaustible energy source and its cost is equal to zero, and second, energy that is obtained by its usage is much cheaper and safer for health when comparing it with the energy obtained from carbon combustibles. At the present stage using wind as renewable energy source (RES) is developing mostly in some European regions, USA, India. Several countries' experience (Israel, Germany and Denmark) indicates high RES efficiency, especially in rural regions and for small scattered objects' power supply [1, 2, 3].

In the beginning of the XIX century there were 6208 windmills on Moldova's territory, and by the end of the century it occupied fifth place in the world for wind energy resources usage [4]. In present Republic of Moldova's climatic conditions, technical and economical possibilities allow using sun, wind and hydraulic energy, biomass and organic waste. The strategy based on governmental newly adopted legislation [5, 6, 7] has defined state politics in organization and carrying a set of works aiming to use different types of renewable energy sources and to increase their share in fuel and energy balance of our republic with the aim of end-users' power-supply improvement and countries' increase in energy security. According to this strategy in perspective for 2015-2030 period there will supposedly be created and installed wind-power units with gross output of 8 MW, and also wind-works (gross power up to 30 кW) for water supply, feed preparation, power supply of the end-users that are not connected to the common electrical network.

Materials and investigation methods

An investigation result for complex of characteristics of wind regime's and estimate indicators defined by the statistical models and probability distribution functions are given in this article. Taking into account the investigations previously made in this direction [8-11], comparative analysis for spatial and temporal wind climate indexes distribution was executed. Hydrometeorological State Service's primary data for 14 weather stations placed in various republics' landscape zones for 1964-2001 periods was used as data source. Wind energy potential was estimated on the basis of modern GIS-technologies and wind's main characteristics and energy, operation speed's durations and wind engine's stoppage was mapped. Maps, obtained with the help of application program «SURFER», allow identifying the most perspective regions for wind energy purposes and give quantitative estimation for mean wind resources for each of them, and also to get a general idea of wind's impact in major fuel and energy balance of the country.

Investigation results

In present times RES are not yet competitive with traditional types of fuel and energy resources because of low technologies familiarization. However, RES usage problem exists and is global. International market of installations for renewable energy obtaining and transformation is forming and United Energetic space' creation works are executed.

The following indexes of wind regime were analyzed in order to estimate wind-driven electric plant's placement perspectives: average multiyear wind speeds, their annual and diurnal variation, operation 3 m/s and 8 m/s speed's frequency.

Investigation of multiyear wind speed values spatial variability on Moldova's territory shows their variation from 1.8 to 3.9 m/s (Fig. 1). Wind speed' maximum values were registered in winter in the South in Cahul

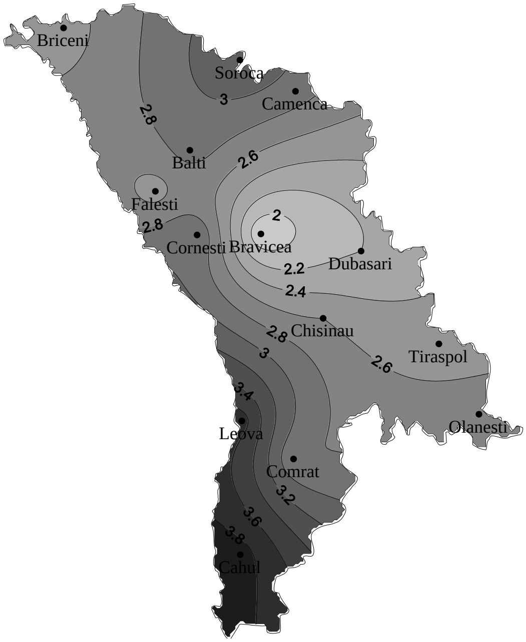
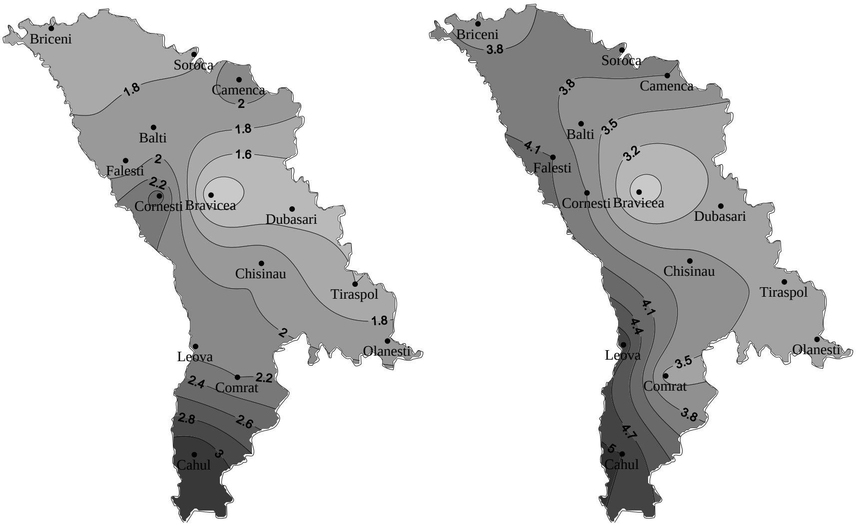


Figure 1. ***Average annual wind speed (m/s) for 1964-2001 period***.



a b

Figure 2. ***Mean minimum (a) and maximum (b) wind speed (m/s) for 1964-2001 period.***

(January–6.7 m/s, February and March-6.2 m/s). Minimum values (0.4 m/s) were registered in August in Soroca weather station (Fig. 2 a, b).

Diurnal wind speeds show that it reaches maximum values in the day-time, as a general rule, after midday. Minimum speeds are observed before the sunset. Wind speed's increase in the day-time is an advantage factor for wind-engine for electrical energy production.

Because wind energy usage means the realization of natural geophysical process's energy, therefore wind regime data needs to be presented by objective numeric characteristics.

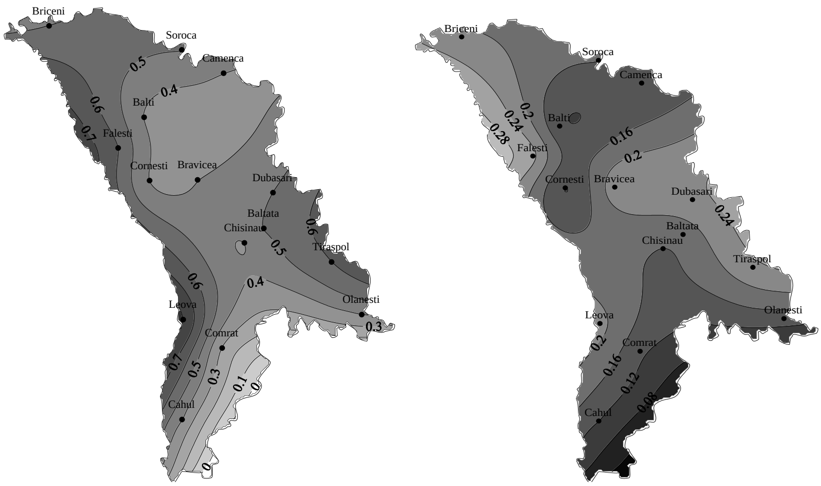
The process of wind energy finding can be presented as: CF $\rightarrow$ EU$\rightarrow$PU, where CF are climatic factors forming wind energy regime, EU – energy unit and its technical parameters, PU – power of the unit [12].

Climatological studies in the first place must take into account spatial and temporal particularities of wind flow of the region in question. Deeper formulization of wind energy's structural and regime characteristics applied to certain natural and geographical conditions are needed in order to calculate wind energy parameters with high priority speed factor. In this relation mean statistical indexes of standard deviation (σ) and variation coefficient (C_v) for representative weather stations placed in various landscape conditions in Republic of Moldova were calculated in Statgraphics Plus software. The distribution of σ (fig. 3 a) allows estimating general variability of average wind speed, and C_v (fig. 3 b) – allows tracking its relative variability.

It is obvious that for Republic of Moldova's territory standard deviation's geographical distribution (σ) is similar to mean speed's distribution and varies from 0.3 m/s till 0.8 m/s during year.

Parameter's maximum values are characteristic for the Region of Budgeac steppe dissected plains; minimum variability is identified in the areas of forest-steppe hills and plateaus. Annual values of C_v coefficient for the most weather stations is within 0,12-0,23 limits, and only in South-Western part of republic, where intensive persistent winds are observed, it decreases till 0,10. The obtained cartographical models allow selecting regions with low and significant wind potential on Republic of Moldova's territory

Wind's structure varies with its height above the ground surface, air flow stability increases in high air's layers. The difference in wind speed requires certain constructive approach at wind-powered generating plants (WPGP) Newest scientific and experimental developments for transformation of wind's kinetic power into electrical one are included in modern WPGP constructions. It consists from windmill device (of rotor or propeller kind), electric power supply, automatic devices coordinating work of wind engine and generator, and facilities for their installation and attendance. Wind engine's power depends from windwheel's size, wind speed and mast's height



a b

Figure 3. ***Statistically average parameters distribution on Republic of Moldova's territory: a) σ - standard deviation, b) C_v - variation coefficient***

Average annual wind speeds' study registered on Republic of Moldova's weather stations demonstrated that their variations are connected with general change of wind speed on republic's territory, and also with wind vane's heights difference and its safety level. In order to exclude its influence we have carried out comparative analysis of mean multiyear values and wind speed on 16 m and 26 m height, which corresponds to wind wheel tower heights at typical wind engine, and also was investigated energy distribution at the given heights (fig. 4).

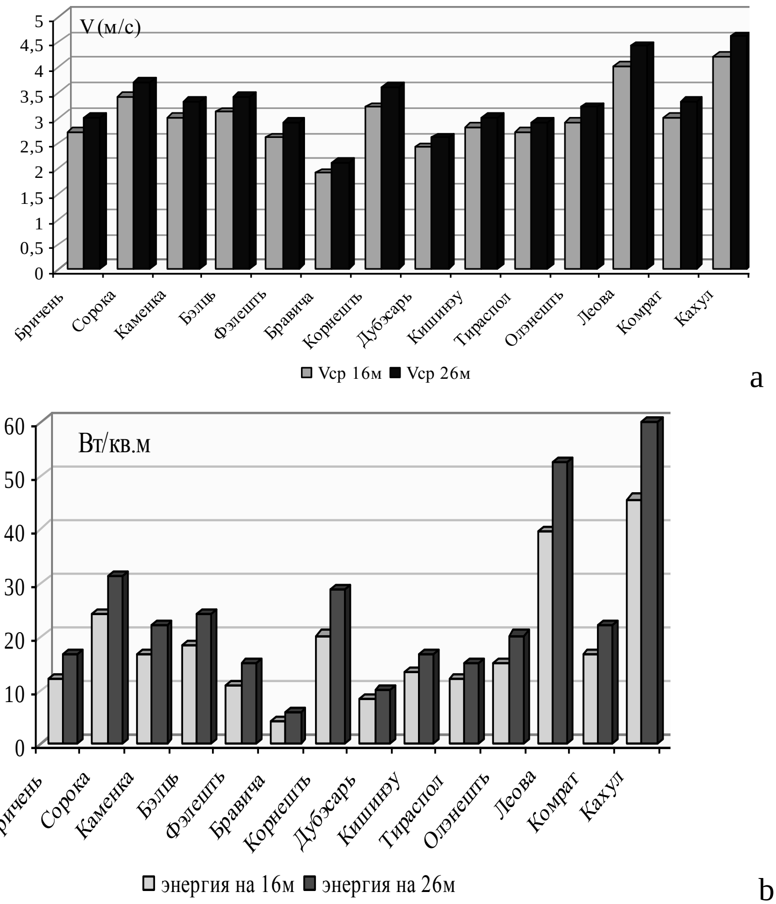
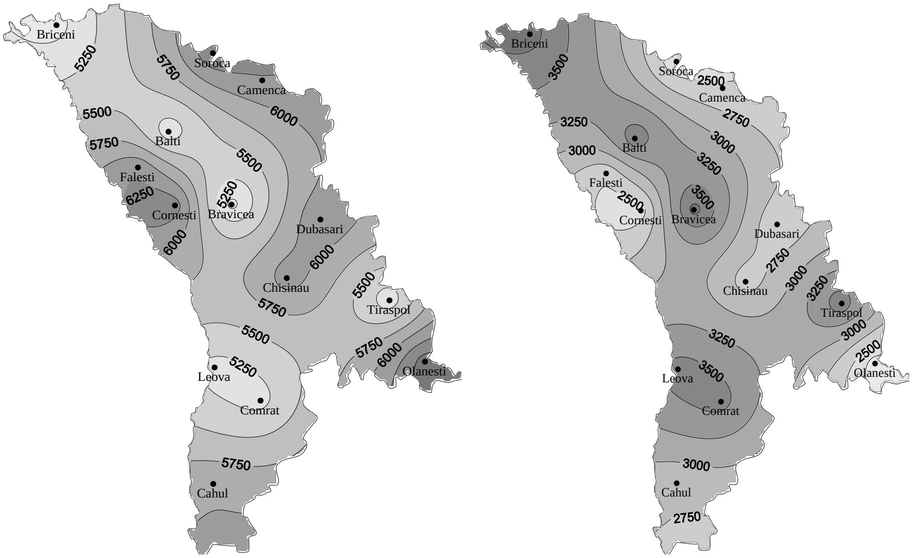


Figure 4. ***Distribution: a) of speed and b) of wind energy on the wind-turbine's 16 m and 26 m heights***

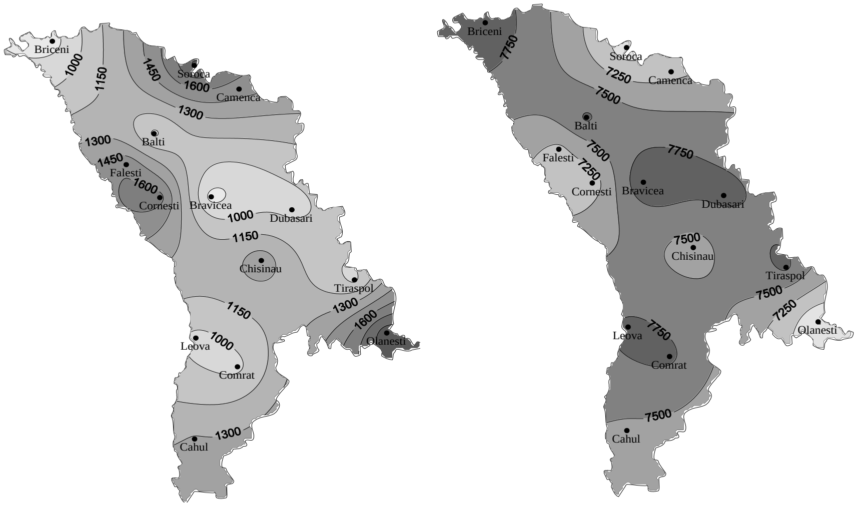
From the obtained calculated data it is obvious that wind speed at 26 m height in comparison with 16 m increases by 0,2-0,4 m/s, and wind energy increases from 1,5 till 14,3 W/m^2. We can draw a conclusion that by increasing wind turbine height we would obtain optimal energy for its functioning.



a b

Figure 5. ***Duration (hours): a) wind turbine work; b) wind turbine idle at wind speed ≥3m/s***

When studying wind from the point of view of effective propelling power along with diurnal, annual and multiyear wind speed, we need data on its operation speed frequency – 3 m/s (the speed at which plant begins its work) and 8 m/s (the speed at which major economic effect is attained). Numerical values of these parameters were calculated as a result of investigations, and also wind turbine's idle duration was calculated. The obtained data is presented as maps on Figures 5 and 6.



a b

Figure 6. ***Duration (hours): a) wind turbine work b) wind turbine idle at wind speed ≥8 м/с.***

As we can see from cartographical models, wind turbine's engine can work economically effective at wind speed equal to 3 m/s from 5000 hours a year (Bravicea, Briceni) till 6600 hours (Cornesti, Cahul). At the wind speed exceeding 8 m/s, which is observed rarely on Republic of Moldova's territory, wind turbine's working hours vary from 900 till 1800 hours. It's obvious that the higher the wind turbine's design speed is, the less hours it is working, but with the bigger average power.

Conclusion

The obtained wind characteristics and wind energy potential calculations yield of computer cartography and presented models can be used in the investigation of a wide range of issues connected with creation and usage of installations and systems for renewable energy obtaining in Republic of Moldova.

World practice shows us that wind power stations number's growth rate is increasing by 30% each year. WPGP's effective use is most attractive as natural energetic balance on the planet is not disturbed and simultaneously we use non-waste, ecologically pure technology of energy creating for streets illumination, heating of buildings, houses, farms, field camps, grain elevators, pastures, beeyards etc.; electrization, battery charging and electric energy storage, and also electric power supply in district electrical supply.

References

1. Koek, F.B. and G.P. Können, *Determination of terms for wind force/present weather. The Dutch case*. Climatic Change, 2005, 73, 79-95.
2**.** Хоффман Л., Ярас А., Обермайер Г. *Энергия ветра.* –М.: Мир, 1982, 256 с.
3. *Resursesele de energie eoliană în seciul XX.* Revista română de statistică, 1996, №5, p. 51-53
4. *Обзор Бессарабской губернии.* Бессарабского статистического комитета. Кишинев, 1902 и 1912.
5**.** *Национальная программа по энергосбережению на 2003-2010гг.* Постановление Правительства РМ №1078 от 5 сентября 2003г.
6. *Энергетическая стратегия Республики Молдова до 2010 г.* Постановление Правительства РМ №360 от 11 апреля 2000 г.
7. *Закон об энергосбережении №1136-XIVот 13 июля 2000г.* Официальный монитор РМ, 2000,№157-159, с.1183
8. Борисенко М.М., В.В. Стадник. *Атласы ветрового и солнечного климатов России.* Санкт-Петербург, 1997, 173с.
9. Москалюк И.С. *Применение новых типов ветронасосных установок в сельском хозяйстве Молдавии*. Кишинэу, 1972, с. 84
10. Романенко Н.Н. *Основы ветроэнергетических расчетов и ветроиспользования в условиях пересеченной местности.* Автореферат диссертации на соискание ученой степени кандидата технических наук. Краснодар, 1966, с.24
11. Ambros T., Arion V., Guţu A., Sobor I., Todos P., Ungureanu D. *Surse regenerabile de energie.* "Tehnica-Info", Chişinău, 1999, p.159-164
12. *Клімат Украіны. За редакціею В.М. Ліпінського.* Видавництво Раевського. Киів. 2003, 343с.