LARGE SCALE WIND CLIMATOLOGICAL EXAMINATIONS OF WIND ENERGY UTILIZATION

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Abstract
The aim of this article is to describe the particular field of climatology which analyzes air movement characteristics regarding utilization of wind for energy generation. The article describes features of wind energy potential available in Hungary compared to wind conditions in other areas of the northern quarter sphere in order to assist the wind energy use development in Hungary. Information on wind climate gives a solid basis for financial and economic decisions of stakeholders in the field of wind energy utilization.

Keywords: wind climatology; NCEP/NCAR reanalysis; wind energy utilization

1. Introduction

Increase of wind energy utilization in the European Union and many other countries has priority as fight against climate change has become a key issue of national energy policies. In several countries the free wind energy potential is used for security of energy supply. For future development of wind energy potential it is essential that we study temporal and spatial availability of wind energy and also that we know those characteristics of wind energy potential which can assist to include wind turbines into the electricity network without disturbing security of supply. Information on the wind climate support the serious financial-economic decisions of those interested in wind energy utilization (investors, transmission system operator, leaders of balance circles, electric energy consumers).

The pattern of the characteristics of wind flow is studied with large spatial resolution for 50 years of time period in the northern quarter sphere based on the homogeneous diurnal, monthly and annual datasets of the NCEP / NCAR re-analysis between 1956 and 2005 (Kalnay et al. 1996). In conclusion the most important aim of the research is to help wind energy utilization in short, middle and long term by providing wind climatic information

2. Applied data and methods

The database for the large scale wind climatic examinations is the daily dataset of meridional and zonal wind vectors with the resolution of 2.5x2.5 degrees related to the northern quarter sphere measured for 50 years between 1956 and 2005 in the NCEP / NCAR (National Center for Environmental Prediction / National Center for Atmospheric Research) re-analysis project (Kalnay et al. 1996). This was supplemented by the measurement set of 2006. The 'u' and 'v' wind vectors are related to the lowest so called 995 sigma level used for the construction of the re-analysis. This level is relief tracking, i.e. represents the wind conditions about 80 m above the surface. The horizontal resolution of the model is T62, i.e. 2.5° both in meridional and zonal directions. This means larger and larger grids towards the Equator due to the spherical shape of the Earth. The length of the meridional side of the grids is around 280 km. The spatial resolution of the re-analysis model is not very detailed but it covers the entire sphere of the Earth. The other advantage of the model is the continuous homogeneous dataset for a known framework, covering almost all of the parameters of the atmosphere in 28 height levels measured by the same method from 1948 till nowadays.

The re-analysis of the American National Center for Environmental Prediction - National Center for Atmospheric Research (NCEP/NCAR) was chosen because it is available outside the closed system and it is refreshed operatively daily. The daily 'u' and 'v' wind vectors were downloaded from the database of the Climate Research Unit (CRU) in the form of a matrix consisting of 73 columns and 37x365 rows. The data are related to the area between the -90° and 90° western and eastern longitude respectively and between the North Pole and the Equator covering 2701 grids in total. Due to the scale of the resolution the northern quarter sphere was analysed thus apart from Hungary the wind climate of the entire European continent with its wider environment can be reviewed and analysed.

For the wind climatic analyses wind velocity data calculated from the wind vectors (u; v) according to the rules of vector calculation were applied.

Monthly, seasonal, annual and multi-annual averages were calculated from the daily datasets. Based on these wind indexes interpreted in different time scales were calculated. Wind index (%) can be calculated so that the value observed at a given time is related to the multi-annual average:

3. Results

Based on the macro-scale wind climatic observations related to the northern quarter sphere are the followings (Kircsi 2008):

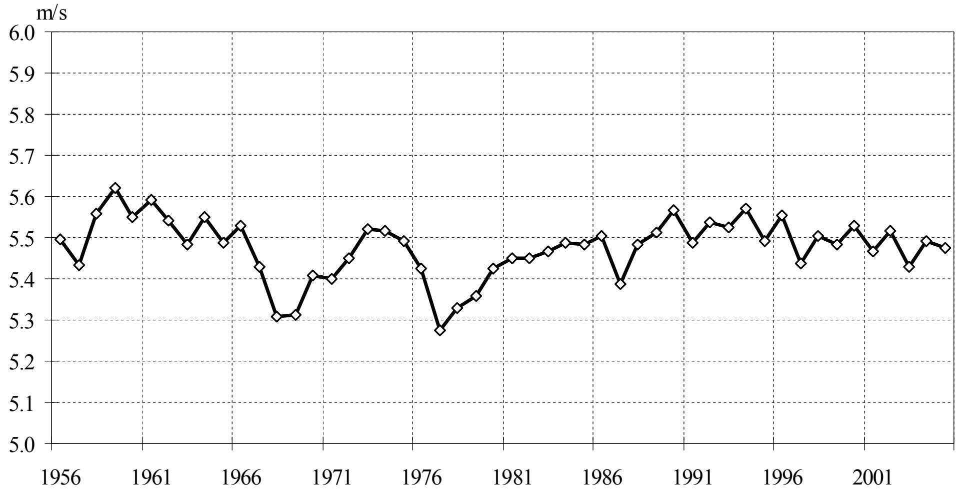

Fig 1. Yearly average wind speed of northern hemisphere between 1956 and 2005 by NCEP/NCAR reanalysis

On the basis of the daily wind velocity dataset between 1956 and 2005 studied by the NCEP / NCAR re-analysis constantly one way change in the annual average of the wind velocity is not found in the northern quarter sphere (Fig. 1). The late 1950s and the 1990s are characterised by stronger winds while, in general, the 1970s were the least windy. Following the 1970s wind were intensified in the ocean territories of the moderate and polar climates.

The direction and magnitude of wind velocity between 1956 and 2005 in the 2.5°x2.5° grids depend strongly on the geographical position and the length of the studied period (Fig. 2).

To characterize the particular years and months such a wind index was applied that assures objective comparison of diverse areas of the northern quarter sphere. Average wind energy velocity of any particular month or year is given in comparison to long-term means, in %. Using Denmark as an example it is demonstrated that the wind index based on macro-scale wind velocity averages is in harmony with the wind energy index from the power generation of wind turbines in the country. This proves that wind data of a macro-scale re-analysis model can be used to characterize power generation of wind turbines.

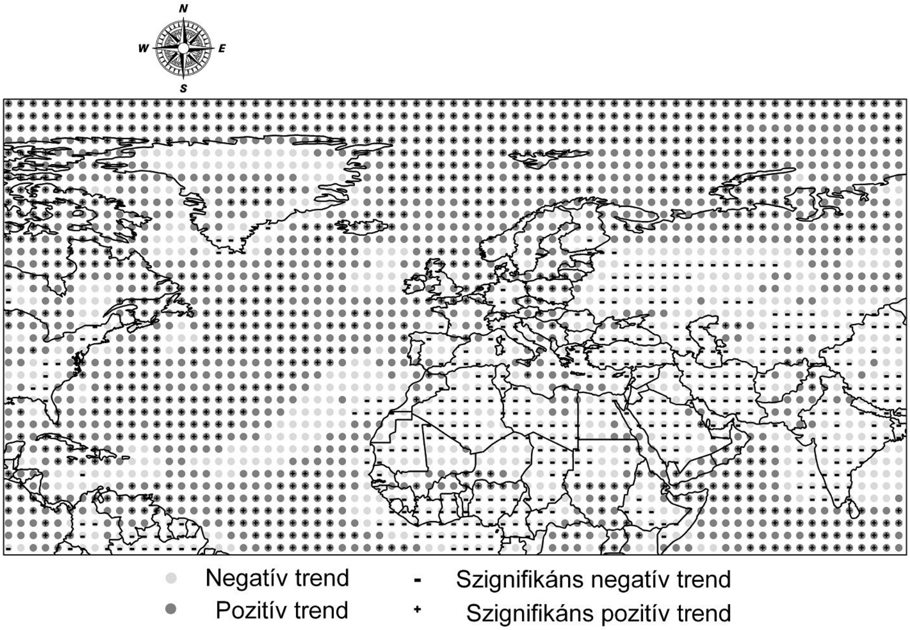

Fig. 2. Significant trend in wind speed data between 1956 and 2005 in Northern hemisphere

It was proved that the length and the time of the period the applied long-term is gained is important for calculating the wind index. In Hungary in the case of 30 years long periods wind indexes can be calculated with 5% of differences depending on the time of the interval. The conclusion is that temperate climate zone is an ideal area for wind energy utilization as variability of wind velocity is the minimum both within a year and on long-term basis. Variation of average annual wind velocity in Hungary is larger compared to Denmark and Spain in Europe. In Hungary average wind velocity, energy of air movements and technical potential can be estimated with a lesser punctuality than in Denmark or in the Iberian Peninsula. Deviation of annual wind index increases towards the East therefore the annual average wind capacity can be estimated statistically with less accuracy in the eastern parts of the country.

In Hungary variation of monthly wind velocity is more moderate than in Denmark the extremely windy months are less prominent compared to the long-term average. At the given wind conditions in Hungary a wind energy power plant can generate twice or three times more energy in the winter half-year than in the summer.

Practically there is no strong relationship between the daily wind velocity values of the three grids covering Hungary (N47.5° E17.5°, N47.5° E20° and N47.5° E22.5°). Based on the values of the correlation coefficients relationships between the areas are stronger in winter than in summer.

Daily mean wind velocities differ from the 50-year daily average by 40% on the average in the grid covering Western Hungary. Statistically daily wind velocity averages can be estimated with bigger mistakes in winter and summer; with lesser mistakes in spring, when the average wind speed is higher (Fig. 3).

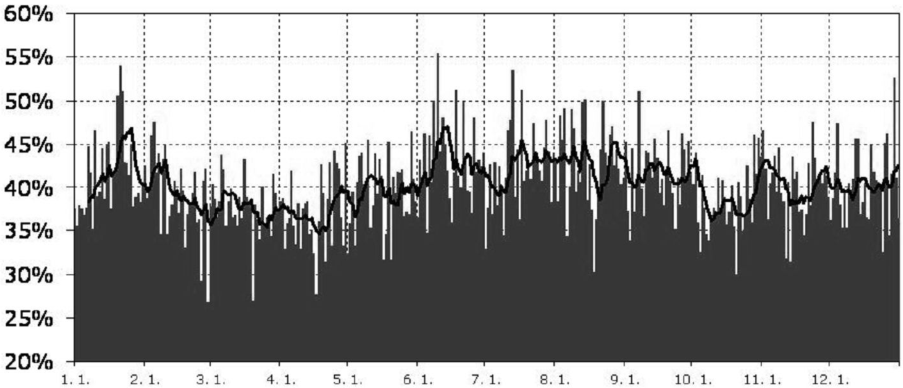

Fig. 3. Average differences of daily mean wind velocities from the 50-year daily average in Western Hungary grid (N47.5° E17.5°).

4. Conclusion

To summarize the above it can be claimed that Hungarian wind energy potential is worthy for utilization by both industrial size turbines connected to the network and by household size smaller turbines as its availability is more stable during long time periods and on a large scale than either world market cost of hydrocarbons or legal conditions of development during the turbines' lifetime.

Wind energy potential of an area is an objective fact, its features cannot be changed, accordingly any possible conflict between wind energy and other areas can be solved optimally only knowing and complying with the wind climate. Future development of wind energy utilization in Hungary is possible only by implementation with this approach.

References

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