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WIND POWER ENERGY - INTERACTION OF THE ATMOSPHERE WITH THE ENVIRONMENT

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ABSTRACT
The objective of this paper is to sketch, in a general context, influences on construction of wind power plants and problems associated with them when choosing the right area for their construction.

1. INTRODUCTION

A turning wind power plant must belong to a few sights that delight every favourer of alternative energy sources.
This sight rarely appears to an observer in the Czech countryside and it is therefore considered more as a rarity if not a curiosity. This situation is partly caused in general awareness of laity even specialists by not very well embodied knowledge of options of the alternative sources use but also by weather conditions in the Czech basin. None of these two situations is favourable. This paper, however, is not aimed at increasing knowledge of general public in the field of alternative sources but on the contrary, it is focused on a very specific field, namely on the problems of wind power plants installation.
When building a wind power plant, the only decision is alpha and omega - the right choice of the place. The right place for the construction of a wind power plant provides good energy profits, few dead plates on account of unfavourable environmental conditions, briefly a satisfactorily operating project. On the contrary a wrong choice of the place leads slowly but necessarily to fairly big financial losses. The Czech Republic does not have as convenient conditions for the use of wind energy as for example coastal countries (Denmark, Great Britain), nevertheless there exist good areas in our country where it is profitably possible to install wind power plants. How to find out whether the area which seems to be good for the construction of a plant is really the right one?

2. INFLUENCE OF THE ENVIRONMENT

This question can be answered by experts in the field of wind power energy. They use very sophisticated mathematical models by the estimation of wind energy in a specific area. Even though those are well developed models, it is necessary to stress the word estimation on behalf of externality. In despite of well developed models, everything is only a calculation, no measurement. In this field the same way as in other fields, the following thesis is valid: Calculation is as accurate as input values are. Have a more detailed look at the mentioned input values which are related to the successful choice of the place.

Flow represents a motion of mass particles which make the atmospheric mass. This variable motion can be described by two values, namely by speed and direction. The environment surely has an influence on speed and direction values.
Air move is influenced in ground layers most markedly by the following items:

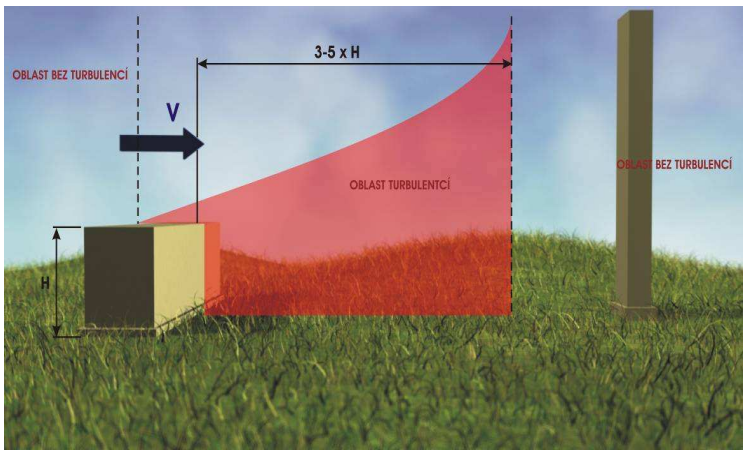
- *features of ground*
- cover of ground

Look briefly what the mentioned terms mean.

3.FEATURES OF GROUND

The term "orography" is known better than "features of ground". Orography is a word compound of two words. "Oros" is a Latin word indicating a barrier or a hill, "graphis" means a line or graphite.

To the orography there can be included features and gradient of ground, which mean physical demonstrations of the environment risen from long time lasting geologic processes. Altitudinal inequality of the environment results in the change in direction and speed of air mass in the ground layer. The nearer the ground we are, the more significant the change is.
Ground roughness can be divided into positive (hill, mountain, etc.) or negative (valley, steep, etc.) types. Interaction of these both basic types with the atmosphere has an effect on the flow. In general we can say that wind medium speed is changed above the roughnesses of the positive even negative type. The speed change size is influenced above all by the geometry of a barrier. The principle of speed increase and decrease can be explained by so called aerodynamic action of an object. If any roughness is in the way of air flow, the flow will change its dynamics and thereby the speed will change as well. The further from the ground we are, the smaller influence the orography has. There is no surprise that the importance of orography influence grows up with the growing altitude of ground roughness. What exactly happens if the flow meets ground roughness? The flow collides with a barrier, loses its dynamics and in result of it the motion is slowed down. Not only flow slowing down can happen but also the contrary effect.
We all may know wind speed increasing on a hill. The shape of a hill generates places with different air density. The biggest concentration is on the top of a hill. At the moment when flow gets behind a hill top, it means to the area with smaller space limitation, expansion and internal pressure decrease is reached. As a result the wind speed immensely increases. This wind increase is in English literature called *Speed-up effect*. From above mentioned it results that the highest speeds cannot be expected on the windward side before or on hill tops but as far as behind the hill top on the leeside. This result is not valid every time, it depends very much also on the side slope, wind speed, temperature of the environment and other factors. Orography in itself essentially influences behaviour of the ground layer of the atmosphere.
Let´s describe one of the special orographic cases - a barrier. Everything what markedly surmounts surrounding ground and cannot be classified as a ground roughness is classified as a barrier of flow. It is possible to say that the barrier is in many cases an object of man-made origin, e.g. a building, chimney or another high construction.
We are interested in barriers due to the similar reason as we were dealing with the above mentioned parameter of the environment. We are interested in the influence of a building on the flow and direct connection with the rise of turbulent flow.
To be able to define the influence of a barrier on the flow we must describe its evident parameters well. It is not enough to define only proportions of the object. An important parameter when investigating the influence on the flow form is e.g. surface permeability. It is a ratio of poruses surface to total surface of the object. If the surface permeability is high, the permeability of the object is huge. For example an iron grate must have a smaller influence on the form of ground-layer atmospheric flow than a stone wall of the same size. If we choose an interesting wind place, we should avoid a place with a big barrier in its neighbourhood. Anything else cannot be worse for the wind power plant operation than turbulent flow.



In the area of turbulent flow wind speed changes suddenly. Random speed changes have a negative impact on wind-mill motors. The place affected by turbulent flow goes up behind the barrier approximately to triple of its

height, so rotor near the barrier must be placed higher in order not to be subjected to beats and vibration whereby financial demands of construction of the power plant body tube grow up. The influence of turbulence becomes weak with the growing distance from the barrier.

4. COVER OF GROUND

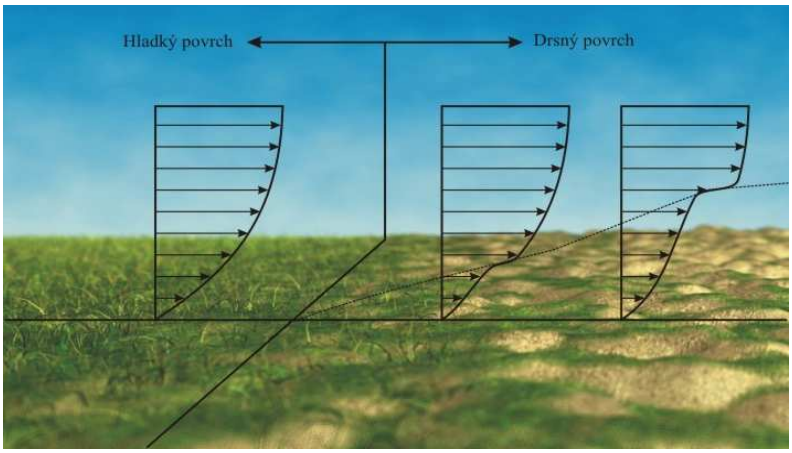
Another but certainly indispensable is so called influence of ground cover. In technical, meteorological and building field the cover of ground is characterized by so called roughness of ground. If it concerns the specification of categories in term of ground roughness, every country has developed its own table of roughnesses and uses different types of roughness influences on the flow. These tables differ a little bit. The following table is used in the Czech Republic.

No.	Classification	Z_0 [m]
0	Seas or shores exposed to high sea	0,003
I	Lakes or flat areas with insignificant green and no blocks	0,01
II	Areas with low greens as grass and separated barriers (trees, buildings) whose distance is more than 20 heights of the barrier	0,05
III	Areas evenly covered by greens or buildings or with detached barriers whose distance is maximum 20 heights of the barrier (as villages, suburbs, continual forest)	0,3
IV	Areas in which at least 15% of the surface is covered by buildings whose average height is more than 15 metres	1,0

This table contains data about the roughness made on the basis of the construction of so called wind logarithmic vertical profile. This profile records vertical changes of wind speed caused by surface differences.

$$u(z) = \frac{u}{\kappa} \ln\left(\frac{z}{z_0}\right)$$

z_0 is surface roughness parameter, κ is *„von Karman“* constant *($\kappa \approx 0,4$)* and u is dynamic (friction) speed. The assumption of the validity of the wind profile logarithmic definition is a neutral thermal stratification of the atmosphere (air temperature does not change with the increasing altitude) with a small correction dedicated to the deviations from this basic stage caused by instability of the atmosphere.



What is the imagination of it? In the following picture there is illustrated a vertical profile of the air at the moment when transiting from a flat to rough surface. As it is evident from this picture, during the transition from grass to rough stony ground there happens a radical reduction of the wind speed not only in the neighbourhood of the ground but subsequently also at higher

levels. If we substitute roughness by e.g. grown forest, the change caused just by the roughness can achieve unexpectedly big values. Choosing the place of a wind power plant construction should take this influence into account as well. Certainly a bad choice will be to place a power plant among grown trees, near the forest or on the meadow surrounded by grown tree species from three sides.

5. CONCLUSION

Is it possible to say what environment is the most suitable for wind power plants construction? The most interesting areas are medium steep unwooded shores, standalone unwooded hills, water levels... simply the places where nothing is in the way of flow and where acceptable flow acceleration happens due to appropriate conditions.

The objective of this paper was not to describe all details about the relations of the flow of atmospheric ground layer and landscape in a complex way but to show the fact how significant role is played by the right choice of the place of wind power plant construction. Only two most significant elements of all were shown here. By the right calculation of these factors during area choosing total energy and financial yield of wind power plants can be significantly influenced.

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