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51707-IC-3-2004-1-CZ-ERASMUS-IPUC-2

WIND SPEED ENERGY - SPEED AND UNIT POWER WIND MAPS

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Abstract

Power levels of new wind power units are increasing and their axes reach heights about 100m over ground with the rotor diameters about 90m for 4MW unit. It is very necessary to know long term average values of the wind speed and others stream relations in these overground levels of atmosphere as well. This article deals with creations of air streams maps and their application in practice.

The speed and power maps

Before a new wind power stations is designed, few questions need to be answered: where to build the power stations, what is the suitable axis level and what is the power level. Incorrect selection of only one of these parameters can have a principal influence on the investment costs and the payback period.

The wind power station (WPS) building is basically close connected to the wind speed data in the power station location. The larger rotor or the higher wind speed the higher investment costs. Therefore the question is how to optimise the selection risk of the location, height and power of the unit. Two principles can be used.

The first method is based on the long-term measurement of the wind speed and its direction in the place we plan to build the WPS. This process is very accurate but very expensive and time consuming. In some cases it is necessary to process two years long wind speed measurement. It is connected with some difficulties such as building of a measurement tower, anemometer servicing in the winter, suitable collection of the data etc… If the measurements present that the chosen locality is not suitable for the building of the WPS, the financial and time losses of an investor could be unnecessarily high.

The second way, which is presented in this article, is slightly less exact than the long term measurement but much quicker and cheaper. In this case we discuss a mathematical model of the wind behaviour in the earth-bound atmosphere levels. One of the mathematical models was used in the project that was realised in the Czech Republic in 2004 - 2006. A wind speed and unit power map of the wind in Czech Republic was created in cooperation between University of West Bohemia, Faculty of electrical engineering, Department of power engineering and ecology and Czech hydrometeorology institute (CHI). The results of the maps give the general overview of the situation and wind speed. Based on these maps we were able to predict the suitable power places for building a WPS. The next step is connection of this wind speed map and an orthographic map. Then we can obtain information about the technical suitability of the location. Therefore we could determinate applicability of a single locality. The role of the landscape type, distances from the ground route, electric power network and residences and the jural classification of the ground plot is very important for the wind power station project.

We combined a couple of procedures to get sufficient accuracy of the maps. Primary, it was necessary to ensure the correct data. The data was afforded by CHI. CHI has more then 100 years tradition. It ensures continual wind speed and direction measurements in the height of 10m since its establishment. Data of the wind speed and direction from 90 meteorology stations (MS) since 1960 till 2000 were used for the purpose of the model. Next, data from German and Polish stations were used too. The data was subsequently analysed, distorted data was filtered and the daily wind speed computations were made. We used the software WAsP 8.0. (Wind Atlas Analysis and Application Program) to evaluate the wind speed and wind power in the next stage. The first version of WasP was created in 1987 in Riso National

Laboratory in Danish Röskilde. Since this date, the constantly investigation has been made on this software. The software structure is innovated along the latest knowledge base. The software is composed from couple of physical modules. These modules simulate the streaming of the earth-bound atmosphere levels with ground influences in the mind. Using the WAsP software we computed the wind speed and unit power for all the meteorology stations in higher overground levels. After that the wind speed histogram for the each point was made. Then we got set of values representing the situation in real places in Czech Republic. It was necessary to connect separate places into order to continue the process. We used suitable software that offers service in the GIS area (Geographic Information System) for this purpose. The SURFER 7.0 software was chosen. This software made a data interpolation among the meteorology stations. It was necessary to make data extrapolation between foreign MS in close of Czech Republic border to cover all the Czech territory. After all these procedures we obtained:

- average years wind speed map in level 10 m
- average seasons wind speed map in level 10 m
- average years wind speed map in level 100 m
- average years unit power map in level 100 m

The year map offers compact view on the wind power potential in the Czech territory. Compared to the year map, the season map records the power fluctuation caused by the season climatic phenomena. The season map grows into the simple identifier of the wind speed stability in the concrete height interval.
The mathematical models, that describe the natural processes, are based on the long-term measurements. Each model is as accurate as it can describe the dynamic of surroundings and depends on the representative data that are used for the computations. It is reasonable to take the deviations from reality into account. After several confrontations between the results from this model and direct measurements we can express that the model we used is suitable for the wind power prediction with sufficient accuracy. The deviation between the real and computed values is in interval between 2 – 20 % depending on the ground type. Hills and highlands bring bigger imprecision to the computations than flat or curly areas.
The maps are made from average values. Therefore it is not desirable to deduce the final conclusions for smaller localities using the data from these maps. In the case of serious interest in the utilisation in the specific territory with small size, it is suitable to make more detailed analysis.
We use the second generation of WAsP programs (WAsP Engineering) to analyse the smaller regions. What is the Wasp Engineering? The purpose of the WAsP Engineering is to support the estimated loads of wind turbines situated in a complex terrain. The wind properties that are treated are extreme wind speed, wind shears, wind profiles and turbulences.

In conclusion we can say that the situation in the climatic conditions describing the Czech Republic is very good. Therefore the wind speed maps can help to develop the usage of wind power.

Trends

The wind power stations are growing up in the output power range and in the heights as well. If we look trough the set of VESTAS company produced since 1984 we can find that the power output has increased from 55 kW to 4.5MW, what means the increase for about 820%. The rotor diameter has increased from 15m in 1984 to 90m at present time as what we can see in the table n.1. The rotor axis height over the ground increased from 36m to 100m. Their last

model V 120-5 MW should be presented on the market in 2009 and it is supposed to be used as the offshore unit.

POWER OUTPUT	INSTALLATION YEAR	ROTOR DIAMETR
[kW]		[m]
55	1984	15
75	1985	17
90	1986	19
100	1987	20
200	1988	25
225	1989	27
400	1989	34.8
500	1991	39
600	1995	44
660	1997	47
850	1997	52
1650	1997	66
2000	1999	80
3000	2002	88

Tab.1 Parameters of the Vestas wind units.

The next large company in the field of wind power stations is ENERCON. Their series E 33, E 48, E 70, E 82, E 82, and E 112 determinate the above mentioned trends. The last type E 112 with the power output 4,5-6 MW has the axis height 124 m and the rotor diameter 114 m.
Keeping the mentioned issues in the mind, it is necessary to know the most frequent wind speed and other parameters (direction, frequency, power strokes etc.) in the height of 100m to predict the production in the specific area.

Conclusion

The preferential utilisation of the renewable energy sources has a contribution to the power electricity production. In combination with other energy sources it has also a contribution to the creation of relatively local independent energy systems. Wind power engineering goes through the era of high increases of the installed power outputs, mostly in Europe, and it also has a big contribution to protection of the Earth climate.

This paper was supported by GACR (Czech Science Foundation), research project GACR No. 102/06/0132.

References

[1] Company materials of VESTAS and ENERCON
[2] Company materials of RISO National laboratories

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