“长江首城人才交流大会暨人才主题周”活动开幕式暨主旨演讲会议议程

—— Opening Ceremony& Keynote Speech--"Talent Exchange Conference in the Yangtze River First City"& Talent-themed Week ——

Agenda

第一阶段：开幕式 Phase One: Opening Ceremony

一）市领导致辞；

Address by Yibin Municipal Leader

二）中省相关单位领导讲话；

Speeches by Relevant Leaders from Central Commissions or Departments or the Province

三）签署合作协议；

Signing Ceremony of Cooperation Agreements

四）揭（授）牌仪式；

Awarding Ceremony

五）发布“宜宾人才白皮书”；

Issuing the "Whitepaper of Talent in Yibin"

六）启动“宜宾人才大数据平台”。

Kicking-off of "Yibin Talent Big Data Platform"

第二阶段：主旨演讲Phase Two: Keynote Speeches

一）罗伯特C默顿：21世纪的科学、教育及金融实践

1) Robert. C. Merton, Science, Education and Financial Practice in the 21st Century

二）邓绍平：智慧医疗与健康中国

2) DENG Shaoping, Smart Medicine and Healthy China

三）维克托迈尔-舍恩伯格：培养大数据人才，发展大数据产业

3) Viktor Mayer-Sch nberger, Cultivate Big Data Talents and Develop Big Data Iindustry

四）周涛：数字经济发展的生态建设

4) ZHOU Tao, Ecological Construction for Digital Economy Development

五）杰尼索夫·亚历山大：乌克兰科学技术，超导太赫兹

Denysov Oleksandr: Ukrainian's Science and Technology, Superconducting Terahertz

六）保德古林可·弗拉基米尔：工业风生产商业用电的模型

Podhurenko Volodymyr: Modeling of Production of Commercial Electricity by Industrial Wind Farm

Volodymyr Podhurenko

MODELING OF PRODUCTION OF COMMODITY ELECTRICITY BY INDUSTRIAL WIND-ELECTRIC STATIONS

The analysis of numerous wind energy publications has shown that the most important scientific and applied problem of selecting efficient multimegawatt wind turbines (WTs) for specific wind conditions for the construction of industrial wind farms (WF) is far from being resolved.

Problematic issues of mathematical and computer modeling of high-power wind turbine parameters, which should generate as much commercial energy as possible and satisfy the price / quality ratio, remain open. It has already become a global trend that the efficiency of wind turbines increases due to the growth of their rated power. The studies performed show that focusing only on this indicator can lead to significant losses in electricity production.

The process of choosing a wind turbine is influenced by many factors: rated power, rotor diameter and hub height, operating time in characteristic zones of the power curve, installed capacity factor (CF). Therefore, a necessary condition for competent synthesis is only a differential approach to assessing each of the influence factors.

The resolution of these problems in the strategic plan for the modernization of the electric power industry is **super actual, the most perspective and priority.**

The purpose of the work is the development of methods and computer tools for optimizing the operational parameters of industrial wind farms in the wind conditions of Ukraine.

Research materials. Electricity production of wind turbines of high power in wind conditions of the Northern Black Sea region of Ukraine

For predictive calculations of the electricity generation volumes of any wind turbine, it is necessary to have data on the wind potential of the site where the wind farm equipped with these wind turbines is located, and a characteristic of the wind turbine itself (power curve), that is, the dependence of the electric power of the wind turbine on the wind speed at the hub height.

The construction of an industrial wind farm in the Northern Black Sea region is planned in the areas adjacent to the Adzhigol pilot wind farm (AWES), for which the distribution of wind probabilities by speed gradations for a period of 18 years of measurements at a representative military aerodrome meteorological station (MS) is investigated, as well as wind speed and direction measurements at the AWES site with an instrument Logger # 9200 for 26 months at an height of 27 - 31.5 m and simultaneous measurements at heights of 31.5 and 10 m.

The average long-term wind speed from representative MS measurements, reduced to the measurement conditions at the AWES site (vane height 31.5 m), is 6.0 m/s. This speed is the lowest when calculated by different methods, which provides the most reliable forecast for the long-term operation of the wind farm.

To perform calculations of the volumes of electricity production by various wind turbines, the gradations of wind speeds at the height of the wind vane to the heights of the studied wind turbines hub were recalculated. To recalculate wind speeds from one height to another, the well-known Hellman dependence was used:

$$\frac{V_{hub}}{V_{van}} = \left(\frac{h_{hub}}{h_{van}}\right)^{m} \qquad (1)$$

Here:

V_{van} – wind speed at the height of the weather vane h_{van} = 31,5 m;

V_{hub} – the desired wind speed at a height h_{hub} of the investigated wind turbines;

m – is an exponent of the function, the so-called coefficient of the vertical profile of the wind speed. As special tests have shown the average for wind at AWES **m = 0.227**.

Transforming the formula (1) to the form

$$V_{hub} = V_{van}\left(\frac{h_{hub}}{h_{van}}\right)^{m} = V_{van}\left(\frac{h_{hub}}{31{,}5}\right)^{0{,}227}, \qquad (2)$$

determined the wind speed on the hub height of the investigated wind turbines.

Using formula (2), we transform the data of the distribution of wind speeds at the AWES site at a height of **h_{van} = 31.5 m** to the annual distribution of the recurrence of wind speeds at various heights of the wind turbines hubs under study.

The calculation of the annual potential power generation was carried out according to the formula:

$$Q_n = \sum P_i \cdot T_i \quad \text{, где}$$

Q_n – annual electricity production, MW•h;

P_i – the generated power at a wind speed V_i at hub height, kW (according to the power curve);

T_i – wind speed V_i of i-th gradation duration.

The duration of the year is 365 days • 24 hours = 8760 hours.

As a result of numerical simulation, the predicted power generation of 43 megawatt wind turbines of the world's leading manufacturers in the wind conditions of the Northern Black Sea region of Ukraine was obtained.

The most important distinguishing feature of the obtained indicators is the use of actual multi-year real measurements of wind speeds and their probability distribution over gradations at the AWES site. This is precisely the main difference between them and those hypothetical ones that various researchers used earlier. Therefore, these quantitative indicators are laid in the basis of computer modeling.

A numerical study has established a multifactorial dependence of the expected calculated power generation of a specific wind turbine.

As a result of computational studies, it was first established that, for example, some wind turbines with less power produce more energy than with more power. It follows that when choosing an effective wind turbine, focusing only on an indicator of its rated power will lead to significant losses in electricity production.

Development of a mathematical model of annual electricity production

The task is a statistical study of the influence of individual parameters (explanatory factors): rotor diameter, hub height, rated power of the generator and others on the annual output of wind turbines and the development of a mathematical model (MM) for this dependence. The resulting MM will allow the world market to purposefully select (or design) the most efficient wind turbines for the wind conditions of a particular place of construction of an industrial wind farm.

Correlation study of the stochastic effect on the annual production of the turbine **Q** (MW · h) - the explained variable - explaining factors: ***X1*** - rated generator power (MW); ***X2*** – rotor diameter (m); ***X3*** — hub heights (m) in combination with a regression study made it possible to create MM.

The resulting model has a high coefficient of multiple correlation R explained variable **Q** with all the explanatory factors ***X1***, ***X2*** and ***X3*** at the same time (0.9939); high coefficient of determination R^2, normalized to the number of model factors (0.9870); relatively small standard error (272.09 MW · hour). The model is significant as a whole according to Fisher (PF $< 2.04 \cdot 10^{-37}$). The significance level of the coefficients with explanatory factors according to Student is extremely small. The relative errors of the regression coefficients do not exceed 9.53%, that is, the MM has no visible disadvantages.

The resulting MM has the form:

$$Q = -7126{,}25 + 1348{,}594 \cdot X1 + 97{,}52617 \cdot X2 + 28{,}81139 \cdot X3. \quad (3)$$

Its meaning: an increase in wind turbine rated power by 1 MW leads to an increase in annual turbine production by 1348.594 MW · hour; an increase in rotor diameter by 1 m leads to an increase in annual production by 97.526 MW · hour; an increase the hub height by 1 m leads to an increase in annual production by 28.811 MW · hour. Or equivalent to the generation are that an increase in rated power by 1 MW, that a 14-fold increase in the rotor diameter or a 47-fold increase in the hub height.

Conclusion. Comparison of model studies with actual operating results

The reliability and admissibility of accepted idealizations in the development of any dynamic model of a real system can be verified and evaluated only by comparing the results of theoretical studies with experimental data. The industrial operation of the first wind farms in the wind conditions of Ukraine provided rich experimental material. In a comparative study, we use the results of their operation to increase the degree of credibility and validity of conclusions.

Using the first obtained MM (3), we estimate the possible annual production of electricity by the Dmitrovka Wind Cluster (DWC) of the Ochakov Wind Farm, equipped with wind turbines FL 2.5–100 for a five-year period.

Table

DWC production comparison

Q_M, $\frac{MW \cdot h}{\%}$	$\frac{8879}{100}$	**WT FL 2,5-100: *X1* = 2,5 MW, *X2* = 100 m, *X3* = 100 m Dmitrovka wind cluster, "Wind parks of Ukraine" LLC Mykolaiv Region**				
CF_M, %	40,5					
Years of operation	2013	2014	2015	2016	2017	over the 5 years
Q_{OPER}, $\frac{MW \cdot h}{\%}$	$\frac{7828}{88,2}$	$\frac{7316}{82,4}$	$\frac{7275}{81,9}$	$\frac{7696}{86,7}$	$\frac{7900}{89,0}$	$\frac{7603}{85,6}$
CF_{OPER}, %	35,7	33,4	33,2	35,1	36,1	34,7
$Q_M > Q_{OPER}$, %	11,8	17,6	18,1	13,3	11,0	14,4
Availability rate (*AR*)	0,959	0,890	0,961	0,941	0,921	0,934
Q'_M by *AR*	$\frac{8515}{100}$	$\frac{7902}{100}$	$\frac{8583}{100}$	$\frac{8355}{100}$	$\frac{8176}{100}$	$\frac{8296}{100}$
Q'_{OPER} by *AR*	$\frac{7828}{91,9}$	$\frac{7316}{92,6}$	$\frac{7275}{85,3}$	$\frac{7696}{92,1}$	$\frac{7900}{96,6}$	$\frac{7603}{91,6}$
Proportion $Q'_M > Q'_{OPER}$, %	8,1	7,4	14,7	7,9	3,4	8,4

In the upper part of the table (highlighted in bold), explanatory factors of the influence of ***X1***, ***X2*** and ***X3*** wind turbines FL 2.5–100 are presented and the explained variable is calculated: annual production Q_M = 8879 MW · h and capacity factor CF_M = 40.5%.

At the bottom of the table are the actual power generation Q_{OPER} with the actual values of capacity factor CF_{OPER}.

The annual values of Q_{OPER} are less than the values of Q_M (and this is quite natural, because downtime is inevitable for all kinds of reasons): a minimum of 11 and a maximum of 18% (average for 5 years by 14.4%).

Taking into account the real actual values of the coefficient of availability rate (***AR***), these ratios decrease from a minimum of 3.4 to a maximum of 14.7 (an average of 8.4% over 5 years), which is a completely reliable result.

In the Tuzly wind cluster (wind turbines FL 2.5–100) the situation is similar, only the average Q_{OPER} decrease over 5 years in comparison with Q_M is reduced to 5%.

A comparison of the results of theoretical research and industrial operation is a convincing and indisputable proof of the legitimacy of the mathematical model (MM) first developed by computer modeling.

An invaluable practically important feature of the developed model is the absence of additional direct measurements of various parameters when using it, in particular, it does not require the processing of weather data from representative meteorological station, which promotes to a significant reduction in errors. And this is due to the fact that its development is based on actual long-term measurements by the automated system Logger (USA) of wind speeds at the pilot AWES and the actual power-law indicator for measuring wind speed by height, which significantly increased the reliability of the calculations.

The mathematical model first developed by computer simulation allows you to:

- quickly and reliably determine the optimal wind turbine in terms of parameters from those offered on the world market for a specific industrial wind farm in a certain territory;
- design and manufacture the necessary wind turbine in the absence of a wind turbine on the world market with the necessary design parameters.

Certificate

This is to certify that, PODHURENKO VOLODYMYR attended the 1st Talent Exchange Conference in the Yangtze River First City& Talent-themed Week held in Yibin, China, from November 6 to 8, 2019, and delivered a keynote speech on this occasion.

Organizing Committee of the "Talent Exchange Conference in the Yangtze River First City& Talent-themed Week"

November, 2019

Certificate

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Organizing [...]

Сертификат

Настоящим удостоверяется, что Подгуренко Володимир принял участие в 1-й Конференции по обмену передовыми достижениями в рамках Первой тематической недели региона реки Янцзы в г. Ибин, Китай, с 6 по 8 ноября 2019 года, и ~~произнёс~~ представил в рамках данного мероприятия доклад на пленарной сессии.

Оргкомитет „Конференции по обмену передовыми достижениями Первой тематической недели региона реки Янцзы"

Ноябрь, 2019

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