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THE OPTIMAL CALCULATION OF ELECTRIC LOSS IN AN ELECTRICAL SUPPLY NETWORK WITH WIND POWER PLANTS

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Recently, there has been a rapid pace of implementation of decentralized electricity supply to consumers, both in Ukraine and in the world. Decentralization of consumers is due to the use of renewable power sources (RPS) such as sun, wind, water, etc. But an increase in the share of such sources leads to complicated scheduling of operating modes of power systems (PS), and their live management [1].

This is due to the fact that most RPSs have a probabilistic nature of work. At present, the cost of construction and implementation of RPS is quite high, therefore, the payback period of such power stations can be 10-25 years, therefore, there is state support for the development of renewable energy, which stimulates research into the design and operation of RPS in order to increase the level of energy security of the country and reduce the impact of energy on the environment [2-3].

However, issues related to the transportation of electricity generated by RPS and the operation of district electrical supply networks (DESN) in new operating conditions often neglected at the design stage of RPS and the choice of their place of connection to electrical supply networks (ESN).

Lack of the design and operation investigation of RPS in modern conditions, their influence on the modes of ESN operation, the inconsistency of the nominal parameters of the main equipment with the needs of such sources, the absence of typical decisions regarding the means of protection and automation of the process of electricity production does not allow to make informed design decisions during their development, in addition, it does not allow them to be effectively operated [4].

Therefore, the development of methodical, informational and technical maintenance of their exploitation is relevant. An important aspect in this direction is the composite nature and methodological unity in decision-making regarding the improvement of operational characteristics of RPS in their work in power grids.

When designing a scheme for the electricity supply from the source to the final consumer, it is necessary to coordinate their work with the power system from which the centralized power supply is carried out. Such a scheme should meet both the requirements of reliability, in order to ensure a stable supply of electricity, and ensure the connection of the source as close to the centre of electricity consumption as possible, which will ensure a minimum of electric loss for its transportation [5].

1. Distribution of electric loss between substations of the electrical supply network

The calculation is made in the program «VTRATY (LOSS)-10/0,4 DPS» for the calculation of the electric loss of the existing network, allows to carry out a graphical analysis of the electric loss distribution between substations of the electrical network (Figure 1).

A graphical analysis of the distribution of electric loss between feeders of the substation is carried out. This made it possible to identify the most loaded feeders of each of the four substations, to which later the wind turbines were connected. The wind turbines of the *Vestas* company (Denmark) were selected for calculations, with the following rated power: 100 kW, 200 kW, 500 kW, 660 kW, 850 kW.

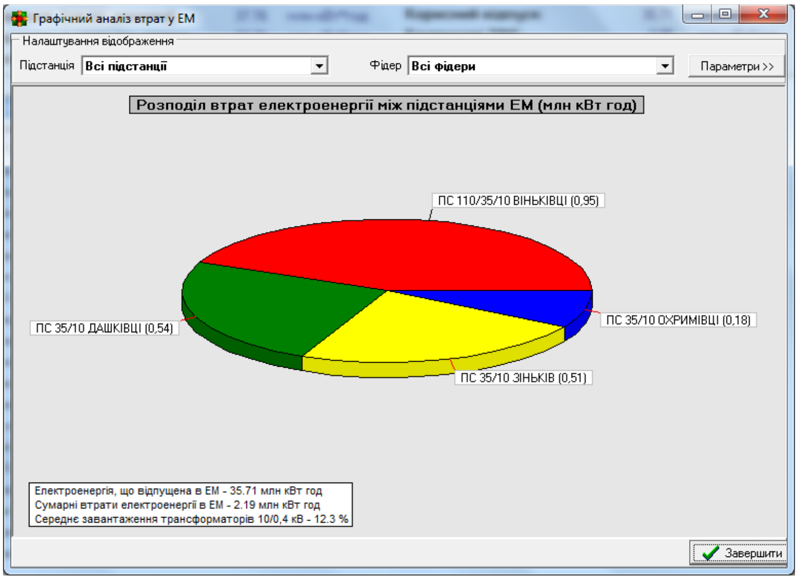

Fig. 1. Distribution of electric loss between substations of the electrical supply network

After connecting a 100 kW wind turbine to the Feeder 24 of the Zinkiv substation, the power losses decreased by 174548,7, but since after the addition of wind generators with a power of more than 100 kW there is an increase in electricity loss, therefore the installation of higher-power wind turbines at this node is less expedient. The calculations for the remaining substations are given in Table 1.

Table 1

Results of electric losses calculation at a substation before and after the connection of wind turbines.

Loss before RPS connection	100 kW	200 kW	500 kW	660 kW	850 kW	Node number	Feeder
277332,4	102783,7	141132,9	168292,5	191370,7	216853,1	cts 257	24
719039,3	70785,5	96546,1	277867,5	436527,2	691555,7	cts 253	41
515822,3	410315,2	417476,4	463256,3	493936,6	472748,9	cts 305	13
475543,6	266707,6	245610,0	414848,5	615118,5	866099	cts 168	33

Further, the dependence of the electric loss on the power generation of the connected substation feeder was constructed:

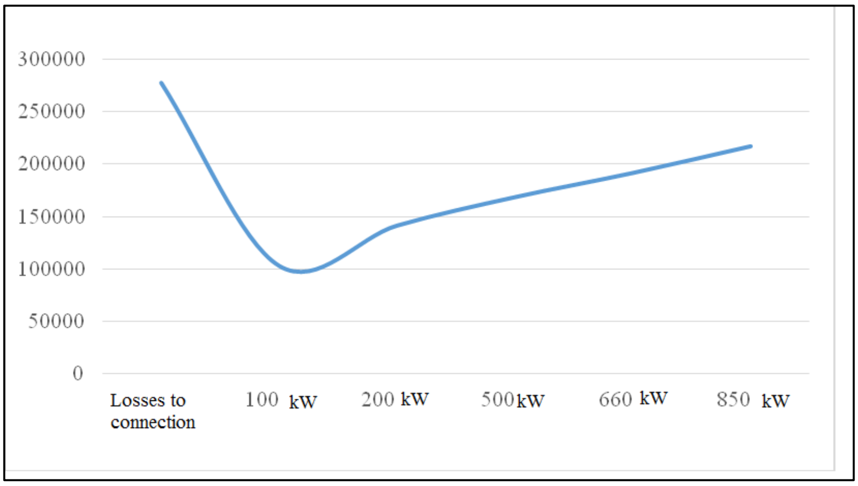

Fig. 2. The dependence of electric loss on the generation capacity of the feeder connected to 24 PS 35/10 «Zinkiv»

2. Calculation of the efficiency of using the installed capacity of renewable energy sources according to a complex criterion in DESN on the example of Vinkivtsi DESN

The calculation was carried out with the help of the software complex of the analysis of electric loss and the formation of saving measures in distributive electric supply networks with the distributed generation «VTRATY (LOSS)-10/0.4 (DPS)».

The numerical value of the total return on operation of the RPS for the day connected to the parallel work to the Vinkivtsi DESN can be written as follows:

$$\Pr ofit^{RPS} = \sum_{j=1}^{n} price_j \cdot P_j^{RPS} \cdot k_{в_j} \cdot T, \quad (1)$$

where $Profit^{RES}$ – the total value of the profit from the operation of *RES*, $ц_i$ – the price of electricity produced by the wind farm in accordance with the «Green Tariff», where $k_{вi}$ – the coefficient of RES use, taking into account the probabilistic nature of the wind, T – time.

The resulting value of total profit may vary depending on the weighting factors k1 and k_2. These coefficients and expediency of stating k_1 = 0,288 relative units (RU) and k_2 = 0,163 relative units (RU) were taken from the dissertation of Malogulko Yu.V.

Consequently, the numerical value of the total revenue from the operation of the Wind generator during the day connected to the parallel work to the Vinkivtsi DESN according to (3.3) can be written as follows:

$$\Pr ofit^{RPS} = \sum_{j=1}^{n} price_j \cdot P_j^{RPS} \cdot k_{в_j} \cdot T = 315.7/100 \cdot 850 \cdot 0.8 \cdot 24 = 51520(\text{UAH}).$$

Thus, non-compliance with normative power loss reduces the total profit from the operation of the Wind turbine connected to the feeder number 33 of Substation 35/10 «Dashkivtsi» by 23%.

As can be seen from the results of the study, the connection of a 200 kV wind turbine to the feeder number 33 of the Dashkovskaya substation is optimal. An increase in installed capacity leads to a possible decrease in the voltage quality, which worsens the conditions of the operation of the local electrical supply network.

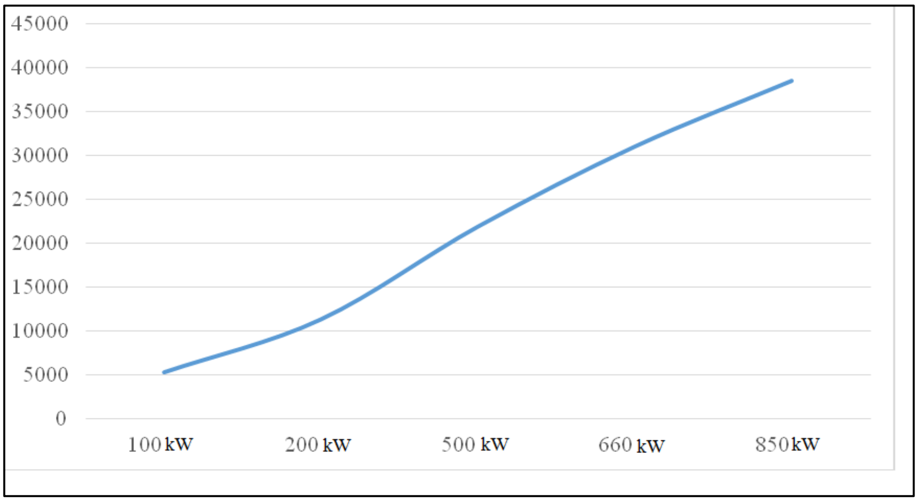

Fig. 3. The dependence of the target function of the problem of determining the optimal installed power of the Wind generator for feeder number 33 of Substation 35/10 «Dashkivtsi» from the generation capacity of the Vinkivtsi connected to the DESN

Conclusions. As a result of the research it was discovered that if we install a wind turbine at the most loaded feeder of each of the substations, we will receive a reduction of electric loss, but with certain restrictions on the nominal power of installed generators, because at reaching a certain upper limit on the power of the installed generation, there is an increase in electric loss.

The calculation was carried out with the help of the program complex of the electric loss analysis and the formation of energy saving measures in Distributed Electric Networks with Distributed Generation «VTRATY (LOSS)-10/0,4 (DPS)».

The numerical value of the total profit from the operation of the wind turbine for the day connected to the parallel work to the Vinkivsky DESN was obtained; the target function of the determination of the optimum installed power of the Wind generator for the feeder number 33 of «Dashkivtsi» Substation 35/10 was calculated. Having obtained the numerical values of the target function, it was found that when the installation of 200 kW wind turbine total losses amounted to 7.22%, when installing 850 kW wind generator due to non-compliance with the standard specifications of power loss, and the standard for fluctuation of power, the total returns from the operation of the Wind generator connected to the feeder number 33 of «Dashkivtsi» Substation 35/10 decreased by 23%, and the total loss amounted to

21.54%, therefore, as it is evident from the results of the study, it is optimal to connect a 200 kW wind turbine to feeder number 33 at «Dashkivtsi» substation. An increase in installed capacity leads to a possible decrease in the voltage quality, which worsens the operating conditions of the local electrical supply network.

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НАПРЯМКИ РОЗВИТКУ МОБІЛЬНИХ РОБОТІВ ДОВІЛЬНОЇ ОРІЄНТАЦІЇ В ПРОСТОРІ

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Процес еволюції технічних систем в області машинознавства й машинобудування, як правило, приводив до виникнення нових засобів виробництва. Незважаючи на те, що до другої половини XX століття науково-технічною думкою створені досить надійні засоби подолання гравітаційної сили у вигляді встаткування літального й реактивного характеру, здатного бути