ECONOMIC ASPECTS OF REALIZATION OF AUTONOMOUS CHARGER STATIONS OF ELECTRIC VEHICLES ON THE BASIS OF ВЕУ

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The volumes of electricity generation in Ukraine for the last year, as well as the dynamics of growth of electric consumption in comparison with the previous year have been analyzed. The current state of development of renewable energy objects of Ukraine is considered, and it is noted that a significant increase in photovoltaic and wind power plants is due to the highest coefficients of the "green tariff" that are valid for the sale of clean energy. It is shown that the rates of increase of capacities of wind power plants are significantly inferior to photoelectric stations. It is noted that the wind energy potential of Ukraine significantly exceeds the energy potential of solar radiation. Taking into account the rapidly growing dynamics of electric vehicle growth in Ukraine, the need to accelerate the use of the energy potential of Ukraine's wind through the implementation of autonomous charging stations of electric vehicles with wind turbines has been substantiated. The downward dynamics of the cost index of wind power plants and lithium-ion batteries is considered. The basic investments for realization of the system of an autonomous charging station of an electric motor with wind power plants and buffer batteries of energy are determined. On the basis of the analysis of the seasonal nature of the change in the production of wind power plants, as well as the tariff policy for the sale of electric energy at the charge of electric vehicles, it has been established that the payback period for the sale of an autonomous charging station of this type may be from 9-10 to 19-20 years. It is noted that the index of the guaranteed electric vehicle charge will be maximal only if the wind speed distribution is evenly distributed during the year. Ref. 8, fig. 4.

Keywords*: wind turbine, autonomous charging station, electric vehicle, buffer battery.*

List of used symbols and abbreviations:

RES - renewable energy sources;

АЗСЕМ - autonomous charging station for electric cars;

UES - integrated power system;

ВЕУ- wind power plant;

Efficiency - efficiency;

АБ - rechargeable battery;

ЕМ - electric car.

Introduction. Electricity generation in 2018 in Ukraine amounted to 146.11 billion kWh. In the total electricity production, 1.9% (2.78 billion kWh) was generated by

renewable energy facilities, and its share in the cost was 8.61% [1]. There have been no significant changes over the last year. Only the volumes of electricity production increased by 2.7% compared to 2017, but the ratio of consumption by households and industry has not changed.

Fig. 1. Dynamics of capacity growth of renewable energy sources in Ukraine

Renewable energy is gradually increasing its share in the overall energy balance of the country as evidenced by the dynamics of increasing the capacity of RES (Fig. 1) [2]. In particular, in 2018, 813 MW of new renewable capacity was introduced, the main share of which fell on solar (716 MW) and wind (68 MW). The capacity of other types of renewable energy introduced in 2018 was 29 MW. Significant growth rates of solar energy facilities are explained, first of all, by the highest green tariff coefficient, which makes them the most economically attractive for investors. However, the photoelectric potential of the Sun's energy is 2.95 million tons AD. significantly inferior to the energy potential of wind in 15 million tons AD [3]. This, in turn, indicates an underestimation of wind energy, which can significantly increase the production of clean electricity.

One of the options for faster development of wind energy potential and, accordingly, obtaining additional production of clean energy is the use of wind turbines to charge different types of electric vehicles (both fully electric and hybrids that can be recharged). This paper considers the economic issues of wind energy use in the use of wind turbines as part of an autonomous charging station for electric vehicles (A3CEM).

The purpose of this work is to establish the economic feasibility of expanding the use of wind energy potential through the use of autonomous charging stations of wind turbines as the main generators of electricity for charging electric vehicles.

Statistics show [4] that the electric car market in Ukraine continues to grow rapidly. As of November 1, 2018, there are already more than 11.5 thousand electric vehicles in Ukraine (Fig. 2), more than 9.5 thousand purely electric (BEV) and more than 2 thousand rechargeable hybrids (PHEV), while in 2014 there were only 95. Today, Ukraine already has more than 2,000 charging stations, but almost all of them are connected to the country's integrated energy system (UES). The growth of powerful single charging stations for electric vehicles (from 100 kW and more) and their number can lead to a significant impact on the operation of the UES of Ukraine.

Fig. 2. Distribution of the market of electric vehicles in Ukraine

For calculations we will accept average consumption of the electric power by one electric car at the level of about 80 kWh a day (about 30 MWh a year). We will also include in the calculation the technical and economic characteristics of fast charging stations (Chademo or SSC technologies - with fast charging modes (100 kW in 10-30 minutes)). We

set a task to reduce the negative impact on the operation of the UES by creating autonomous charging stations for electric vehicles based on wind turbines, which will be located on major roads far enough from power lines.

The installation of A3CEM on the basis of wind turbines should be provided in places with the existing demand for electric vehicles for recharging, while ensuring the conditions of guaranteed charge and convenience for access of electric vehicles. Only under the condition of maximum possible operation of the installed capacity of generating and converting equipment can the minimum payback periods of the costs of the owner of the charging station for its design, installation and operation be achieved.

Analysis of the dynamics of the cost of wind turbines [5] shows that the average cost of 1 kW of installed capacity as of 2018 is about $ 1,000. USA (Fig. 3). For calculations we accept cost in 1,0 dollars. USA for 1 W of installed ВЕУ power.

Fig. 3. Dynamics of the cost index of the wind turbines

It is expected that the main volume of energy consumption at A3CEM will be observed in daylight, as the traffic during the day is much higher than at night. In view of this, the autonomous charging station for electric vehicles based on wind turbines provides a buffer battery that will be charged during the presence of wind. Regardless of when the electric car arrives on charge, there must be enough energy to recharge it. According to [3], the efficiency of the best wind wheels is in the range of 0.3 ÷ 0.35. By adopting an efficiency of 0.3 wind farms with an installed capacity of 20 kW on average per year, for example, for a region such as Melitopol, Zaporizhia region, Ukraine at a support height of 66 m it is possible to generate 50 ÷ 60 MWh of electricity per year.

To calculate the required power, choose a charging station for two connections with a capacity of 100 kW.

In this article we will assume that the following preconditions are met:

1) own needs of A3CEM (lighting, etc.) at the level of 3 kWh per day;

2) the residual charge of the АБ ЕМ when the electric vehicle arrives at the charging station is 20% of its maximum value, ie $0.2 \cdot E^{EM}_{АБ}$, because at lower residual values of the battery charge the electric car may not reach the charging station;

3) the probability of arrival of the electric vehicle at the charging station with a residual charge of АБ ЕМ of 80% and more is 0, because recharging the electric vehicle in the range from $(0.8 \div 1)\ E^{EM}_{АБ}$ must be carried out in stationary (not accelerated) charge mode;

4) the excess energy of the buffer АБ A3CEM must be at least 20% of the nominal value, ie $k_З^E = 1,2$;

5) the maximum value of the buffer voltage АЕ3CEM is taken equal to $U^{БУФ}_{АБ} = 600$ В, according to [4];

6) we take for calculations the efficiency of the buffer battery equal to 80% ($\eta_{АБ}^{БУФ} = 0.8$), and the charge factor of the battery of the electric car - equal to 90% ($\eta_{АБ} = 0.9$).

In this case, the energy of the buffer battery to ensure the operation of the filling station with a charge of one EM with a maximum demand of 80 kWh should be:

If you need to generate 137.83 kWh per day (or 50.37 MWh per year), the required installed capacity of the wind farm should be about 20 kW. At the same time, 89 kWh per day, or 32485 kWh per year, will be used for sale for EM charge. The rest (17885 kWh) will be spent on the A3CEM's own needs, as well as losses in the conversion and transmission of energy from wind turbines to the final consumer.

If we take into account the random nature of wind power generation both during the day and in seasonal terms, then for the summer season it is necessary to increase the capacity of wind turbines, because in these months of the year there are slightly lower wind speeds. That is, for the summer period of the year, the installed capacity of wind turbines required to ensure the daily charge of the electric vehicle and the A3CEM's own needs will increase by 1.5 ÷ 2 times.

The estimated cost of wind turbines for gas stations, with a uniform distribution of wind speed (ideally) will be:

In addition to the cost of wind turbines, it is necessary to take into account the cost of chargers and batteries. According to [6], the reduced cost of the fast charge device is $ 200 / kW, or UAH 5,600 / kW. Accordingly, a 100 kW charging station can be estimated at $ 20,000, or UAH 560,000.

Analysis of the dynamics of the cost of lithium batteries in the period from 2010 to 2017 inclusive shows a stable dynamics of reducing the cost of 1 kWh from $ 1000 to $ 209, respectively (Fig. 4) [7]. If we take the cost of 1 kWh at $ 209, or UAH 5,852, the cost of the buffer battery for gas stations with an energy consumption of 138 kWh is UAH 807,576 thousand.

To charge the electric car at 80 kWh and meet the charging station's own needs, a

Fig. 4. Dynamics of the cost index of lithium storage batteries

Taking into account the main costs for the implementation of filling stations based on

wind turbines with a buffer energy accumulator, we have a total cost of about UAH 1.927 million. To this should be added the cost of land, installation, commissioning and operation of the charging station within 25% of capital investment. That is, the full implementation of A3CEM on the basis of wind turbines with a buffer battery of energy based on the guaranteed charge of one electric vehicle with a maximum energy consumption of 80 kWh will be about 2.5 million UAH.

When selling electricity for fast charging of electric vehicles at a night rate of UAH 4 per 1 kWh [8], the payback period of A3CEM on the basis of wind turbines will be about 19 ÷ 20 years.

If you sell electricity at fast charging stations at a daily rate of UAH 8 per 1 kWh of fast charge [8], the payback period of the station as a whole is reduced to 9.5 ÷ 10 years, which makes these charging stations a very attractive area of investment, however according to this indicator, they (A3CEM on the basis of wind turbines), so far, are inferior to charging stations connected to the UES, which is explained by the additional costs of wind turbines and buffer battery. Also note that the cost of infrastructure required for charging stations on wind turbines, we accept the same as for traditional gas stations (entrance, lighting, markings, signs, signs, etc.).

Conclusions. 1. The dynamics of increasing the installed capacity of renewable energy facilities is analyzed and it is established that the dynamics of using the wind energy potential of Ukraine is much inferior to the development of solar energy potential, due to greater investment attractiveness of photovoltaic plants due to high "green" electricity tariffs. however, in terms of specific indicators, the energy potential of wind is more than 5 times higher than the photoelectric solar potential.

2. A preliminary cost assessment of an autonomous charging station for electric vehicles based on wind turbines and found that the total cost of the system may be about 2.5 million UAH, or 89.3 thousand dollars. USA (at the rate of early 2019).

3. The payback period of A3CEM based on wind turbines with a buffer energy accumulator can range from 9-10 years to 19-20 years, depending on the cost of electricity that will be sold for a number of electric vehicles.

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