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RESEARCH ON INFLUENCE OF WIND POWER PLANTS ON THE LOAD OF LOCAL POWER SYSTEM WORK MODE

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Анотація

Досліджено вплив вітрових електричних станцій на режим роботи локальної електроенергетичної системи, окремі питання стосовно стабільної роботи таких станцій у складі енергосистеми та проблеми керування локальною електричною системою з вітроустановками.

Ключові слова: вітроустановка, вітрова електрична станція, локальна електроенергетична система, системи керування.

Abstract

The influence of wind power stations on the operation of the local power system, some questions about the stable operation of those power stations and the problem of control of the local power system with the wind turbines have been investigated.

Keywords*:* wind turbine, wind power station, the local electric power system, control system.

Introduction

The development of wind energy, which has been observed in recent times, is stipulated by the state policy of promoting the development of alternative energy sources (amendments to the Law of Ukraine "On Electricity" of 01.04.2009, the KMU Resolution of 19.02.2009 "On the implementation of investment projects for the construction of wind farms in the Autonomous Republic of Crimea and Mykolaiv region", etc.). However, there are currently no scientifically substantiated volumes of wind power capacity that can be placed in separate regions of Ukraine based on the availability of wind, economic feasibility, environmental safety, the maintenance of the sustainable operation of the integrated energy system (IES) of Ukraine, the need for electricity in the areas of wind power (WPS) etc. The Institute of Renewable Energy of the National Academy of Sciences of Ukraine and the NNPP "Ukrenergomash" of the National Academy of Sciences of Ukraine developed the justification for the addition to the "Energy Strategy of Ukraine for the period up to 2030" in the part of wind energy development". NPC "Ukrenergo" considered the said Justification to "Energy Strategy of Ukraine for the period up to 2030" and to submit proposals and remarks by a letter dated December 31, 2008, No. 02 / 02-1-3 / 7867, which says that the volume of the planned wind power capacities must be in line with the current state and promising development of the Ukrainian power engineering sector [1].

NPC "Ukrenergo" supports the development of wind energy within its powers, but insists that ensuring the development of the wind energy industry and its work with maximum efficiency will require the completion of the development of the Energy Strategy of Ukraine in the sphere of wind energy with the development of a scheme for the distribution of wind power across the country and regulatory documents, which will determine the conditions for the parallel operation of wind power plants from the IES of Ukraine [2].

Research results

Among the main problems to be solved when deciding on the construction of wind power plants and requiring separate research in each particular case, there are a number of issues related to the unstable nature of the wind. So, the characteristics of the wind vary during the transition to another locality, another season, and in different years, vary even at the same point and in the same season; these changes are random, but they have certain patterns that require study in relation to specific conditions. The wind speed has a variable elevation profile, which depends on the nature of the terrain, the underlying surface, weather and other factors.

In addition, the wind flow has a pulsating nature, caused by turbulence, which affects the mode of operation of wind turbines (WT). Wind turbines have an energy characteristic (the ability to convert the kinetic energy of the wind into electric one), which in practice can be determined only approximately, depending on the stability of the wind flow. WTs also themselves are able to influence the wind flow, distorting it and changing the nature of the work of neighbouring WT.

Stable operation of the wind farm in the local power system (LPS) requires knowledge not only of long-term prospects for generating electricity, but also short-term changes, that is, forecasting in the coming hours and days. Thus, at large volumes of WPP implementation to LPS, they can significantly affect both the overall stability of power supply, including the modes of peak load, and the economic component due to the growing demand for reserve capacities [3-4].

The degree and nature of this impact can only be assessed with a certain probability, taking into account the specifics of a particular LPS, typical wind regimes of the WPP placement areas, available predictive accuracy, and so on. Traditional LPS management principles and rules were developed on the basis of the deterministic nature of the generating facilities, of course, with an amendment to the technical reliability of the equipment and the presence of a random component in the mode of electricity consumption. However, the presence of WPP introduces additional uncertainty, which may require the development of special forest management algorithms [5-6].

The growth of the share of wind power plants within the EPS complicates the possibility of adjusting the energy balance due to the random nature of wind energy. One of the problematic issues is the growing demand for regulatory capacities that can compensate the unexpected change in electricity generation at the wind farm. Important factors in this case are the speed and amplitude of change, their consistency with the daily changes of electricity consumption and its production by other power plants.

The influence of wind power plants on the work of LPS is analyzed mainly by mathematical modelling [7]. At the same time, there is considerable experience in the practical use of wind power plants, in particular in terms of changing their power in case of sudden wind speed fluctuations. Thus, according to the IEA (International Energy Agency), for wind power plants in extreme weather conditions, jump of power was recorded at a rate of 10-35% of rated power per hour (individual values – almost 40%) [8]. However, the average rate of change is 5% for 180 hours. For changes in one minute – the maximum values of 0.5-0.8% of rated power are recorded.

The swing of power fluctuations for separate units is generally larger than for wind farms occupying a significant area. Thus, for a 1-hour averaging, the standard deviation increases by about a third at the transition from a large number of WT (more than 250) to small (up to 14 units). On longer intervals of time, more significant fluctuations of power are possible; in extreme situations the wind turbines stop completely. Considering that the thunderstorm usually takes 4-6 hours to cross the area in hundreds of kilometres, for such a time scale, the application of different methods of forecasting the work of WPP is relevant.

According to the World Wind Energy Association, the world's wind power has reached 336 327 MW by the end of June 2014, of which 17 613 MW were added in the first half of 2014. This growth was significant in the first half of 2013 and in 2012, when 13.9 GW and 16.4 GW respectively were added. The total installed power of wind power by mid-2014 was about 4% of the world's electricity demand. World wind power has increased by 5.5% over the six months (after 5% in the same period in 2013 and 7.3% in 2012) and by 13.5% per year (mid-2014 in compared to mid-2013).

For comparison, it should be noted that the annual growth rate in 2013 was lower by 12.8% [1]. According to the experience of the countries of the world, a certain share of the electric power produced by the wind power plant can absorb the power system practically without any difficulties, but when this quantity is exceeded, there are difficulties of both network and regime nature. For the most part, the threshold is estimated at 10% of the total electricity consumption in the country.

Integration of significant capacity of wind farms can seriously affect the work of LPS – its stability, reliability and efficiency, as well as significantly impede the work of dispatching services. This causes a number of requirements for wind farms, which should be preceded by the connection of the wind farm to the network. In particular, mechanisms are needed to compensate for power changes from nominal to zero for a short time. There are corresponding technical requirements for the WPP control system [6].

The severity of the requirements depends on the accuracy of prediction of stream-handling power. It is important to predict wind speed and corresponding wind power to plan the work of the grid in accordance with work schedules and contractual obligations. If the share of wind energy is considerable, even small errors in the prediction of wind behaviour will cause a substantial error in determining the active power, while the exact forecast is able to maximize profitability and minimize risks.

Conclusions

The efficiency of wind power stations varies according to wind speed, while the power system must maintain a balance between generation and energy consumption. The impact of wind power changes on controllability and sustainability of LPS is an important factor.

Thus, a large wind power plant can become a significant destabilizing factor that will affect even neighbouring power systems in the absence of appropriate regulation.

In order to keep the LPS in a stable condition, producers of energy must constantly adapt to the alternating load from consumers, using also the storage system. However, for WPPs, additional fluctuation of power is typical due to wind changeability. If the active power of the wind turbine can sometimes be reduced by decreasing energy requirements, then it can not increase as the needs grow, due to the limited wind speed. Therefore, the greater the proportion of wind energy, the harder it is to maintain the balance of the power system.

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