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DEVELOPMENT OF EMERGENCY SYSTEM OF POWER GRIDS WITH A SIGNIFICANT RENEWABLE GENERATION

The need for the development of adaptive emergency system of the power grid with a significant renewable generation has been substantiated. The main stages of the system development have been presented that enables to define settings of the emergency systems considering the features of the renewables, as well as to develop the system, which has been implemented for the power grids of Odesa Oblast.

Keywords: power system, adaptive emergency system, renewables, stability, voltage, and simulation.

In recent years, the installed capacity of renewables (RES), especially, the solar power plants (SPP) and the wind farms (WF), have been increasing worldwide and in the interconnected power system (IPS) of Ukraine. Along with the advantages of the renewables, such as reduction of the environmental impact and conservation of fuel resources, the growing share of the renewable energy in the structure of generating capacities are associated with some problems caused by features of power system operation in the normal and, particularly, in the emergency modes. This is due to certain restrictions on power system operation, especially, in terms of providing the voltage stability during the emergency operation. Because of differences between the renewable energy generation technologies and those used in the «traditional» power generation, this necessitates the improvement of emergency control for the grids by designing adaptive emergency systems that consider the features of renewable generation. It should be noted that voltage drop in the operation of power system can lead to tripping of SPP invertors with their further disconnection from the power grid, which results in increasing power flows to the deficit energy areas and further voltage drop in the grid. Considering the mentioned above, providing a reliable emergency control of RES-based power systems in order to prevent RES disconnection from the grid is of paramount importance.

To solve this problem, it is necessary to improve emergency control of RES-based power systems by developing the structure of adaptive emergency system and solving a set of research, engineering, and practical tasks to improve the existing emergency control methods and to develop the new ones. *Firstly*, it requires developing methods for adaptive control, which enable preventing voltage drops below the critical value in the grid in order to prevent the disconnection of SPP invertors from the grid. *Secondly*, the probabilistic character of renewables generation during a day (in particular, the SPP) leads to redirection of active power flows, which requires adaptive setting adjustment of the emergency control systems. *Thirdly*, considering a local character of voltage change, it is necessary to develop a centralized system for monitor-

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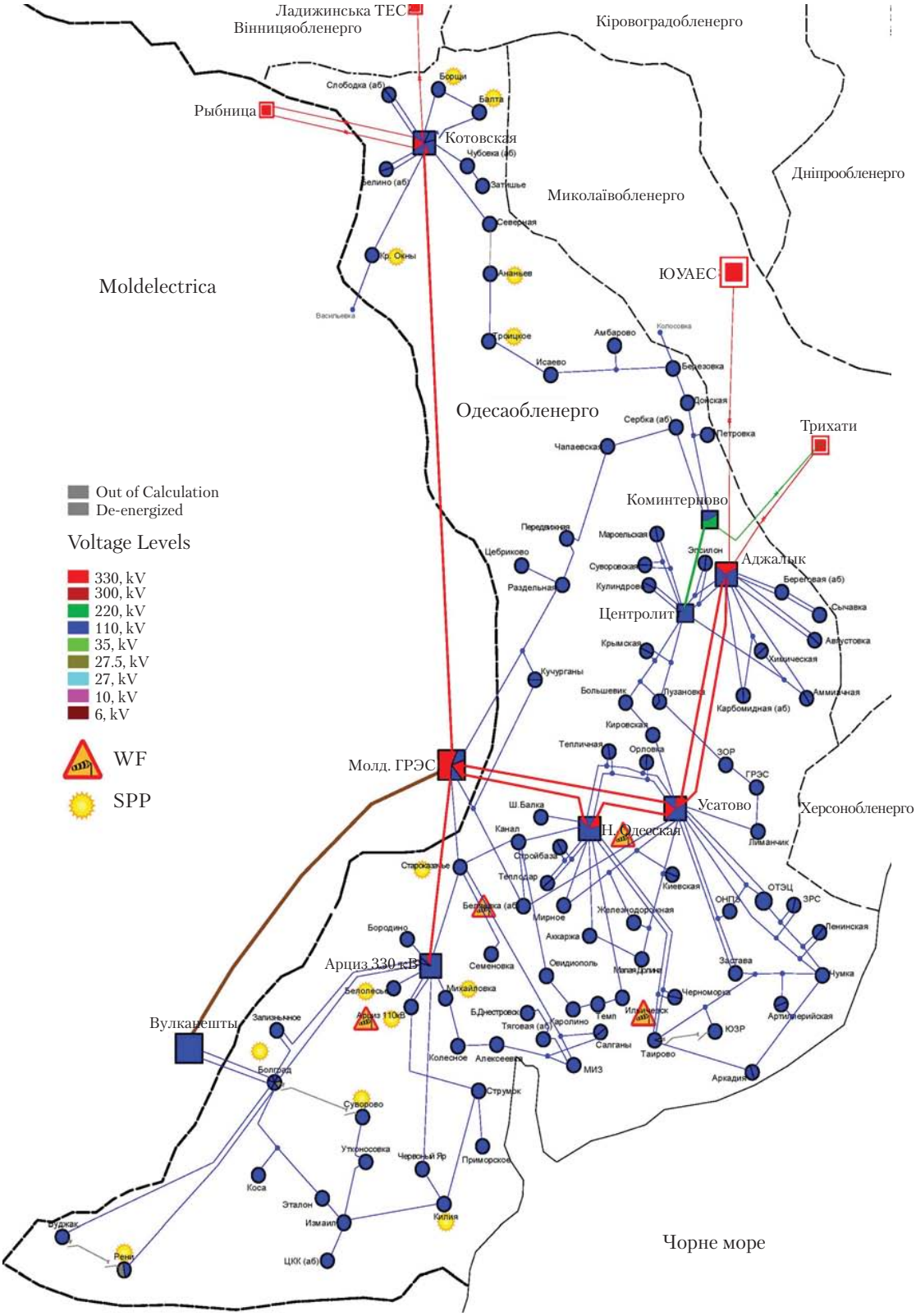

Fig. 1. Calculation model of power grids of the south-western part of Odesa Oblast for 2020

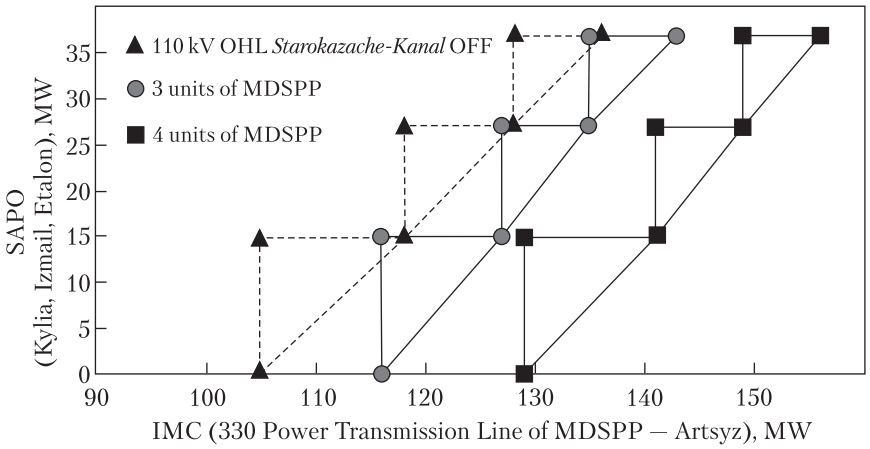

Fig. 2. Settings for continuous and discrete automated unloading in case of 330 kV OHL MDSPP — Artsyz disconnection, three various cases

ing and control of regional load in order to coordinate the operation of emergency systems at the levels of the system and the object.

It should be noted that in this research, an adaptive emergency system (AES) has been developed for the grids of the south-western part of Odesa Oblast, whose operation is characterized by a large share of SPP in the generation structure of the region. In addition to the known functions of emergency control, the developed AES enables implementing a set of new tasks, including the formation of control action groups to prevent critical voltage drops; adaptive change in tripping settings and defining control actions considering periods of the day, seasons and other factors. In addition, the proposed AES enables monitoring and visualizing the current status of the power system.

At the first stage, the current and prospective operation of power grids of the south-western part of Odesa Oblast has been analyzed, which enables developing respective computation models for the current and prospective years (Fig. 1). The main generating node in the south-western part of Odesa Oblast is Moldavian state district power plant (MDSPP). The analysis of its operation has been made for various operating scenarios of the Southern power grid. Also, among the factors effecting the voltage variation in the normal and emergency modes of power grid operation there are the characteristics defining the load structure in 110 kV grid. Taking into consideration the mentioned specific features of the operation of RES-based stations, the criteria for assessment of permissibility of modes, namely, critical voltage and permissible current loads of power transmission lines, which define the scope of «action» of adaptive AES have been developed in the project.

At the second stage, a load flow of 330–110 kV power grids in the south-western part of Odesa Oblast and the static stability for various conditions of regional power grid operation have been calculated. This enables to identify the voltage weak zones, and to define the places for installation of AES devices.

Based on the settings of initial mode control (IMC) and specified share of special automated power outage (SAPO), the automated unloading of disconnected line has been defined for 330 kV overhead line MDSPP – Artsyz in the following cases (Fig. 2):

a) operation of three power generating units of the MDSPP;

b) operation of four power generating units of this station;

c) disconnection of 110 overhead line *Starokazache—Kanal*.

It should be pointed out that the automated equipment setting is performed in accordance with the SPP operation: it considers the day time during which the plants are operating and decrease in generation by SPP in nighttime, which is typical for night minimum of daily load curve.

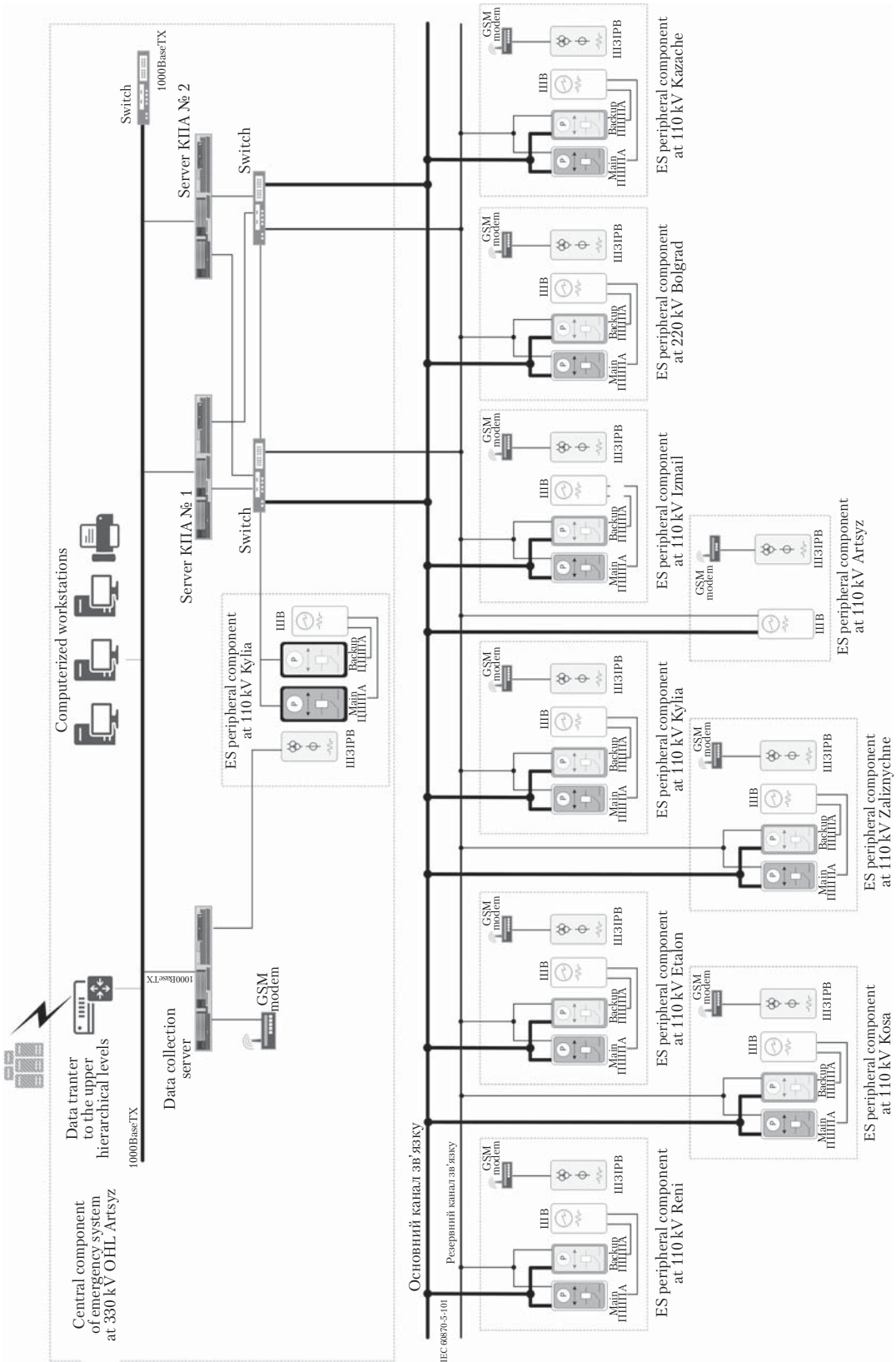

Fig. 3. Diagram of the AES of the Southern Power System

The configuration of regional AES has been designed on the basis of research data. It consists of the central and the object devices of emergency systems. The operation of such system in the steady and dynamic modes have been studied. This complex study has made it possible to verify the effectiveness of the developed system for various power grid operating conditions in the south-western part of Odesa Oblast (Fig. 3).

It should be noted that the developed AES has passed the state examination and is being implemented in the south-western part of Odesa Oblast. The automated equipment controls the sources of active and reactive power and disconnects less important consumers in the region. The algorithm of AES operation is based on calculations using the developed digital model of AES in the steady and transition modes.

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РОЗРОБКА СИСТЕМИ ПРОТИАВАРІЙНОЇ АВТОМАТИКИ ЕНЕРГОСИСТЕМИ ЗІ ЗНАЧНОЮ ЧАСТКОЮ ВІДНОВЛЮВАНОЇ ГЕНЕРАЦІЇ

Обґрунтовано необхідність створення адаптивної системи протиаварійної автоматики енергосистеми зі значною часткою відновлюваної генерації. Представлені основні етапи з розробки такої системи, що дозволило визначити налаштування протиаварійної автоматики з урахуванням особливостей відновлюваної генерації, а також розробити структуру цієї системи, яка впроваджується в мережах Одеської області.

Ключові слова: енергосистема, адаптивна протиаварійна автоматика, відновлювана генерація, стійкість, напруга, моделювання.

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РАЗРАБОТКА СИСТЕМЫ ПРОТИВОАВАРИЙНОЙ АВТОМАТИКИ ЭНЕРГОСИСТЕМЫ СО ЗНАЧИТЕЛЬНОЙ ДОЛЕЙ ВОЗОБНОВЛЯЕМОЙ ГЕНЕРАЦИИ

Обоснована необходимость создания адаптивной системы противоаварийной автоматики энергосистемы со значительной долей возобновляемой генерации. Представлены основные этапы разработки такой системы, что позволило определить настройки противоаварийной автоматики с учетом особенностей возобновляемой генерации, а также разработать структуру этой системы, которая внедряется в сетях Одесской области.

Ключевые слова: энергосистема, противоаварийная автоматика, возобновляемая генерация, устойчивость, напряжение, моделирование.

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