

INTELLIGENT ELECTRIC POWER SYSTEMS AS A WAY TO IMPROVE CIVIL DEFENCE

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Abstract. The issue of increasing the level of energy security as the main element of national security and civil protection was considered in the article. Modern models and schemes for building “intelligent” electrical systems have been analyzed. The problems faced by electric power engineers have been outlined. Methods for solving such problems using modern technologies were proposed.

Keywords: electricity, renewable energy sources, intelligent technologies, self-regulating power systems

Анотація. У статті розглянуті питання стосовно підвищення рівня енергетичної безпеки як основного елементу національної безпеки і цивільного захисту. Проаналізовано сучасні моделі та схеми побудови «інтелектуальних» електричних систем та основні проблеми з якими стикаються електроенергетики. Запропоновано методи вирішення цих проблем, використовуючи сучасні технології.

Ключові слова: електроенергетика, відновлювані джерела енергії, інтелектуальні технології, саморегульовані енергосистеми

Introduction. The basic element of civil security is energy security. Energy security encompasses several main functions: ensuring a stable power supply in normal and emergency situations; the possibility of normal functioning of all consumers; the use of different types of fuel for electricity generation; automated remote systems for protecting power plants and power supply systems from natural, technical cybernetic interference. Let us consider the main ways to implement such requirements in modern conditions.

Analysis of the state of the issue. Today, global demand for electricity is growing faster than demand for primary energy sources. According to the forecast of the International Energy Agency (IEA), by 2030, the growth rate of demand for electricity will outpace the growth rate of demand for primary energy sources by 1.5...2 times [1].

The lack of reserves of thermal generation capacity during peak load periods, especially in conditions of intensive expansion of renewable energy sources (RES) capacity, can lead to imbalances in the power system operation mode and, as a result, to disruptions in sustainable electricity supply. Studies conducted by the European Network of Transmission System Operators for Electricity (ENTSO-E) have shown that since 2015, generation reserves have decreased in almost all European countries. It was decided that “to maintain a sufficient level of generating capacity by 2020, it is necessary to approve and put into operation about 20 GW of various generating capacities” [2].

The purpose of the work – analyze modern models and schemes for building “intelligent” electrical systems and the main problems faced by electrical engineers.

Methods, materials and research results. As a result of the IEA's analysis of the state and development of the global energy sector, it was concluded that the successful solution of new problems within the framework of the previous concept of extensive development of the electric power industry through the increase in generating capacity and the expansion of the quantitative composition of energy and electrical equipment, even with improved characteristics, turned out to be insufficient.

The most effective measure to overcome the electricity shortage in these conditions is the unification of power systems and the mutual flow of electricity between the power systems of neighboring countries, especially during the period of development of modern and “intelligent” inter-system connections (including DC inserts). On March 16, 2022, the power system of Ukraine was fully synchronized with the power grid of continental Europe ENTSO-E. On December 14, 2023, the highest governing body of ENTSO-E – the General Assembly – during its meeting announced that NPC Ukrenergo became a full member of the Association of European Network of Transmission System Operators for Electricity ENTSO-E [3].

The need to develop a new concept for the development of the electric power industry is due to economic growth, which is inextricably linked to an increase in energy consumption, and increased requirements for the quality and reliability of energy supply. The concept, which is adopted and implemented in the energy sector, is based on a system of views on the role and place of the electric power industry in society, agreed at national levels, a comprehensive vision of the goals of its development and ways to achieve them, as well as the definition of the necessary technological basis for its implementation.

Instead, most European countries have begun to develop "intelligent" technologies (“Smart Grid”) in the electric power industry as the basis for the future development of the energy sector. In 2004, the European Smart Grid Technology Platform was created, the documents of which define these as “electric networks that meet the requirements of energy-efficient and economical operation of the power system through coordinated management using modern two-way communications between elements of electric networks, power plants and electricity consumers" [4]. The Smart Grid concept is formulated as “a fully integrated, self-regulating and self-regenerating electric power system that has a network topology and includes all generating sources, main and distribution networks, as well as consumers of electric energy, united by a two-way flow of energy and information, controlled by a single network of automated devices in real time” [5].

Currently, power companies have developed a concept for innovative renewal of the power industry based on the following initial provisions:

1. Systemic modernization of the industry covers all its components: electricity generation, dispatching, transmission and distribution, sales, and energy consumption management.

2. The electrical network (all its segments) is considered as the main object of forming a new technological basis and developing the functional properties of the power system.

3. The energy system is developing as an “Internet-like” infrastructure for the formation of relationships between all energy market entities and other stakeholders in the energy, information, economic, and financial spheres.

4. The process of forming concepts covers the entire range of work – from preliminary research to the widespread implementation of innovations and is carried out at all levels of innovative development of the electric power industry: regulatory, technological, technical, organizational, managerial and informational.

5. The development and implementation of concepts and corresponding programs for the introduction of “intelligent” technologies is innovative in nature and provides an impetus for the transition to a new technological level in the electric power industry and the economy.

Apparently, Smart Grid is interpreted today all over the world as a concept of innovative renewal of the electric power industry, which makes it possible to increase the efficiency and reliability of energy systems through the use of the latest technologies. The central place among energy-efficient developments is occupied by “intelligent” networks that combine automated self-regulating energy systems. Energy systems, thanks to the latest information technologies, are able to make energy supply more reliable, energy consumption more economical, and the negative impact on the environment as limited as possible. In energy-scarce regions, load management technologies are used when modernizing power grids. This mode involves the introduction of “smart” multi-tariff meters to provide tariff incentives for consumers to reduce electricity consumption during periods of maximum load in the power system.

During the global economic crisis, it is planned to achieve an increase in the efficiency of energy resources use and reliability of electrical networks by reorganizing their management. The priority method is the implementation of two main components of the Smart Grid concept: flexible energy flow control systems and voltage level regulation (FACTS (flexible alternating current transmission systems), STATCOM) and a system of “smart” multi-tariff metering of energy consumption (Smart Metering). Almost all leading companies producing metering systems are working on creating simple, reliable and cheap metering systems for household consumers. When developing such systems, two main provisions are adhered to: the system must be cost-effective; ensure reliable operation.

The basis of AMR/AMM/AMI systems is a three-level pyramidal structure (lower level – accounting, middle – communication (data transmission), higher – information processing). The key elements of the system are reliable storage of measurement results and data, multifunctionality, fast and reliable communication, data transmission protection (validation, verification and authorization), security and user friendliness. Technical solutions implemented in AMR/AMM/AMI systems based on PLC technology (data transmission over electrical networks) allow:

- introduce differentiated tariff systems for each consumer, changing only the software in the data collection device, without any installation work and replacing meters;
- record meter readings of an apartment building in a few seconds, remotely, without entering the premises where they are installed. At the same time, the controllers themselves lose the ability to change meter readings;
- detect electricity theft, record, and even remotely disconnect non-payers.

“Intelligent” meters, as the main element of the Smart Metering system, are an economical means of obtaining reliable information, enabling energy systems and pricing authorities to widely introduce differentiated tariffs for consumption depending on the time of day and season and to monitor and manage energy consumption through incentive tariff formation, ensuring the rational use of energy resources. AMR/AMM/AMI systems combine the activities of electricity market participants: electricity producers, suppliers, transmission organizations, distribution companies, consumers, and manufacturers of modern electrical equipment.

Conclusion. In general, “intelligent” Smart Grid networks combine elements of traditional electric power engineering and the latest electric power technologies. Comprehensive control tools (WACC – Wide Area Control System) and monitoring (WAMS – Wide Area Monitoring System), information technologies and means of communication, “intelligent” metering systems are being introduced. Such networks allow for dynamic management of electric networks (Dynamic Grid Management) and energy flow (FACTS), regulation of demand (Demand Response), installation of “intelligent” meters (Smart Metering). Such systems increase operational safety, reduce the duration of repair and emergency work, and reduce energy consumption.

It was determined that the main methods for implementing the Smart Grid concept are: integration of heterogeneous electricity sources, including renewable energy sources, into electrical systems; selection of the optimal composition of generating sources, including distributed generation; automatic detection, elimination or reduction of the consequences of accidents in the operation of electrical systems at both the local and system levels; management of electricity consumption, stimulating consumers; resistance to the impact of threats to civil and information security.

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