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STANDARDIZATION OF INTELLECTUAL LOCAL POWER SYSTEMS FUNCTIONING AT THEIR INTEGRATION INTO SYSTEMS OF CENTRALIZED POWER SUPPLY IN UKRAINE

СТАНДАРТИЗАЦИЯ ФУНКЦИОНИРОВАНИЯ ИНТЕЛЛЕКТУАЛЬНЫХ ЛОКАЛЬНЫХ ЭНЕРГОСИСТЕМ ПРИ ИХ ИНТЕГРАЦИИ В СИСТЕМЫ ЦЕНТРАЛИЗОВАННОГО ПИТАНИЯ В УКРАИНЕ

Summary: Development of power generation industry set the problem of gradual transition from traditional technologies that expect use of electric networks centralized generating to basically new solution that is directed to wide application of distributed energy sources and active networks able to provide services on transfer, keeping and transformation of electrical power. Active electric systems are able to adapt quickly to variable needs of interested parties – owners, consumers, vendors. They are considered to be the key element of infrastructure of the future “intellectual” power systems. At present all the aspects of creating “intellectual” power systems are viewed within the Smart Grid concept, the most known and popular concept for electric networks modernization.

Key words: local power systems, standard, distributed energy sources.

Аннотация*:* Развитие энергетики поставило вопрос о постепенном переходе от традиционных технологий, предусматривающих использование централизованного генерирования электрических сетей, к принципиально новому решению, которое ориентировано на широкое применение рассредоточенных источников энергии, и активных сетей, которые способны оказывать услуги по передаче, хранению и преобразованию электрической энергии. Активные электрические сети способны быстро адаптироваться к

меняющимся потребностям заинтересованных сторон - собственников, потребителей, продавцов. Они рассматриваются как ключевой элемент инфраструктуры «умных» энергосистем будущего. На сегодняшний день все аспекты создания подобных «умных» энергосистем рассматриваются в концепции Smart Grid, наиболее известной концепции электрических сетей.

Ключевые слова: локальная энергосистема, стандарт, рассредоточенные источники энергии.

Problem formulation. Today many world countries has a set of Smart Grid standards for means of relay protection, control and monitoring of main and distributed networks [1-9]. Among them special attention is paid to standards related to connection of renewable energy sources of distributed generation for parallel work with existing electric power systems. These standards are technologically neutral and universal for all types of distributed energy sources (DES) up to 10 MVA and regulate technical specification to electric power systems with renewable sources of generation. Standards include general requirements to DES at normal and emergency modes, requirements to voltage quality indicators, separate and parallel work with electric power system, requirements to connection and synchronization of DES generators, as well as specifications and requirements to design, production, assembling, putting into operation and periodic tests.

The purpose of the article. It is necessary to study the state and prospects of the implementation of intellectual local power systems in their integration into the centralized power supply systems in Ukraine, using the experience of developed countries.

Analysis of recent research and publications. Experts believe [10] that the use of modern management technologies, along with the widespread use of the latest information and communication technologies, will enable the ability to maintain demand and supply in a "smart" power grid at the level of a separate device. Smart grid will allow consumers to consciously participate in the operation of power systems, and also improve the use assets in energy and economic efficiency will

increase, the quality of electricity and the stability of power systems will increase to unauthorized external influences. Finally, the "smart" power systems will develop the new types of products and services, as well as the formation of new markets.

The statement of the main material. There are about hundred standards that relate to Smart Grid. Among them - IEC standards (“Standards for power quality” and “Flicker Standards”), CSA standards (CAN3-C235-83, 107.1/UL1741, C22.2, C.22.3, C22.1), IEEEP2030 standards and other.

Standard IEEEP2030 provides guidelines in understanding and defining smart grid interoperability of the electric power system with end-use applications and loads. Integration of energy technology and information and communications technology is necessary to achieve seamless operation for electric generation, delivery, and end-use benefits to permit two way power flow with communication and control. Interconnection and intra-facing frameworks and strategies with design definitions are addressed in this standard, providing guidance in expanding the current knowledge base. This expanded knowledge base is needed as a key element in grid architectural designs and operation to promote a more reliable and flexible electric power system [11-12].

In complex with these standards, principles of providing interoperability to power technologies, information technologies with elements of power systems, automation of end users and users loading devices are considered. The main standard that regulates DES connection to parallel work is the standard of the Institute of Electrical and Electronics Engineers (IEEE 1547) [13]. This document provides a uniform standard for the interconnection and interoperability of distributed energy resources with electric power systems. It provides requirements relevant to the interconnection and interoperability performance, operation, and testing, and, safety, maintenance and security considerations.

This document provides guidelines for smart grid interoperability. This guide provides a knowledge base addressing terminology, characteristics, functional performance and evaluation criteria, and the application of engineering principles for smart grid interoperability of the electric power system with end-use applications and

loads. The guide discusses alternate approaches to good practices for the smart grid. The standard establishes test procedures for electric energy storage equipment and systems for electric power systems (EPS) applications. It is recognized that an electric energy storage equipment or systems can be a single device providing all required functions or an assembly of components, each having limited functions. Components having limited functions shall be tested for those functions in accordance with this standard. Conformance may be established through combination of type, production, and commissioning tests. Additionally, requirements on installation evaluation and periodic tests are included in this standard.

The current standard sets up criteria and requirements for connecting DES with power network. System of IEEE 1547 standards includes a number of documents concerned with different aspects of providing interaction and coherency between distributed resources, integrated to the composition of power systems, and consists of parts:

- IEEE 1547.1 – standard for the general procedure of accordance of connecting RE to a power system.
- IEEE 1547.2 – provides detailed instructions of connection to parallel work.
- IEEE 1547.3 – requirements to information exchange, DES monitoring and control.
- IEEE 1547.4 – requirements to equipment and its exploitation in separate power systems with RE.
- IEEE 1547.5 – assigned to DES with the power higher than 10 MVA.
- IEEE 1547.6 – practical aspects of connecting DES to distributed grids.

Nowadays the process of connecting to parallel work of DES to Ukraine’s power systems does not have any clear branch regulatory guide or standard. That is why growth of DES quantity leads to worsening of technical problems regarding arrangement of their parallel work in power system – providing consistency of operation, quality of electric power, arranging dispatch control, including control of separating DES from power system, synchronizing DES with power system.

Parallel work of DES in power grids is partially regulated by rules of

connecting electricity-generating equipment to power grids, approved by regulation of National Energy and Utilities Regulatory Commission dated by 14.12.2005 with changes and attachments dated by 20.09.2007 [14]. The regulation includes just organizational moments of connecting electricity-generating equipment destined for electric power production. So, technical specifications of connecting DES to power systems are regulated by a number of regulatory documents, all-Union State Standards and Ukraine State Standards. With the aim to verify the possibility to use the experience of foreign countries, it is sufficient to compare technical specifications of IEEE 1547 standard, Germany standards [15], project of requirements of connecting DES in Ukraine [16] and acting all-Union State Standard 13109-97 «Quality standard for electric power in the systems of electricity supply of general purpose» [17] that is basic for Ukraine's energetic. Comparative analysis of requirements to quality of electric power according to provided regulatory documents is shown in table 1.1

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Table 1.1 – Comparative analysis of electric power quality indicators

Indicator	Specifications according to regulatory document			
	IEEE 1547	All-Union State Standard 13109-97	Project of requirements to connection of DES in Ukraine	Standards in Germany
Frequency deviation	Allowable frequency deviation in DES should not exceed the value from -0.2 to +0.5 GHz in synchronized systems.	Frequency deviation in synchronized systems of power supply should not exceed ± 0.2 GHz; in separate systems of power supply deviation makes up ± 1 GHz.	Frequency should retain between 49.6 (allowable critical decrease of frequency) and 50 GHz (allowable normal increase of frequency).	Frequency should retain between 47.5 (allowable critical decrease of frequency) and 51.5 GHz (allowable normal increase of frequency).
Harmonics	Maximum harmonics component of current makes up 4% for odd harmonics n $\leq$ 11.	Value of harmonic component of current is between 0,2 and 6% of $U_{nominal}$%.	Value of harmonic component of current is between 0.2 and 6% of $U_{nominal}$%.	Maximal harmonic component of current is between 0.058 – 0.04%, for odd harmonics 0.06 – 0.18.%
Voltage fluctuation	Voltage fluctuation on DES wires in normal working conditions should not exceed value from -12 to +10 %.	Normal allowable voltage fluctuation is ±5%. Allowable critical one is ±10%.	Normal allowable voltage fluctuation is ±5%. Allowable critical one is ±10%.	Voltage fluctuation within power grids on DES wires is not more than 2%.

Conclusions. Comparative analysis shows on appropriateness of solving a complex of tasks on DES functioning optimization in local power systems considering indicators of quality and loss of electric power with further conversion to a single standard. This standard will regulate connection to parallel DES work in Ukraine taking into account the strategy for developing power systems. This will expand opportunities to use DES and users' resources, as well as allow to perform local electric systems functioning optimization taking into consideration improvement of interaction between all system's subjects in real time.

Modern implementation of Smart Grid elements in many countries give the possibility to affirm that technologically such systems create preconditions for highly efficient use of DES for solving both local (maximization of profits from their exploitation) and systemic (increasing of DES functioning quality) tasks.

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