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ВЛИЯНИЕ ВНЕДРЕНИЯ ИННОВАЦИОННЫХ ТЕХНОЛОГИЙ НА ЭНЕРГОЭФФЕКТИВНОСТЬ ЭЛЕКТРИЧЕСКИХ СЕТЕЙ

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Аннотация

В данной статье речь идет о влиянии внедрения инновационных технологий на энергоэффективность электрических сетей. В процессе работы были определены основные проблемы, относящиеся к оптимизации энергосистемы нашей страны. С учётом анализа были предложены технические решения, которые смогли бы повысить качество передаваемой энергии и минимизировать ее потери.

Ключевые слова: энергоэффективность, энергоресурсы, Smart Grid, сверхпроводниковый кабель, графен, энергосбережение.

IMPACT OF THE IMPLEMENTATION OF INNOVATIVE TECHNOLOGIES ON THE ENERGY EFFICIENCY OF POWER GRIDS

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ABSTRACT

This article deals with the impact of the implementation of innovative technologies on the energy efficiency of power grids. In the course of the work, the main problems related to the optimization of the energy system of our country were identified. Taking into account the analysis, engineering solutions were proposed that could improve the quality of the transmitted energy and minimize its losses.

Keywords: energy efficiency, energy resources, Smart Grid, superconducting cable, graphene, energy saving.

At the moment, there are many discussions in the field of development and application of innovative energy saving technologies. These issues are relevant both now and in the near future and are considered at the level of state and international politics. It also covers topics related to limited natural energy resources and climate change, as well as other environmental issues that should not be silent about. The Russian Federation has its own peculiarities, it is the country with the coldest climate in the world and it has vast territories. So, it becomes more and more problematic to transport large volumes of fuel over long distances and deliver the generated energy to consumers with the least possible losses. In such conditions, there is no other way out but to reduce energy consumption for the production of electrical and heat energy, balancing the economic component.

In 2009, Federal Law No. 261-FL "On energy saving and increasing energy efficiency in the Russian Federation" was adopted. The main objective of this law is to reduce costs per unit of GDP(Gross Domestic Product) by 40% by the end of 2020 [1]. The decree of the President of the Russian Federation of December 31, 2015 No. 683 "On the strategy of the national security of the Russian Federation" came into force on January 1, 2016, and the decree of the President of the Russian Federation of May 13, 2017 No. 208 "On the strategy of economic security of the Russian Federation for the period up to 2030 " was also adopted. With regard to energy, these laws state it is necessary for the economy to ensure its energy security in the long term. And, first of all, energy security is the quality of management of the fuel and energy complex of the Russian Federation [2]. The constant rise in prices and tariffs for energy resources is directly reflected in the production process of any enterprises, municipal and residential buildings. The solution to this problem comes down to one thing - there is a need to save energy and carry out activities that contribute to saving.

Among the developments and measures that could minimize energy losses and balance the efficiency of its transmission over long distances, there is an innovative discovery called Smart Grid. An efficient, smart power system (Smart Grid) is a modernized electricity grid that uses ICT (Information and Communication Technologies) to collect information about the production and consumption of electrical energy, which makes it possible to increase the technological and economic efficiency of the continuous technological operation of the electric power system and improve the reliability of power supply to consumers (Fig. 1).

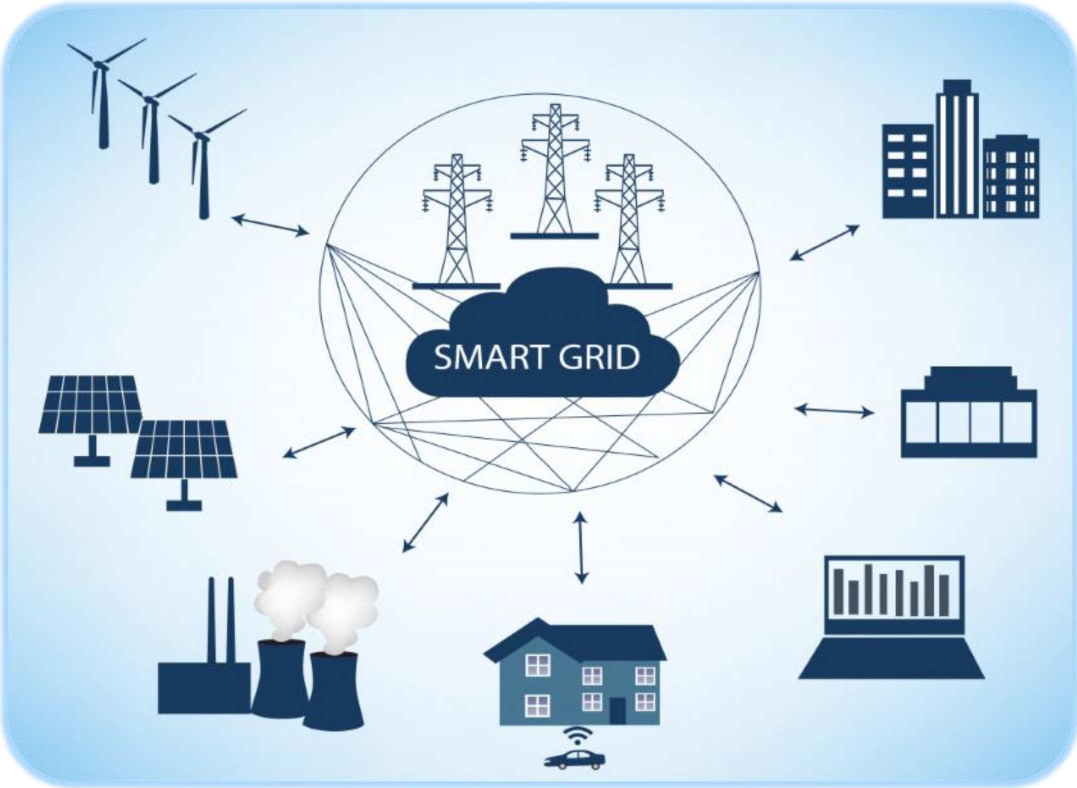

Figure 1. *Smart Grid infographic.*
[Electronic resource]. [*http://soyuz-energo.ru/informatsiya/novosti-i-stati/pozdravlyaem-s-dnem-rabotnikov-neftyanoj-i-gazovoj-otrasli-2*](http://soyuz-energo.ru/informatsiya/novosti-i-stati/pozdravlyaem-s-dnem-rabotnikov-neftyanoj-i-gazovoj-otrasli-2)

The system collects information on the production and consumption of electricity, which allows to distribute energy resources correctly and to ensure the reliability of their consumption and efficiency of use. Classic smart grids in the electric power industry have the following characteristics:

- manage the work of consumers;
- recover from failures without assistance;
- protect against physical and cybernetic external interference;
- provide power supply of the necessary quality;
- synchronize the operation of generating sources and energy storage centers;
- increase the efficiency of the power system as a whole [3].

In other words, smart power system Smart Grid in the electric power industry is a certain automated software package. It allows to distribute all available energy between consumers correctly, based on information received from all objects of the system and intermediate elements of the grids. This development ensures the stability of the power grid in terms of transmitted energy. In addition to its main function, such a smart grid is able to establish connections of consumers with new sources which may include generating sources with zero or reduced carbon dioxide emissions. The security of the entire system is achieved by reducing dependence on centralized power plants, the ability of grids and equipment to self-diagnostics and self-recovery [4].

The main task of an intelligent system is to carry out digital processing of data which gives confidence in the security and efficiency of network management.

In general, the Smart Grid project has a medium- and long-term horizon of investment payback. There is a need of a whole range of activities to make the grid cost-effective and smart.

A year and a half is required for the system to reimburse investments based on European countries experience.

Today the vast majority of innovative technologies in the energy industry has been developed abroad. Therefore, most smart systems of control and monitoring cannot be fully used in Russian grids, because there are some technological differences in the energy infrastructure of Russia and Western countries. In this regard, domestic developments in the Internet of Things, smart microgrids, systems for energy systems analysis and management have all chances to secure a foothold in a huge market that has just begun to develop [5].

Another important project also stands out from a huge number of innovative developments in the field of energy saving. It is one of the most expensive and technically complex solutions. This is a superconducting cable.

The phenomenon of superconductivity was discovered in 1911 by the Dutch physicist Heike Kammerling-Onnes [6]. He found that when reaching a certain, very low temperature, the resistance of some materials drops sharply to zero. Subsequently, a wide range of components (27 elements and more than 1000 alloys are known today), demonstrating the phenomenon of superconductivity, was discovered.

Two classes of superconducting materials have been well studied: the so-called low-temperature ones, operating at liquid helium temperatures, and high-temperature superconducting (HTSC) materials, for which liquid nitrogen is used. Products based on low-temperature superconductors have long been introduced into narrow industries, in particular, they are used in particle accelerators, thermonuclear fusion installations and magnetic medical tomographs.

In power engineering, the second class is in demand - high-temperature superconductors of the second generation (the first or second generation of HTSC - depends on the chemical compounds used). The use of liquid nitrogen in cooling systems, which is quite simple to handle, has seriously expanded the range of areas of industrial use of superconductors. The basic product of the HTSC industry is a superconducting (SC) tape (or SC wire) with a thickness of about 0.1 mm with sequentially applied layers on it. Various products are produced from HTSC tape: superconducting cables, current limiters, power plants, energy storage devices and a number of others [7]. According to experts, due to its high current carrying capacity, a high-temperature superconducting cable can transmit five times more energy than a copper wire of the same size (even with a cooling system). This property makes these cables very promising for use in megalopolises, where it is often impossible to build a new substation or dig an underground tunnel of the required diameter due to high-density development. The production of superconducting cables is quite costly, but these losses pay off within 5 years. One kilometer of a superconducting cable costs about 30 million rubles, but, firstly, it is not necessary to build an expensive cable collector for it since it is much smaller in size, and, secondly, the consumer will get rid of technical problems. This design is quite compact compared to copper cables (Fig. 2). Another advantage is a rather long lifetime - ordinary cables are reported to last about 25 years (since they operate at elevated temperatures), and superconducting ones - about 100 years (the insulation does not age because of low temperatures) [8].

Figure 2. *An example of a superconducting cable.*
[Electronic resource].
https://zen.yandex.ru/media/id/5a8575bf9b403cf16b68e7bc/sverhprovodiascaia-kabelnaia-liniia-osnovnoi-etap-ispytanii-zavershen-5a8aaec2a815f12ad9784b99

Until recently the practical application of a superconducting cable was very limited due to its operating temperatures. However, in 2021, the world's longest high-temperature superconducting cable line (HTSC CL) 2.5 kilometers long will be introduced in the power system of St. Petersburg. Electricity transmitted through this line will have practically no losses that is confirmed by large-scale operational tests carried out by Rosseti FGC UES on the basis of its scientific and technical center. The solution being implemented is the company's own development. The volume of investments will amount to 3.5 billion rubles. This technology, capable of increasing the quality level of transmitted energy, is far from the only one in the field of energy saving [9].

Lately, an innovative solution was presented to the world that shocked many scientists and experts in the field of energy and nanoelectronics - a two-dimensional crystal consisting of a single layer of carbon atoms, known as graphene (Fig. 3).

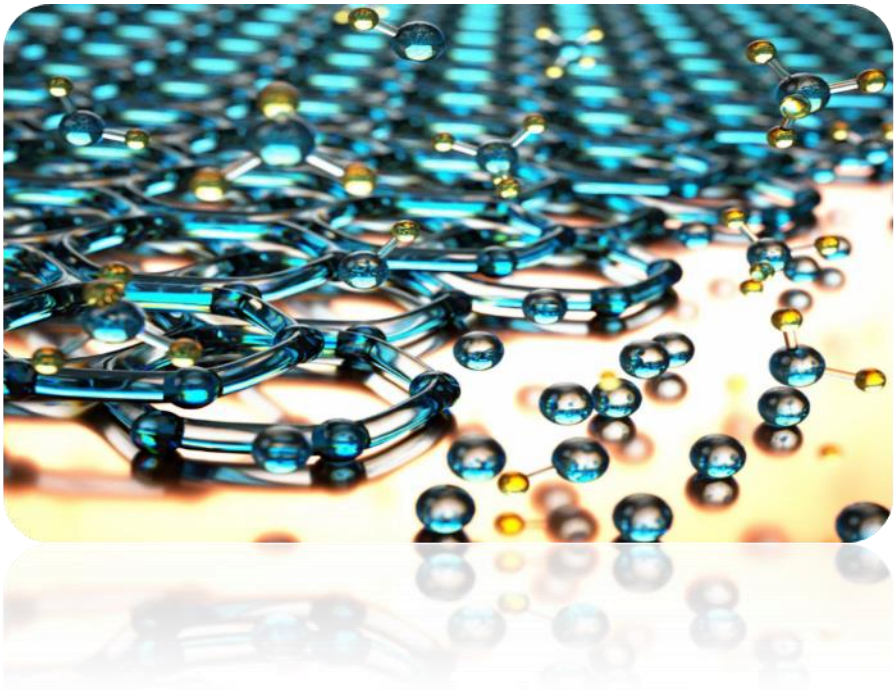

Figure 3. *Graphene model.*
[Electronic resource]. *https://naked-science.ru/article/video/grafen-mozhet-reshit-mirovoy-vodnyy*

The existence of graphene in nature is a phenomenon that became possible due to the fact that scientists found a "loophole" in the laws of physics and forced a continuous two-dimensional atomic fabric to behave like a three-dimensional material. More and more new studies are revealing useful applications of this material, and the predictions sound very encouraging: it turned out that graphene can be used to obtain an almost infinite amount of energy.

The special properties of graphene allow not only to remove heat efficiently, but also to convert it back into electrical energy. Considering the graphene plane is one atomic layer thick, it is easy to predict that the density of elements on a chip will increase dramatically and can reach 10 billion transistors per square centimeter. Graphene transistors and microcircuits, frequency mixers, modulators operating at frequencies above 10 GHz have already been implemented.

Today, scientists can say with any certainty that all devices of the future will contain graphene or another two-dimensional material in some form.It is impossible to list all the potential applications of graphene, as everyday people of different professions work on discovery of ways to use this development which will subsequently help answer the main questions of energy. Graphene is already on sale for less than one euro per square centimeter, and by 2022, according to forecasts by one of the largest graphene manufacturing companies, it will cost less than one euro cent per square centimeter. That is, a square meter of graphene will cost researchers less than one hundred euros [10].

The combination of graphene production technologies with existing technologies of microelectronics and other industries will make it possible to create a whole class of new products and materials, having a huge positive impact on the development of the electric power industry as a whole. Nevertheless, the qualitative assessment of the implementation of technologies based on the use of graphene at the moment is the main difficulty since it is still problematic for scientists to use two-dimensional material in a three-dimensional world.

Every day, innovative technologies are gaining momentum in the field of energy efficiency. Specialists who have a license for this type of activity are doing their best to make sure that every urgent problem related to inefficient use of energy is solved as soon as possible. Modern scientific developments certainly need to be applied in power grids. But their implementation is associated with various difficulties, such as labor-intensive and long-term research in this area and the use of expensive innovative materials. However, it is precisely the new technologies that must be fully implemented and timely respond to the most demanded requests of mankind related to the economy and quality of transmitted energy.

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