WORLD EXPERIENCE IN IMPLEMENTING THE ENERGY EFFICIENCY IMPROVEMENT METHODOLOGY

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Abstract. *There is an urgent problem of researching ways to improve the efficiency of energy use in enterprises. The modern development of the industry gives high priority to the use of energy-saving methods, technologies and materials in the process of modernization. One of the main reasons for this is the scarcity of energy resources, as a result of which their cost increases while the current level of consumption maintains the same. Successful renovations to improve the energy efficiency of enterprises require a systematic approach that includes the application of various methods aimed at reducing energy consumption. This is achieved through the development and use of energy efficient solutions in space-planning and design aspects, as well as through the use of energy efficient equipment and regulated energy supply systems, including non-traditional approaches. Measures to improve energy efficiency include both direct impacts on the behavior of economic entities in the field of energy saving and energy efficiency, and indirect methods that are aimed at improving the efficiency of production, transportation and use of energy resources. These measures are achieved through innovation, environmental approaches, increasing the level of manufacturability, the development of new industrial directions and other decisions related to industrial policy. This is due to the fact that "technological progress significantly affects the energy structure" . Therefore, energy efficiency measures should include not only the energy sector, but also other industries.*

Key words: *energy, energy saving methods, energy resources, energy efficiency, energy saving, innovations, manufacturability of production, energy intensity of technological operations, energy consumption structure.*

Introduction. In world practice, taking into account the priority role of the energy efficiency factor in industrial development at the present time, a certain set of vectors and an arsenal of tools have been formed that together create a system of industrial policy measures in terms of its intersection with energy conservation policies aimed at improving the efficiency of energy use. According to the results of a study commissioned by the European Commission, the global energy saving potential of industrial motors alone by 2030 could amount to 13.286 terawatt-hours (billion kWh), which is equivalent to 1,140 million t.n.e. [4]. At the same time, various measures demonstrate different effectiveness when implemented in economic practice, which actualizes a more detailed study and systematization of world experience in solving the problem of increasing energy efficiency and using it in domestic conditions. In accordance with the Decree of the President of the Republic of Uzbekistan dated August 22, 2019 No. PP-4422 «On operational measures to improve the energy efficiency of economic and social sectors, the introduction of energy-saving technologies

and the development of renewable energy sources» in order to increase the energy efficiency of the Republic of Uzbekistan by attracting existing resources and untapped potential, taking into account advanced foreign experience, energy-saving technologies and widespread introduction of renewable energy sources, It provides for a comprehensive organization of work on a sharp reduction in energy consumption of economic and social sectors, as well as ensuring the rational and efficient use of fuel and energy resources. Research on ways to improve the energy efficiency of enterprises is relevant. When carrying out reconstructive work to improve energy efficiency, an integrated approach is needed that ensures the use of methods that reduce energy supply in enterprises through the development and use of energy-efficient space-planning and design solutions and measures based on the use of energy-efficient equipment and regulated, including unconventional energy supply systems.

Materials and method. Since the problem of energy efficiency is the most important part of modern industrial policy, we have paid much attention to the study of publications of domestic and foreign researchers devoted to the methodological and conceptual foundations of the formation of industrial policy as part of the economic policy of the state. Among them: Dachs V., Feng S., Gerstlberger W., Schroter M., Markova V.D., Pluzhnik M.V., Popov A.I., Rifkin D., Romanova O.A., K.R.Allaev, G.J.Allaeva, M.S.Saidov, D.U.Mirzaraimov, S.E.Zokirov, M.S.Saitkamolov. Despite the fact that these studies are an important scientific and methodological source, to date, scientific research aimed at improving the energy efficiency of thermal power plants and improving its methodology has not been carried out enough in our republic.

Taking into account the relevance of energy efficiency in modern industrial development, a certain set of directions and tools has developed, where certain factors together constitute a set of industrial policy measures that intersects with energy-saving policy and is aimed at optimizing the use of energy resources. Moreover, almost all international energy development forecasts updated in 2018 (including the World Energy Outlook 2018 of the International Energy Agency, OPEC's World Oil Outlook 2018), the AEI's International Energy Outlook United States (International Energy Outlook - 2018) and BP's Energy Outlook (Energy Outlook- 2018) contain a change in the prerequisites for the implementation of baseline scenarios under the influence of various national plans (and related measures and instruments) to modernize energy complexes in line with sustainable development through energy efficiency, the growth of renewable energy sources, environmentally friendly and energy-saving technologies [1].

Measures to improve energy efficiency include both direct tools to influence the behavior of economic entities in the field of energy conservation and energy efficiency, and indirect means of influencing the efficiency of production, transportation and use of energy resources through innovation, greening, increasing the level of manufacturability of production, developing new industrial areas and other decisions related to industrial policy. This is due to the fact that "technological progress has a decisive influence on the energy structure" [2]. At the same time , measures to improve energy efficiency should cover not only the fuel and energy complex itself , but also other industries.

According to a study conducted by the European Commission, the global energy savings potential of industrial motors by 2030

could be 13.286 terawatt-hours (billion kWh), equivalent to 1.140 million t.n.e. [4]. At the same time, various measures demonstrate different results when implemented in economic practice, which actualizes a more detailed study and systematization of foreign experience in solving the problem of increasing energy efficiency.

The volume of global electricity production in 2010-2021, (TrW).[28]

Countries	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2010 – 2021 (%)
In the world	21579	22273	22795	23478	23910	24348	25061	25734	26738	27063	26906	28433	131,8
OECR	10988	10950	10933	10942	10891	10929	11011	11047	11227	11085	10786	11106	101.1
G7	8039	7951	7886	7937	7893	7884	7892	7871	8016	7869	7621	7778	96,8
BRICS	6996	7625	7990	8518	8873	9116	9590	10093	10738	11120	11300	12287	175,6
Europe	3866	3822	3848	3823	3752	3814	3853	3901	3901	3849	3717	3860	99,9

According to the above table, in 2021, the volume of electricity production in the world is 28,433 trillion watts, which is 31.8% more than in 2010. It should be said that in 2021, positive changes in the volume of electricity production were observed in BRICS. In particular, compared to 2020, it is equal to 108.7% and has increased almost 1.76 times compared to 2010. In 2020, the output of the OECR member countries amounted to 11 106 trillion watts, an increase of 1.1% compared to 2020. According to this indicator, the countries of the «Big Seven» accounted for 7778 TrW in 2021, which is 3.2% less than in 2020. As a result of the introduction of modern energy-saving technologies, which are gradually being introduced in the countries of the European region, the amount of electricity generated is also decreasing.

Significant institutional and instrumental experience in this area has been accumulated by the International Energy Agency, which has developed a so-called integrating strategy to ensure the use of already existing energy efficiency technologies, the application of which will double the level of energy efficiency. According to the agency's experts, the greatest attention should be paid to the mass deployment and application of the best available technologies, as this will allow: to achieve a sharp reduction in losses in all links of the chain of energy value creation, distribution and consumption of energy; achieve 50 percent of the goal of reducing carbon emissions without compromising economic growth; double the level of energy efficiency; to reduce the total volume of consumed energy resources, as well as to provide a quick economic effect, since investments in these technologies quickly pay off by reducing operating costs .

At the same time, Ghisetti and Rennings found that innovations that reduce the use of energy or materials have a significant positive impact on firms' profitability in terms of operating margins, while innovations that only reduce externalities (e.g. with emissions, CO2 or noise), significantly reduce the profitability of companies.

Along with this, many researchers note that the success of the practical implementation of a wide variety of energy saving projects is largely determined by the

[28] Prepared by the author based on information from Enerdata Intelligence+consulting/https://www.enerdata.net/.

interest rate of the loan under which the implementation is financed [5], which determines the importance of financial measures by the state as a macroregulator to strengthen the vector for the energy efficiency of industry. An equally important role is played by direct budget financing of energy efficiency programs, which, in addition to the implementation of specific projects, allows attracting co-financing in the area under consideration. It is precisely with a sharp reduction in budget expenditures in the direction of increasing energy efficiency and a reduction in subsidies for the corresponding regional programs that the difficulties of reducing the energy intensity of the economy are largely associated [6].

As world experience shows, significant progress in energy saving has been achieved by those countries that have been able to form multi-channel financing of projects and initiatives in the field of energy efficiency improvement with the participation of the state and private business, including: preliminary commercial or project financing, supplier loans, leasing, bonds, guarantees risks, credit lines from commercial banks and development banks, public energy service companies, creation of a specialized energy efficiency fund, financing of utilities, budget financing, grants with co-financing, etc. Specialized international organizations have systematized the main financial products in the field of energy efficiency, taking into account their advantages and disadvantages, and the characteristics of the sectors for implementation [7].

In recent years, researchers have given a significant place among the tools for improving energy efficiency to information measures, which include, for example, energy certificates or energy audits [8], special information and PR programs.

From the standpoint of implementing the concept of sustainable development, an important role in improving energy efficiency is played by a shift in the energy balance towards renewable energy sources and tools related to financial incentives to attract private companies to renewable energy: creating a favorable institutional framework, reducing administrative barriers, tax holidays, duty-free import of the corresponding equipment, revolving portfolio standard, etc. [9]

According to the 2017 IEA Global Report , renewable sources will account for two-thirds of total investment in the electricity industry [10]. In EU countries, renewable energy sources will account for 80% of new capacity, and wind energy will become the leading source of electricity soon after 2030 [11]. Recognizing the important role of government measures in improving energy efficiency, no less attention should be paid to the economic motivation of energy saving by specific industrial companies. [12]

According to the results of research by the company's specialists in the industrial sector, most business entities can reduce the overall energy intensity of technological operations by at least 10% with relatively small investments and by 35% with a more significant investment. In particular, "in integrated steel corporations in Europe or the United States, savings can be at least 10-15%, and in chemical companies - 10-20%" [12]. This requires a full-scale systematic recording and planning of the structure of energy consumption at each stage of the execution of technological processes, taking into account potential losses, savings, and various effects within the framework of the concept of lean production, applied directly to the field of energy efficiency.

The solution of all these tasks is possible, as noted earlier, within the framework of the Industry 4.0 concept, as

applied to specific enterprises, which is being practically implemented through the development of the industrial Internet of things, the creation of «smart factories», «smart networks», «smart wells». In this case, we are talking about the use of a whole stack of technologies, making adequate management decisions, creating organizational mechanisms that ensure the formation of effective cyber-physical systems that ensure energy saving at each stage of development, creation and sale of products.

According to experts from the International Energy Agency, in the coming decades, digital technologies will make energy systems around the world more interconnected, intelligent, efficient, reliable and sustainable. Modern advances in data, analytics and connectivity are enabling a range of new digital applications such as smart devices, distributed mobility and 3D printing. Digital energy systems in the future will be able to determine who needs energy and deliver it at the right time, in the right place and at the lowest cost. Digitalization is already improving the security, performance, availability and resilience of energy systems, while facilitating new security and privacy risks, transforming markets, business and employment, creating new business models for production/generation and consumption of energy, building interconnected energy system architectures, effectively disrupting traditional boundaries between supply and demand [13]. In terms of energy demand in the industrial complex, the use of advanced process control systems, the connection of smart sensors with analytical systems to predict the operation of equipment, the use of 3D printing to use lighter new materials, are among the priority areas for cost-effective energy saving. In turn, in the electricity sector, digitalization will save about $80 billion a year by reducing operation and maintenance costs, improving the efficiency of power plants and networks, reducing unplanned downtime, and extending the life of assets.

Thus, digitalization is an important priority for improving energy efficiency, bringing together a whole range of solutions, technologies and effects. In particular, according to experts, the effects of digitalization (subject to the full-scale implementation of digital technologies in production processes) for the oil and gas industry can be manifested in a reduction in oil and gas production costs by 10–20%, an increase in the volume of recoverable hydrocarbon reserves by 5%. This is just one example of the use of digital technologies, the potential of which covers a wide range of tasks ranging from ensuring information transparency between business entities and tax and other government agencies to optimize taxation parameters and increase the investment attractiveness of projects, to fine-tune industrial policy measures and develop competition, reducing the risk of accidents, etc. [1]

Over the past few years, investments by energy companies in digital technologies have increased dramatically. For example, global investment in digital power infrastructure and software has grown over 20% annually since 2014, reaching $47 billion in 2016. Digital investments in 2016 were almost 40% higher than investments in gas-fired electricity generation worldwide ($34 billion) [13].

Digital interconnected systems can fundamentally transform electricity markets through:

- «smart» response to demand;

-integration of various energy sources, primarily renewable;

-development of distributed energy resources, etc.

Maximizing the benefits of digital energy efficiency and addressing the associated challenges, including cybersecurity, data privacy and job loss, requires the development of appropriate macro- and meso- sectoral and cross-sectoral policies.

In turn, the digitalization of the energy subsystems of individual enterprises and organizations is determined by such factors as the complexity of the production process, the financial potential of the company, the dependence of the economic entity on the volatility of energy prices, market competition and the flexibility of supply chains. Cultural factors also influence the extent and pace of digitalization, in particular the willingness of an enterprise to take on a higher level of risk when introducing new technology or changing established business models or ways of working.

Consequently, the implementation of «smart» digital innovative solutions, the policy of economical and rational use of energy resources at the micro level requires the formation of an appropriate corporate culture and management systems, and, therefore, is largely determined by the degree of compliance with these tasks of the professional competencies of employees.

With this in mind, the tools that affect energy efficiency in industry include the methodological apparatus for an adequate assessment of labor potential, rating of employees in terms of their compliance with the tasks of improving energy efficiency, building an adequate system of motivation and assessing the quality of energy management of an industrial enterprise [15].

In line with the above, energy efficiency measures can be structured according to:

-stage of the production and distribution chain of energy resources (the importance of identifying appropriate measures is determined by the fact that about 80% of energy is usually lost before reaching the end consumer;) [4]

-method of influence (direct and indirect);

-the period of exposure and the duration of the effects; in modern conditions, when the country's leadership sets the task of transitioning the economy to another league, a technological breakthrough, it is necessary to focus on short-term and medium-term measures, without the implementation of which the backlog of the country's economy from the leading countries will only increase;

- the subject of implementation, state regulators in this case are responsible for measures that encourage energy saving and energy efficiency, and business entities - for the implementation of energy efficiency measures aimed directly at changing the relevant indicators;

-subject area, that is, technological, financial, organizational, managerial, institutional, informational; at the same time, it does not seem appropriate to draw a clear distinction and use one type of measure without the other.

Recognizing the importance of all measures and conditions for improving energy efficiency, analyzed and applied abroad, it is important to say separately that in order to dramatically change the current situation, it is also necessary to take into account the barriers that hinder energy efficiency activities, including low motivation, lack of information resources and successful investment experience. projects, as well as poor organization and coordination of work [16].

Suggestions. When researching energy efficiency measures in the industrial sector, it is important to take into account potential contradictions. First, an increase in industrial production can lead to an increase in demand for energy resources. Moreover, due to

economic growth, it is possible to increase energy consumption even with an increase in energy efficiency, that is, an increase in energy efficiency does not necessarily lead to a proportional reduction in energy consumption. Second, a reduction in the effective price of energy caused by improvements in energy efficiency may actually cause an increase in energy demand or indirectly cause an increase in disposable income. That is, some «bounce effect» may occur, limiting the effectiveness and scope of energy efficiency and energy conservation policies. With this in mind, it is required to analyze price and cross-price elasticity for energy and other goods and services, as well as general equilibrium effects [8].

According to the author's position, to a large extent, the removal of these contradictions is possible due to the interconnection of industrial policy and energy efficiency policy, therefore, changes in the structure of industry, the transition to a higher technological level of production with a lower level of energy intensity. At the same time, the structure of energy consumption in the industrial segment of the economy that has formed in the country should be taken into account. In addition, when considering measures to improve energy efficiency, it is necessary to take into account that the effectiveness of individual tools is significantly increased if they are integrated in accordance with the integration of the types of policies under consideration and the combination of various measures on a single program-targeted platform. That is, we are talking about the importance of building a systemic complex «policies - programs – mechanisms», establishing the connection «measures – effects» not only in relation to the field of energy saving, but also in relation to the industrial complex as a whole. Moreover, we are talking about the coverage of both demand and supply of the energy resources market. This is all the more important because, according to the International Energy Agency (IEA) is more than 50%, and in the field of electricity production - 80% [20].

Conclusion. As world experience shows, countries and regions have achieved the greatest success, in which measures to ensure energy saving and increase energy efficiency were applied in combination (at least 5-8 measures of a technological, economic, financial, institutional, informational nature), since they are complementary and, in the aggregate, provide a positive synergistic effect.

According to the composition and combination of measures to improve energy efficiency, researchers conventionally distinguish the «Northern European», «American» and «Asian» models, while noting at the same time approximately the same effectiveness of these models. At the same time, it should be noted that the effectiveness of measures to improve energy efficiency is determined by the current situation in the field of energy consumption, socio-economic conditions, industry specifics and the effectiveness of specific energy saving mechanisms. This actualizes the conduct of more detailed studies in the field of energy efficiency assessment and measures to improve it in relation to specific industry systems.

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