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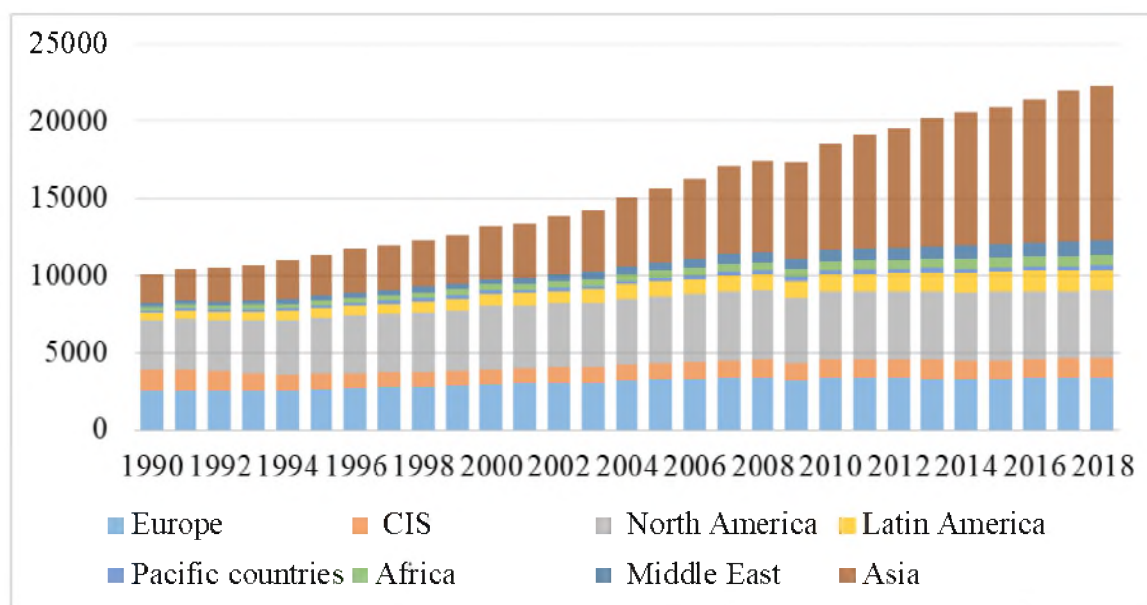
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CURRENT ISSUES OF ENERGY EFFICIENCY IMPROVEMENT IN MODERN ECONOMIC CONDITIONS

Abstract. Electricity consumption is constantly growing in the world. In this connection, there are new urgent problems of increasing energy efficiency and energy conservation. Exactly, the economic development of countries and the change in the citizens' life quality depends on successful solutions in this sphere. In addition, energy efficiency today is the most important developmental indicator of the national economy. The article discusses electricity consumption statistics in the world, a comparative analysis of the statutory conditions and the main implementing energy efficiency methods and programs in different countries.

Key words: energy efficiency; energy saving public policy; economic efficiency; power consumption, energy substitution.

Introduction. One of the largest sectors in world modern economy today is energy. Moreover, it is also the basis for ensuring the viability and states economic development [1]. For more than 27 years, electricity consumption has increased by 52% (figure). In turn, this means the improving energy efficiency relevance, which can beneficially affect both the global and national economies, businesses, the results of solving environmental and political problems, as well as individual household problems of providing electric power resources [15].



Electricity consumption by region 1990-2018

Research overview. Certainly, there is an active policy trend in the energy efficiency field in the use of natural resources. That is why a huge amount of Russian and international researches are being conducted on the topic of improving energy efficiency and energy saving [3]. Opinions of foreign and domestic authors of scientific publications on this issue are similar [20]. In fact, improving energy

efficiency is not the most difficult task. In the course of solving this problem, other questions are simultaneously determined, such as strengthening energy security, improving the environmental situation, improving the population life quality and growing the economies of countries as a whole [11]. Russian researchers talk about the failures of energy conservation measures due to the legislative power imperfection and policies in this direction. In order to overcome the existing state, it is necessary to apply a policy that would allow the government to take a confident course towards streamlining management, improving data quality and creating an organizational-legal regime that will promote long-term energy efficiency projects [6]. The experience of developed countries is of particular interest in the international community. Many countries, in modern conditions, insist on the importance of improving the energy efficiency of industries.

Currently, China is the leader in energy consumption, displacing the United States from first place. Their total share accounts for 56% of all electricity generated [16]. It is quite remarkable that, in recent years, this indicator in the United States has decreased and for 2018 is 38%. India is in the third place after China and the United States. The electricity consumption of India is about 11%. By the way, in India, the growth of electricity production on a large scale continues.

In addition, from 2009 to the present day, there has been an increase in electricity consumption in other developing countries of the Asia-Pacific region (South Korea, Thailand) [12]. Electricity consumption in Japan has been decreasing since 2012, primarily due to measures to save energy after a major accident at the Fukushima-1 nuclear power plant. However, in 2017, the increase in capacity for electricity consumption began.

In the European Union, energy consumption generally remains stable. Relative growth is observed only in Spain, Italy and Poland.

At this rate, it can be concluded that there has been a stable situation in this area. The relationship between the indicators of electricity consumption and global economic indicators is traced [2]. Another significant detail is that global energy consumption is growing faster than other energy carriers due to electrification process.

Materials and methods. The main role in the consumption of electricity by industry on a global scale is played by industrial consumers - 31% and personal electricity consumption - 34.8% (table 1).

Table 1 – World electricity consumption by industry

Sector	Tw / h			Percentage (%)		
	2000	2008	2017	2000	2008	2017
Industry	21.733	27.336	34.231	26.5	27.8	31.0
Transport	22.563	26.747	28.796	27.5	27.3	26.0
Personal consumption and services	30.555	35.861	38.471	37.3	36.0	34.8
Non-energy use	7.119	8.241	8.961	8.7	8.9	8.2
Total	87	98	110.2	100	100	100

The structure of electricity consumption in the Russian Federation is quite stable when comparing the figures of the Russian Federation with world statistics. The industrial sector accounts for about 55% of the total electricity consumption [5]. However, since 2010 this figure has been decreasing and the electricity consumption indicator by the population is growing. Moreover by 2017, it amounted to 14.2% (table 2). The smallest electricity consumption percentage belongs to agriculture and the forest industry, at around 1.6% [17]. Fairly stable sectors for electricity consumption remain transport and communications - 8.6%.

According to experts from the IEA (International Energy Agency), Russia has a potential energy efficiency ratio of around 40%. This includes both production indicators and domestic usage indicators of the electric power industry. Many Western European countries, Japan, the USA began to show close attention to the energy conservation problem more than 30 years ago [13]. These countries have managed to achieve very impressive results, such as a reduction in the energy intensity of GDP by more than 25%. They succeeded in achieving these indicators by laws and regulations on energy conservation, the creation of special governing bodies in this area, as well as the development and implementation of energy efficiency policies [18].

Table 2 – Electricity production and consumption in the Russian Federation (in billion kWh)

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Electricity generated	992	1038	1055	1069	1059	1064	1067	1069	1072
Released outside the Russian Federation	18	19	24	14	16	8	9	8	10
Received outside the Russian Federation	3	2	10	8	11	9	12	10	11
Visible consumption	977	1021	1041	1063	1055	1065	1051	1063	1066
Urban and rural population	121	127	131	137	141	146	147	149	151
Industry	533	554	568	574	565	561	563	562	561
Agriculture, forestry	15	16	16	16	15	15	16	17	16
Construction	10	10	11	11	12	10	11	13	13
Transport and communication	83	86	87	88	90	91	93	91	90
Wholesale and retail trade	112	119	120	28	30	34	31	29	31
Other economic activities				98	99	98	98	99	99
Electrical grid losses	113	108	105	105	105	107	102	105	107

The main tools for implementing these actions are:

- coercive measures (legislative acts, declarations);
- incentive measures (financial incentive measures - government subsidies, tax benefits);
- educational methods (communication with consumers, with the aim of their transition to energy-saving technologies in everyday life, the formation of a culture of using natural resources).

Results. In developed countries, various measures are being taken to interact and ensure energy efficiency (table 3) [9]. In the US, the Energy Policy Act 2005 covers all energy issues. An important feature of this legislative act is that it does not require the adoption of any additional declarations; the responsible authority is the Department of Energy (DOE).

Table 3 – Comparative analysis of energy efficiency measures

Indicators	The United States	Japan	European countries
Government laws	Energy policy act of 2005; Superior Energy Performance of 2012	Energy Conservation Center, Japan Energy Savings Act of 1979	Main Governing Bodies – States Energy Agencies
Taxes, customs, credits and other mechanisms, stimulating increase in energy efficiency and resource conservation	The American Recovery and Reinvestment Act of 2009 , Regulates tools to stimulate energy conservation. Preferential tariffs for energy payments for energy-efficient buildings. State subsidies from 50 to 200 dollars when buying a new, more energy efficient technology.	Tax program For small businesses, a tax credit of 7% of the base cost of equipment purchased. For all enterprises - a tax deduction in an amount not exceeding 30% of the base cost of equipment. Credit programs: in the case of acquisition, rental or energy-saving equipment in the amount of 270 million yen loan at special preferential rates	Tax incentives: incentive tariff for electricity and a project to create a network of smart meters; feed-in tariff program is designed to develop independent production of electricity by individuals and legal entities using renewable energy sources.
Long term tasks	Limit greenhouse gas emissions by 2050 by 83%. Reduce dependence on energy imports	Increase self-sufficiency in energy up to 70%	20% reduction in CO2 emissions; 20% of EU energy consumption comes from renewable energy sources; 20% reduction in primary energy consumption
Place in the world	2	5	From 6 to 10
Energy efficiency assessment criteria	Refusal from import of energy resources, CO2 reduction	CO2 reduction	Reduce CO2 and greenhouse gas emissions

In Japanese practice, among the measures to achieve energy efficiency, there is an extensive network of state subsidies covering the industrial, transport, and commercial sectors [13]. As an example, in the industrial sector, there is support for projects that can provide energy-efficient modernization of production. In addition, for the commercial sector, the introduction, promotion of energy-saving technologies in infrastructure, grants for the natural gas-fired water heaters introduction.

In Western European countries, special attention is paid to the Feed-in Tariff program. This program is an economic and political mechanism designed to attract investment in renewable energy technologies.

In Russia, the process of increasing and achieving energy efficiency is at the initial stages [4]. It can be considered that measures taken by the government to pursue an active energy conservation policy, for example: Decree of the President of the Russian Federation No. 889 of June 4, 2008 “On some measures to improve the energy and environmental efficiency of the Russian economy”. Resolution No. 746 - Resolution of the Government of the Russian Federation of September 5, 2011 “On approval of the Rules for the provision of subsidies from the federal budget to the budgets of entities Of the Russian Federation for the implementation of regional programs in the field of energy conservation and improving energy efficiency”. “The State Program of the Russian Federation for energy conservation and energy efficiency for the period until 2020”. “Energy Strategy of the Russian Federation for the period until 2030”.

Among the main tasks in the Energy Strategy, “the need to increase energy efficiency and reduce the energy intensity of the economy to the level of countries with similar climatic conditions (Scandinavian countries, Canada)” is highlighted. Large-scale structural economic transformations are foreseen both in the industrial sector and in terms of the production of GDP as a whole. The strategy stipulates that industries with low energy intensity, which specialize mainly in high-tech products, will develop at a faster pace [7]. The government plans to create a new growth opportunity based on manufacturing and the high-tech services sector, which have a relatively lower energy intensity. It is expected that by 2030 the share of low-energy-intensive sectors such as food, light industry, engineering will increase with 1.5 times in the structure of the industrial sector and will make up more than half of the total industrial production.

Nevertheless, there are practically no real ongoing actions and measures for industry, transport, the housing and utilities sector, and infrastructure facilities. In accordance with paragraph 21 of Article 381 of the Tax Code of the Russian Federation, “organizations regarding newly commissioned facilities having high energy efficiency are exempted from property tax”. This is almost the only incentive mechanism in the field of energy conservation. State subsidies to regional budgets for energy efficiency and energy saving programs are provided, however, there is no working mechanism for implementing actions [8].

There are a number of problems that impede the increase in energy efficiency in Russia:

- macroeconomic: inadequate project financing, energy prices, economic forecasts of growth and fall;
- problems of the state regulation;
- insufficiently developed institutional sphere;
- problems in creating public information systems;
- difficulties in organizing statistical observations.

Today, according to experts, Russia has a rather large potential in the field of energy efficiency. According to average estimates, it amounts to more than 40%, however, it is necessary to review a number of issues and turn to world experience in solving this urgent problem, mainly by creating specific mechanisms for implementing existing regulatory legal acts and programs. Long-term goals in this area can help achieve such measures as determining tax and credit policies, attracting investments, as well as creating an extensive system of government subsidies for specific measures to improve energy efficiency in both production and the housing and communal sector, and introducing preferential tariffs for industries that switched to Energy Saving Technologies.

The purpose of the prospective formation of the fuel and energy balance of Russia and its effective use can be attained. However, for this it is necessary to increase the level of energy efficiency and energy saving. The modern development of the Russian economy is characterized by the relationship of energy saving and energy efficiency for many enterprises in the industrial sector. As applied to the gas industry, it can be said that energy efficiency is considered as an indicator representing the ratio of the total profit received from the use of energy resources to the total cost of using certain types of energy resources in the production and technological process of gas production and use for certain period [13].

Over the past few years, in the vast majority of developed countries, the relative price of production has been falling as a result of the development of innovations. All innovations are provided and improved by computing power, the pace of development and diffusion of innovations is unprecedentedly fast [10]. Artificial intelligence has achieved significant success due to the rapid growth of computing power and the availability of colossal amounts of data. The value of storing information is currently approaching zero (storing 1 GB today costs less than \$ 0.03 per year compared with \$ 10 thousand two or twenty years ago).

Discussions. Developed and developing countries are focusing on the use of biofuels and improving the technology itself [19]. Due to investments aimed at research and development of alternative and renewable energy sources, it is planned to increase energy efficiency and energy saving (table 4).

Table 4 – Energy Conservation Measures in Developed Countries

Country	Tax benefits	Governmental support
Germany	Enterprises engaged in the production of energy-efficient technologies and high-tech equipment are exempted from taxes partially or completely. When reconstructing residential premises with increasing thermal characteristics, the owner receives a 20% discount on tax payments.	Active state stimulation of the solar and wind energy
Denmark	The tax calculation depends on the amount of carbon contained in the fuel.	Heating supply law
Finland	–	Financial support by the government for the transition to energy-saving energy technologies and energy-efficient equipment. The use of local fuels (peat, wood processing waste) is stimulated by the Government.
Norway	Carbon tax	Investments in technologies related to the production of aluminum and ferroalloys.
Japan	Coal tax is cancelled	installing solar panels, 1/3 of the cost of work is returned to homeowners
USA	–	Energy benefits for energy-efficient buildings. 20% of the cost of work aimed at increasing the energy efficiency of residential buildings is financed by the government. Energy efficiency audit of enterprises.
France	life-line tariffs for the use of energy-efficient equipment and technology.	Investment support for renewable energy projects. Partial refund for the purchase of energy-efficient equipment and technology.
Brazil	–	Financial support for the production of biofuels (ethyl alcohol) using sugarcane.

Another fuel to use is the natural gas. Efficiency of usage such energy sources is strongly depend on the specific conditions of the region [14]. Natural gas is used in many sectors of the economy: to obtain electricity and heat, to meet the household needs, as automobile fuel, as raw material for the chemical industry. Russian gas is a cheap and therefore widely used type of fuel. An analysis of the structure of consumption of initial energy carriers in the Russian economy shows that the grain of gas exceeds 50%, and the grain of gas used as fuel for thermal power plants accounts for over 70% (table 5).

Table 5 – Gas consumption structure by consumer categories

Category	Percentage (%)
Oil industry	39.5
Power industry	14.9
Agro-industrial complex	11.2
Cement industry	10.0
Household consumers	8.5
Auto-agricultural machine-building	7.5
Metallurgical industry	5.5
Population	2.1
Other industries	0.6
Compressed natural gas turnover	0.1

Natural gas is one of the important components of fuel and energy resources - this is the third place of use in production. The share of its consumption is significant in various sectors of the economy. Therefore, the gas industry of Russia, being the basis of its fuel and energy complex, is so important for the growth of the country's economy [6].

The character of gas consumption and special features of the gas powered equipment allows using it at the peak hours, because there are low costs of turning it off and on frequently. The majority of other types of power systems consume colossal loads at the peak hours that lead to rapid equipment wear. These facts are fraught with an increase in accident rate if the gas power equipment will not become widespread. The trend will be strengthened due to continued economic growth and underfunding of energy. Therefore, given the geographical and economic features of Russia, it is advisable to use natural gas at the peak of electricity consumption. It can be used for combined-cycle gas turbine (GTCC) or Gas Turbine Compressor Set. CCGT is the future of energy; analysis of global trends indicates that the construction of CCGT has a high economic meaning. It has the highest efficiency of converting thermal energy into electrical energy in comparison with all other methods, it generates less harmful emissions into the atmosphere, relatively low cost of construction and installation, high maneuverability, the highest coefficient of performance (COP) in comparison with all other methods of converting thermal energy into electrical energy. Russia has huge reserves of associated gas; the development of natural gas substitution technologies at the peak of electricity consumption is a very promising direction in the development of the energy conversion industry.

Conclusion. In conclusion it must be said that generally all the measures related to increase the energy efficiency and saving energy resources can be divided into three main areas:

- 1) saving the raw material base,
- 2) saving in the production process,
- 3) saving fuel and energy resources by the use of renewable energy sources.

Also to have the balanced energy system every country and every government has to analyze their specific opportunities and generate the optimal strategy in energy production, it means that different energy sources must be used according to their specific features and characteristics of the equipment. As for Russian energy system the natural gas may be successfully used in the peak hours because of wide availability of this type of fuel and high level of mobility gas powered generating capacity according to its turn off/on time and costs.

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ҚАЗІРГІ ЭКОНОМИКАЛЫҚ ЖАҒДАЙДА ЭНЕРГИЯ ТИІМДІЛІГІН АРТТЫРУДЫҢ ӨЗЕКТІ МӘСЕЛЕЛЕРІ

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АКТУАЛЬНЫЕ ВОПРОСЫ ПОВЫШЕНИЯ ЭНЕРГОЭФФЕКТИВНОСТИ В СОВРЕМЕННЫХ ЭКОНОМИЧЕСКИХ УСЛОВИЯХ

Аннотация. В мире постоянно растет потребление электроэнергии, в связи с этим появляются все более актуальные проблемы повышения энергоэффективности и энергосбережения, именно от их решения зависит как экономическое развитие стран, так и качество жизни граждан. Кроме того, энергоэффективность на сегодня является важнейшим показателем развития экономики государства. В статье рассмотрена статистика потребления электроэнергии по странам мира, выполнен сравнительный анализ нормативно-правовых баз и основных методов реализации программ повышения энергоэффективности различных стран мира и России. Предложены меры по замещению энергии природным газом.

По оценкам специалистов МЭА (Международного Энергетического Агентства) управление энергоэффективностью в России в сравнении с другими мировыми лидерами потребления электроэнергии неудовлетворительное, коэффициент потенциальной энергоэффективности находится на отметке в 40%. Сюда входят как показатели производства, так и показатели бытового использования электроэнергии. Пристальное внимание к проблеме энергосбережения многие западноевропейские страны, Япония, США начали проявлять уже более 30 лет назад. Этим странам удалось добиться весьма впечатляющих результатов – снижения энергоемкости ВВП на более чем 25%. Достичь данных показателей им удалось по средствам внедрения нормативно-правовых актов об энергосбережении, путем создания специальных органов управления в этой области, а также благодаря разработке и реализации политики энергоэффективности. Важным результатом, полученным в статье, является обзор и систематизация таких инструментов, применяемых в мире. Основными группами инструментов повышения энергоэффективности являются:

принудительные мероприятия (законодательные акты, нормы, декларации); стимулирующие мероприятия (меры финансового стимулирования – государственные субсидии, налоговые льготы);

просветительские методы (общение с потребителями с целью их перехода на энергосберегающие технологии в повседневной жизни, формирование культуры пользования природными ресурсами). В развитых странах мира принимаются различные меры по взаимодействию и обеспечению энергоэффективности, эти меры систематизированы в статье.

В статье выделены основные ограничения и тенденции развития энергетической отрасли в современных экономических условиях. За последние несколько лет в подавляющем большинстве развитых стран происходит падение относительной цены средств производства в результате развития инноваций. Все инновации обеспечиваются и совершенствуются за счет вычислительной мощности, темпы развития и распространения инноваций оказываются беспрецедентно быстрыми. Искусственный интеллект достиг существенных успехов благодаря стремительному росту вычислительных мощностей и доступности колоссальных объемов данных. Стоимость хранения информации в настоящее время приближается к нулю. Развитые и развивающиеся страны концентрируют свое внимание на применении биологического топлива и улучшении самих технологий. За счет инвестиций, направленных на исследования и развитие альтернативных и возобновляемых источников энергии, планируется повышение энергетической эффективности и энергосбережения. Выбор специфических источников энергии существенно зависит от тех особенностей, которые характерны для конкретной страны или региона, данные особенности также проанализированы в статье. Одной из возможностей, в частности в российских условиях, является рост использования генерирующих мощностей на газовом топливе. В силу особенностей газового оборудования такой энергоноситель в современном мире будет целесообразно применять для замещения электроэнергии в пики потребления. Генерирующие мощности, использующие другие типы энергоносителя, могут испытывать существенные перегрузки либо требовать длительного времени и затрат на пуск и остановку. В свою очередь, применение парогазовых установок или газотурбинных установок можно назвать будущим энергетикой, они имеют самую высокую эффективность преобразования тепловой энергии в электрическую в сравнении со всеми другими способами, формируют меньше вредных выбросов в атмосферу, характеризуются относительно низкой стоимостью строительства и установки, высокой маневренностью, самым высоким коэффициентом полезного действия в сравнении со всеми другими способами преобразования тепловой энергии в электрическую. Поэтому в статье отдельно анализируется статистика потребления газа и делаются выводы о перспективах его использования для повышения энергоэффективности в зависимости от географических и экономических особенностей стран.

Ключевые слова: энергоэффективность, энергосбережение, политика государства, экономическая эффективность, энергопотребление, замещение энергии.

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