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WORLD EXPERIENCE OF THE ELECTRIC POWER INDUSTRY RESTRUCTURING

Problem statement. According to the forecasts of the International Energy Agency, in the world primary energy consumption will increase by an average of 1.3% per year, which will lead to 46% growth to 2040 [1]. This is primarily due to the increase of the population, the growth rate of the economy, per capita income and the development of technologies that entail the availability of a large number of household appliances and equipment, as well as inevitably increase in demand for energy-intensive products – cars, air conditioners, etc.

The growth of industrial production and power consumption will inevitably lead to an increase in the amount of greenhouse gas emissions to the atmosphere, which in turn will lead to pollution and deterioration of the overall environment. In order to provide energy with ever-increasing demand and raise the level of energy security without allowing global climate change, the world energy system has to undergo a number of serious transformations. Taking into account the tendency of many countries of moving to a competitive electricity market, energy saving technologies and renewable energy sources, the relevance of this article is determined by the need to study the world experience of restructuring the industry with the aim of improving the global energy industry as a whole.

Analysis of recent research and publications based on the problem under consideration. Systematic approach and methodological basis for solving the problems of enterprises restructuring are highlighted in

the works of V. N. Burkova, I. I. Mazur, V. N. Trenev, D. V. Sokolov, And M. B. Sokolowski, A. K., Tutunjian, M. J. Jenneskens, T. Rantalainen, M. Hammer. Issues concerning enterprise restructuring in the electricity industry are analyzed in detail in the works of A. A. Tukenova and V. V. Khlebnikov [2-6]. However, despite the high degree of theoretical development and practical use of the electric power industry restructuring methods, the need of development an integrated approach determines the relevance of research on this topic.

The main aim of this work is to analyze the world experience of restructuring the electricity industry.

The research object is modern methods of the electricity industry restructuring in different countries.

Presentation of basic material of the research. Energy is not only a fundamental branch of the economy, determining its real limits and opportunities, but also one of the most conservative industries. Since the cost of large power plants building is estimated at billions of dollars, and the project lifetime is at least 30-50 years, we can now confidently imagine what the world energy industry will look like in the middle of the century - as now, the foundation of our energy will be a fossil fuel, primarily hydrocarbon.

Over the past decade, electricity production in the world has grown by almost 1.5 times, reaching 24.5 billion kWh in 2015 (fig. 1).

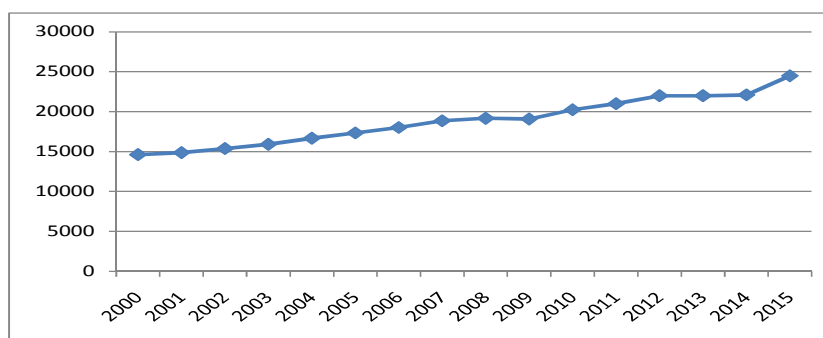


Fig. 1. World production of electricity for 2000-2015, billion kWh

Note: compiled by authors on the basis of World Energy Statistics (Yearbook 2016) <https://yearbook.enerdata.ru/world-electricity-production-map-graph-and-data.html>.

The largest electricity producers in the world are China and USA, which generate about 5,649 and 4,297 billion kWh respectively and significantly outstrip other countries in this indicator [7]. Over the past decades,

there have been significant regional shifts in electricity generation. The share of developed countries has reduced significantly, from 73% in 1973 to 49% in 2016. At the same time, the share of the developing countries

of Africa, Latin America and Asia, especially China, grew from 3% of the world's electricity production in 1973 to more than 20% in 2016 [7].

An essential step during studying the pace of the electric power industry development is the analysis of factors, which influence the increase of electricity consumption. The first factor in increasing power consumption is global population increase. To assess this, we need to plot the global population and the energy consumption on the same figure (fig. 2).

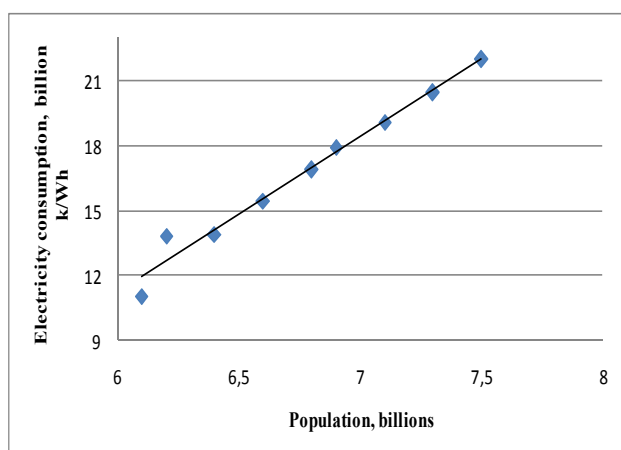


Fig. 2. Electricity consumption and population growth

Note: BP Statistical Review of World Energy, 2016 <https://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2016/bp-statistical-review-of-world-energy-2016-full-report.pdf>, Population.Pyramid.net <http://www.populationpyramid.net/ru/мир-земля/2015>.

The figure shows that the population of the planet increased during 2000-2016 from 6.1 to 7.5 billion people by more than 22%, and world energy consumption – from 11 to 22 billion kWh. There is a direct correlation between the growth of the population and the increase in electricity consumption. Another prerequisite for growth in consumption is an increase in the pace of economic development. To analyze how the growth of per

capita GDP affects the increase in power consumption we need to chart the next figure (fig. 3).

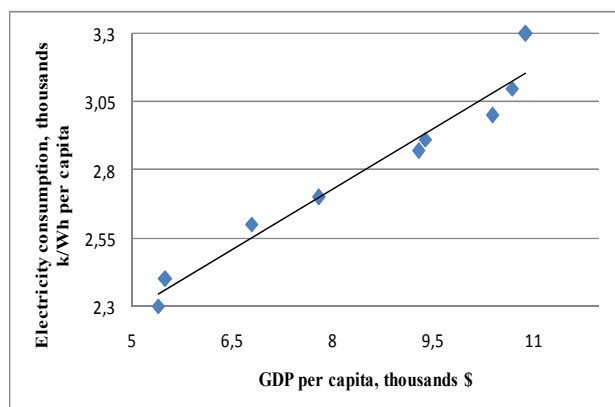


Fig. 3. Electricity consumption and population growth

Note: BP Statistical Review of World Energy, 2016 <https://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2016/bp-statistical-review-of-world-energy-2016-full-report.pdf>, Population.Pyramid.net <http://www.populationpyramid.net/ru/мир-земля/2015>.

Over the past 15 years, that per capita GDP has doubled, while energy consumption per capita increased from 2.3 to 3.3 thousand kWh per capita by more than 43.5%. Thus, we can conclude that GDP is growing more rapidly than the increase in electricity consumption per capita. In other words, the level of the country's economic development can cover production costs and electricity consumption. However, attention should be paid to the ecological component of this increase, since large incomes of the population can result in the availability of a variety of household appliances and equipment, which consume a large amount of electricity and have a detrimental effect on the state of the environment.

We need to analyze the structure of GDP growth and outline in which countries an increase in GDP per capita leads to a greater increase in electricity consumption, depending on the level of their economic development (fig. 4).

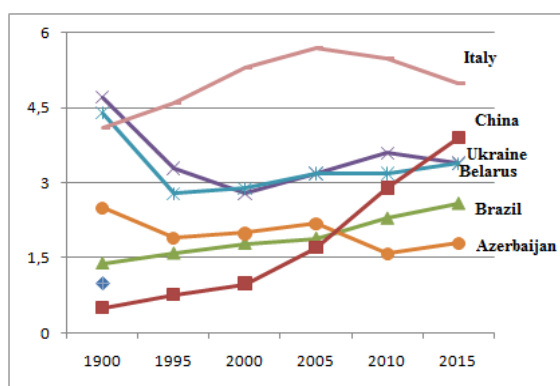
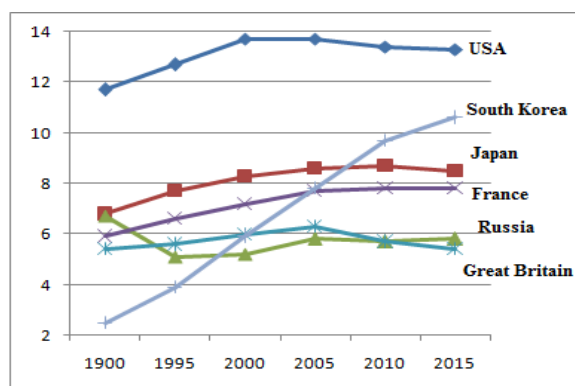


Fig. 4. Dynamics of electricity consumption per capita by country, thousands kWh per capita

Note: International Energy Agency (IEA Statistics © OECD/IEA, Energy Statistics and Balances of Non-OECD Countries and Energy Statistics of OECD Countries <http://www.iea.org/stats/index.asp>, <http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC>.

Analysis of per capita electricity consumption by countries for the period 1900-2015 showed a significant difference in the rate of increase in consumption, depending on the level of economic development of the country. So, against the background of insignificant economic growth of developed countries such as Japan, Britain, France, Italy and Spain, some of which have already reached the upper limit of domestic energy consumption, the demand for hydrocarbon fuel in large developing countries, primarily in China, has increased. Based on the analysis of the figure 4, all the above-mentioned countries should be divided into three groups according to the level of electricity consumption per capita:

1. Countries with rapidly growing energy consumption are mainly developing and some former socialist countries – South Korea, China, and Brazil.

2. Countries with a relatively stable high level of consumption and small fluctuations in energy consumption are almost all countries that have long embarked on the path of post-industrial development – Great Britain, France, USA, Japan, Italy.

3. Countries with a reduction in energy consumption are countries that have not yet fully overcome the consequences of the crisis, in which the reduction in energy consumption was caused not by the introduction of advanced energy-saving technologies, but by the economic and structural crisis, mainly post-soviet countries – Russia, Ukraine, Azerbaijan, Belarus and etc.

The third factor affecting the level of energy consumption per capita depends mainly on the level of technology development and the constant increase in the number of cars per capita. So, the very high level of energy consumption per capita in the US and Japan is due to the exceptionally high level of increase in the number of cars among the population. Compared with North American indices in the industrially developed countries of Western Europe, per capita energy consumption is 2-2.5 times lower and grows poorly, mainly due to intensive introduction of advanced energy saving methods, technological innovations, active improvement of heating systems and insulation of premises, and gradual curtailment of the most energy-intensive industries – primarily the mining and metallurgical and large chemical industries.

It is also necessary to pay special attention on the environmental component of the power industry reform, since the main drawback of modern hydrocarbon energy is emissions of a huge amount, about 30 billion tons / year, of carbon dioxide, which is the main greenhouse gas, negatively affecting the planet's climate (fig. 5).

If we compare the growth of CO₂ emissions with increasing energy use, we will see that greenhouse gas emissions grew more slowly than energy consumption in the period from the 70s to the 90s, then the lines increasingly diverge. This discrepancy is the result of energy reform in many countries and changes in the struc-

ture of the fuel balance, where the share of nuclear power and natural gas has increased, compared to coal during the period under review. Since 2000, the two lines have been running approximately parallel, indicating that there is no further reduction in CO₂ emissions and a predicted increase in the concentration of greenhouse gases that enter the atmosphere when fossil fuels are burned during electricity generation. The increase in energy consumption can lead to catastrophic changes in the environment, affect the climate of the planet and worsen the state of the atmosphere as a whole. Therefore, it becomes obvious the huge scale of the efforts necessary for the successful reform of the industry. Obviously, huge efforts are required/necessary for the successful reform of the industry.

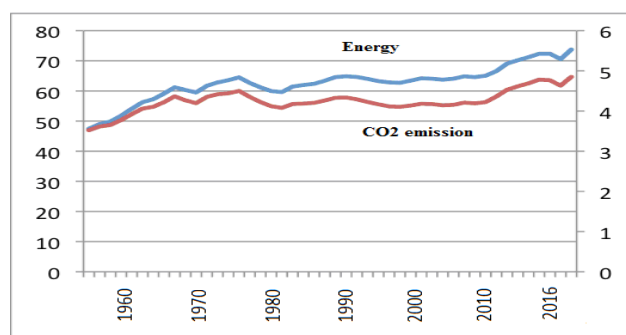


Fig. 5. Dynamic of the primary energy consumption per capita (Mtoe) and CO₂ emissions (metric tons per person)

Note: compiled by authors on the basis of BP Statistical Review of World Energy, 2016 <https://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2016/bp-statistical-review-of-world-energy-2016-full-report.pdf>.

Having a strategic importance, the electric power industry in all countries is subject of state regulation, because the enterprises simply can not cope with constantly arising difficulties by themselves. Therefore, all methods of restructuring must be ensured by state regulation in order to protect the most important interests of the industry, regardless of the degree of liberalization in a particular market. In countries with vertically integrated state monopolies, the main subject of regulation should be tariffs for electricity. In countries where electricity prices are set by the market, greater emphasis should be placed on providing equitable access to transport networks for all producers. The world experience in reforming the electric power industry shows the use of various mechanisms and ways of restructuring in different countries. However, all existing methods can be divided into the following five groups: organizational, method of combining markets, financial, fiscal and environmental:

1. Organizational method. This method by separating the monopoly functions from the competitive unit – the functional division of generation, transportation and sale of electricity – makes it possible to liquidate natural

monopoly structures and introduce competition into the production of electricity. This is due to the fact that recent advances in technology and production of generating capacities have led to the fact that medium-sized power plants proved to be quite competitive in comparison with large power plants that are part of the giant structures of existing vertically integrated companies. Therefore, smaller investors were able to build independent generating capacities and conduct their own commercial activities.

Such a way of reforming the electric power industry was used in the UK, where, as a result of the division of the monopoly company, private power generation companies and sales companies were formed, which allowed to build their own power generation capacities in order to increase the efficiency of meeting the demand for electricity and reduced the load of existing generating capacities. Also, examples of the most successful liberalization of the generation market can be found in Argentina, where through the disintegration and privatization of the largest electric power stations, strict regulation systems for permissible electricity transmission tariffs were created, and the total government revenues from the privatization of the electric power industry exceeded 10 billion dollars [8]. Due to vertical disintegration in many countries, it was possible to reduce electricity tariffs, so in some US states the price of electricity fell by 7.96% [9].

2. The method of combining the energy system. The need of reducing the high tariffs for electricity, as well as the internationalization of global markets, aimed at creating a single economic space, has set the task of many countries to reorganize their own energy facilities. To solve the problems, the method of combining the energy system was used, the main purpose of which was equalization of loads, smoothing of peaks and optimal use of different energy sources for electricity generation. In winter, more electricity is produced by wind farms located in the northern countries, which are part of this system, in summer – by solar power plants that operate in the southern countries. A vivid example of such system is the Scandinavian countries, where an efficient infrastructure for the functioning of the market was created resulted from the separation of public vertically integrated companies [10]. Thus, the result of the Nordic electricity reform was the creation of a common electricity market, the so-called Nord Pool, the successful operation of which improved the reliability of the region's energy systems, leading to a reduction in the significant difference in electricity prices in various regions.

3. Financial method. In our opinion, one of the most reasonable ways to support the use of renewable energy is the provision of investment preferences. Investment preferences may include the full amount of grants. Exemption from customs duties is due on import of equipment and components to it, imported for the im-

plementation of the investment project. State full-scale grants can include land plots, buildings, structures, machinery and equipment, computers, measuring and regulating devices for production using RES. In the event that investment obligations are in compliance with the contract, the property is granted to the investor in the property free of charge. For instance, each year the government of the USA allocates 67 billion \$ for the development of renewable energy technologies, and state R&D grants to enterprises that generate electricity using solar, wind and geothermal energy rather than fossil fuels. In a number of countries, such as France, Germany, Luxembourg and the Netherlands, an accelerated depreciation rate is applied that grants eligible businesses the opportunity to write off investments in energy efficiency projects faster than other investments, which makes it possible to reduce arrears in a short period of time.

4. The fiscal method. The government of the country should pay special attention to non-traditional, clean energy sources, and introduce energy-saving technologies. The combination of financial-tax and industrial policies is aimed at improving the structure of production and raising its level, which is possible when certain laws and tax incentives are adopted. Preferential taxation as the main instrument for stimulating the development of renewable energy is used in many developed countries, such as Germany, the United States and France, where the most effective way to ensure energy conservation is to adopt laws on tax incentives. In this way it is possible to provide tax rebates on the costs of acquiring equipment or services leading to energy savings. In a number of countries, such as Belgium, Denmark and France, a state fund for investing in energy-saving measures has been established. As a rule, the interest rate set by the fund is lower than under normal commercial conditions, which is equivalent to a concessional loan.

5. The ecological method. This method, first of all, includes the introduction of energy saving technologies and the transition to renewable energy sources – solar, wind, hydro power of rivers. The advantage of renewable energy is due to the fact that they do not lead to a change in the climate of the planet and to global warming, in contrast to fuel fossils, which, when burned, emit harmful substances into the atmosphere.

World experience shows that the developed countries began to support and stimulate non-traditional energy, through the implementation of federal development programs, within which various privileges and preferences for this sphere are provided. Today, in the United States, there are already three cities that have completely switched to renewable energy – Aspen, Burlington, Vermont. Germany produces about 14% of energy in installations using biomass, geothermal and solar energy and plans to increase this share to 25-30% by 2030 [11]. The economic use of geothermal sources is

common in countries such as France, Italy, the USA, New Zealand, and Iceland. For example, in Iceland, five thermal geothermal power plants are successfully functioning, due to which 26.5% of electrical and 90% of thermal energy is produced in the country [11]. In the newly industrialized countries of South-East Asia, much of the energy-saving measures are financed by the state itself, which most often installs energy equipment that corresponds to the non-industrial sphere, allocates targeted interest-free loans or subsidies to the owners of residential buildings for the acquisition of materials in accordance with existing standards of energy saving technologies.

Conclusion. The analysis of the global use of electricity has made it possible to identify the dependence of electricity consumption on the population and the level of economic development, as well as the effect of increasing energy consumption on the state of the environment. Based on the identified problems, the world experience in the restructuring of the electric power industry was studied and methods for reforming the industry were proposed. These methods were combined into five groups: an organizational one, a method of consolidating markets, financial, fiscal and environmental. The carried out researches in the field of tools of reforming the electric power industry will, firstly, lead to the construction of such a system of electricity markets that will create incentives for competition, improve efficiency, and also contribute to the development of the industry, and secondly, the considered environmental methods of reforming the industry will reduce environmental pollution, by switching to energy-saving technologies and renewable energy sources in order to improve the energy security and environmental friendliness of the industry.

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Шабаліна Л. В., Булавка О. Д. Світовий досвід реструктуризації електроенергетичної галузі

У статті виявлено фактори, що впливають на споживання електроенергії в світі. На основі вивчення світової досвіду реструктуризації електроенергетичної галузі виділено п'ять груп методів щодо підвищення її ефективності: організаційний, консолідації ринків, фінансовий, податковий та екологічний.

Ключові слова: реструктуризація електроенергетики, перехід на поновлювані джерела енергії, енергозберігаючі технології, навколишнє середовище, тариф на електроенергію.

Шабалина Л. В., Булавка Е. Д. Мировой опыт реструктуризации электроэнергетической отрасли

В статье выявлены факторы, влияющие на потребление электроэнергии в мире. На основе мирового опыта реструктуризации электроэнергетической отрасли выделены пять групп методов повышения ее эффективности: организационный, консолидации рынков, финансовый, налоговый и экологический.

Ключевые слова: реструктуризация, электроэнергетическая отрасль, возобновляемые источники энергии, энергосберегающие технологии, окружающая среда, тариф на электроэнергию.

Shabalina L., Bulavka E. World experience of the electric power industry restructuring

The article reveals the factors affecting the electricity consumption in the world. Based on the study of the world experience in the restructuring of the electric power industry, five groups of methods are identified to improve its efficiency: organizational, consolidation of markets, financial, tax and environmental.

Keywords: restructuring of the electric power industry, transition to renewable energy sources, energy-saving technologies, environment, and electricity tariff.

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