

Article

Modern Trends in Global Energy and Assessment of the Ever-Increasing Role of Digitalization

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Abstract: The global changes which are affecting countries at the moment act as a ‘censor’ of modern energy relations and energy market development strategies in general. The development of the energy market is no longer considered in terms of its efficiency but more in terms of its survivability under the influence of external environmental factors and its ability to maintain an acceptable level of energy safety. In order to fully balance a country’s internal interests and increase its competitiveness in the global energy market, the importance of the problem of choosing a development strategy—following the path of energy independence or cooperative development—is becoming evident. The purpose of this paper is to identify an effective energy strategy for a country under the influence of contemporary challenges. The object of the study is the Russian energy market and the energy companies as its key players. In this context, it examines the situations where Russia and other energy market players are unequally affected by external environmental factors. Particular emphasis is placed on the possibility of overcoming the negative impact of environmental factors during the implementation of measures aimed at ensuring energy safety, achieving a better environmental situation in the country by reducing CO₂ emissions, and strengthening the country’s position in the global energy market by changing its own energy development strategy. The dependence of the financial outcome of the energy complex companies of the Russian Federation on the factors of the external and internal environment was determined as the main direction of the study. The financial outcome of the Russian energy complex companies in this article serves as a landmark indicator of energy market development. The working hypothesis of the research is the authors’ claim that it is necessary for modern energy companies in Russia, as important participants in the energy market of the country, to transform their strategy in the direction of deepening cooperation under the influence of external and internal environmental factors. The methodological and theoretical framework of this study consists of classical and modern economic science, covering the analysis of energy market dynamics and structure, as well as the theories aimed at selecting the most effective strategies under the influence of external and internal environmental factors. The study is based on the works of domestic and foreign scientists devoted to the issues of competitiveness, strategic planning, and sustainable development in the context of total digitalization. Within the framework of the conducted research, we used methods of system and factor analysis; statistical research methods, in particular the analysis of dynamic changes, as well as correlation and regression analysis; and methods of comparison, analogy, and generalization. An important source of data on the financial result of companies in the Russian energy sector was the materials of the Federal State Statistics Service of the Russian Federation. As a result of this paper, a notable influence of external and internal environmental factors is determined. Among the most significant factors, digitalization is identified as a development trend. It also represents a driver of improvement in Russia’s energy market, both in terms of improving its competitiveness and environmental safety and in terms of strengthening the country’s leadership position in the global energy market. In addition to the findings, this article provides a theoretical contribution and recommendations for the development of theoretical ideas concerning the choice of an effective strategy for the development of Russia’s energy market. Future research directions are also considered, and the implications of the presented analysis for further research are discussed.

Keywords: digital energy; digital transformation; global energy; digitalization; digital technologies in the energy sector; energy economy; geopolitical changes



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1. Introduction

The energy sector is an integral part of the fuel and energy complex. Its sustainable functioning largely ensures the energy safety of the country and contributes to the progressive development of the economy [1]. S.Z. Zhiznin writes: “Global energy safety is usually understood as a long-term, reliable and economically acceptable supply of an optimal combination of different types of energy for sustainable economic and social development of the world, with minimal damage to the environment” [2]. Obviously, this approach replaces the problem of supplying the national economic system’s necessary energy resources with the global economy as a whole [3] (pp. 173–186). However, the current energy market dynamics imply a structural change, which in turn has led to the need for some kind of energy independence [4] (pp. 90–100), given the different interests of countries in the world market influenced by the geoeconomic and geopolitical environment. In particular, in Russia it seems important to achieve such goals as “ensuring technological independence of energy sector and sufficient competence in all activities critical for sustainable development of energy, with increasing the level and expanding the areas of global technological competitiveness of Russian FEC,” as described in the Energy Strategy of Russia for the period until 2035 [5].

In the context of energy safety, it is important to understand that the activities of FEC companies play a systemic role in providing resources for economic and public needs [6] (pp. 2485–2496).

The FEC largely determines the development of Russia’s economy and social sphere. The fuel and energy sector were the highest contributors to our GDP and provided two-thirds of the country’s export earnings, as well as generating huge rent payments that funded half of Russia’s budget. Russia’s fuel and energy complex has grown over the past 30 years, primarily in terms of oil and natural gas production and refining. Russia’s share in the global fuel and energy complex is three times higher than its share in the economy. At the same time, it is 5.5 times higher for gas and almost 4 times higher for oil. By its share in fuel and energy exports, Russia’s indicators are 5 times higher than in total exports, including oil exports at 15 times higher, oil products 6 times higher, coal 8 times higher, and gas 9 times higher [7].

The energy sector, known for its slow pace of transformation, is in the process of a dynamic changeover. The urgent need to put challenges such as climate change, energy poverty, and energy safety at the core of the development and industrial strategy has led to the widespread acceptance of renewable energy sources and associated technologies as a key solution. The share of renewable sources in electricity generation is shown in Figure 1.

Thanks to political factors, technological developments, and international cooperation, these technologies have ceased to occupy a limited niche and have become widely used, especially in the last ten years. Even in the midst of the COVID-19 pandemic crisis, renewable energy systems have demonstrated remarkable resilience: electricity systems that use a high proportion of solar and wind energy have confirmed their technical reliability [9]. The evolution of solar and wind power by region, shown in Figure 2, reflects an upward trend. In 2021, electricity generation from renewables continued to grow steadily (+16% in wind and +23% in solar), while global power generation from renewables remained robust (+93 GW in wind and +133 GW in solar). In 2021, total offshore wind power capacity more than tripled (+21 GW) to almost 56 GW, owing largely to China (+17 GW).

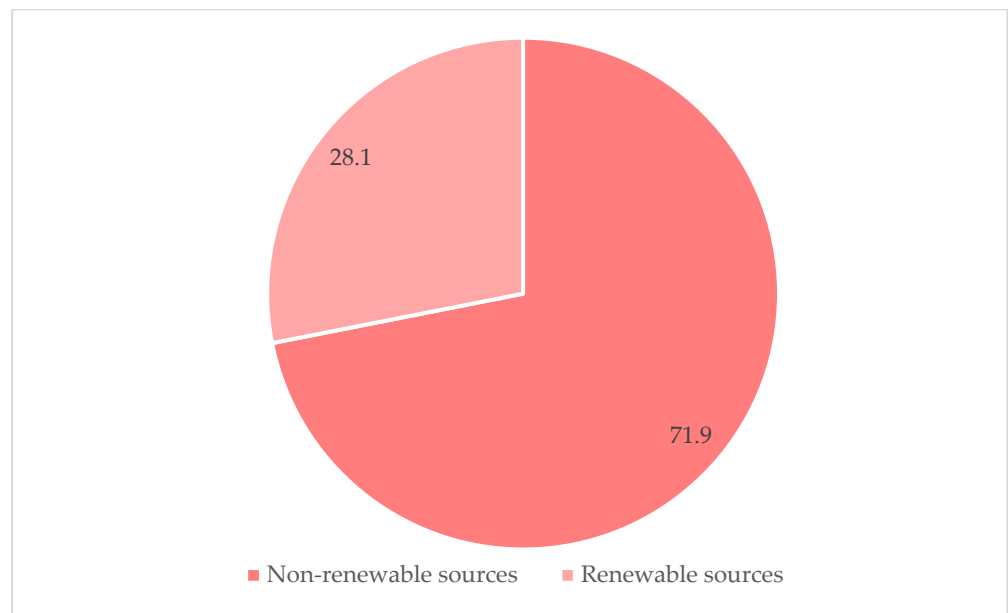


Figure 1. Share of renewables in electricity generation. 2021 r., % [8].

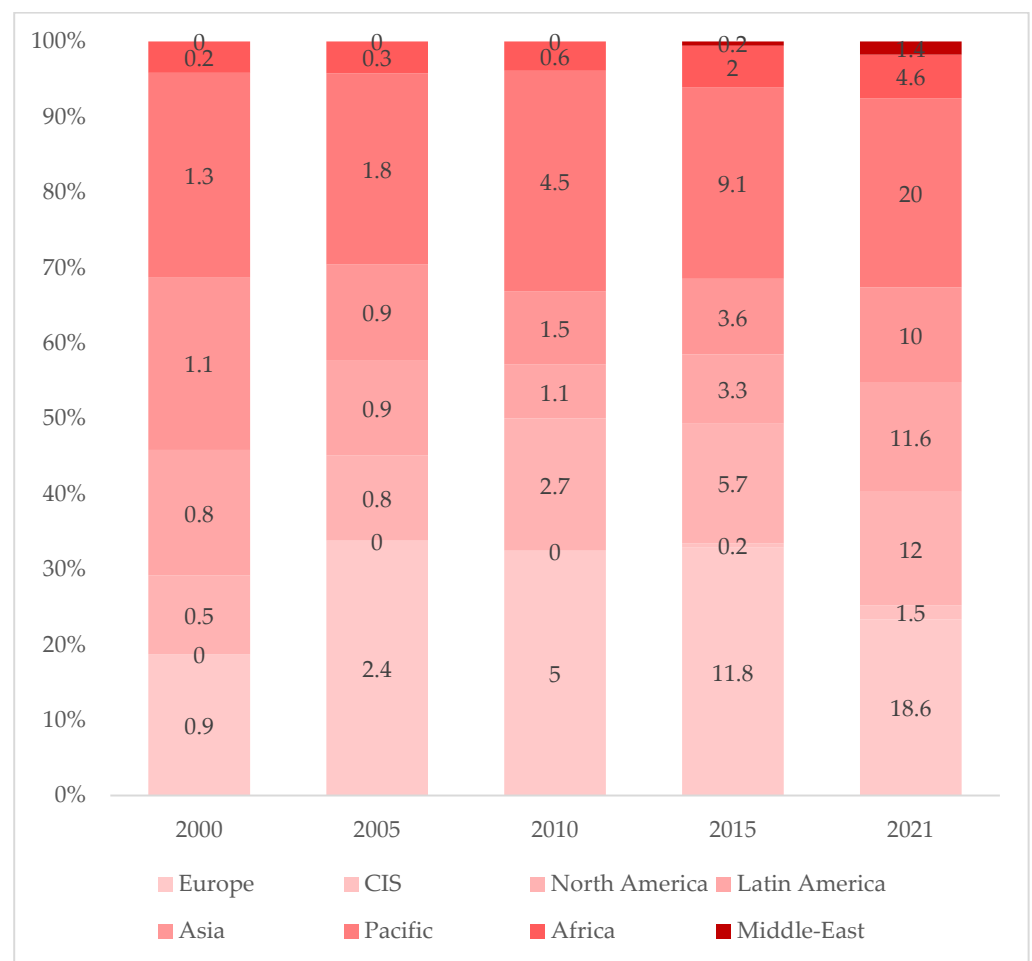


Figure 2. Share of wind and solar energy in electricity generation by region, 2000; 2005; 2010; 2015; 2021, % [10].

Despite the increasing growth of development strategies such as energy independence, international cooperation is also quite relevant and more attractive for less developed

countries and small island developing states [9]. In the area of renewable energy, the growth of cooperation is also evident. An example is the cooperative development within the EAEU [11] (pp. 78–112). The general need to develop and implement new technologies throughout the energy cycle, as well as in specific sectors of the fuel and energy complex, predetermines an objective concern for the formation and deepening of research and production technology cooperation as one of the pillars of the sustainable development of the energy complexes of the Union member states in the common market format. All this is determined by the global trend associated with the dynamic growth of innovative energy technologies and services markets, including the development of renewable energy. Technological cooperation appears as a significant addition to the areas of energy cooperation of the EAEU countries highlighted in the literature, such as joint work on the development of the mineral resource base, the development of new oil and gas fields, etc. [12] (pp. 50–58).

Among the factors in favor of a cooperation strategy are the increased development opportunities associated with synergies, the possibility to accumulate investments, and the development of technology transfer aimed at becoming efficient in terms of digitalization. The latter, in turn, is of significant interest to the scientific community, due to the growing need for digitalization as a driver for improving the efficiency of both the production processes of fuel and energy companies as well as the managerial and organizational processes.

Broadly speaking, digitalization is the conversion of information and measurement results into a numerical format, after which they can be processed, stored, and transmitted electronically. The stages of development of digitalization processes in the energy sector of a country have always been driven by scientific and technological progress: the emergence of new equipment and technologies have immediately affected all aspects of the functioning of enterprises in this sector [13].

The greatest transformational potential of digitalization lies in its ability to break down the boundaries between the energy sector, increase flexibility, and integrate the whole system [14] (pp. 360–363).

The energy sector is at the heart of this transformation, with the digitalization blurring the boundaries between production and consumption and opening up four interlinked opportunities:

- (1) Intelligent demand response;
- (2) Integration of variable renewable energy sources;
- (3) Introduction of smart charging for electric cars;
- (4) The emergence of small distributed energy resources, such as residential solar photovoltaic cells.

These are interlinked, e.g., demand response is important to provide the necessary flexibility to integrate more production from variable renewables [15] (pp. 273–279).

One of the main areas of digitalization in the energy sector in the Russian Federation is the modernization of production facilities, the implementation of information, and digital technologies that improve the operational cycle of production in the energy efficiency management of residential and non-residential housing and utilities, which can reduce the amount of heat and electricity consumption by the population in different regions of the country [16] (pp. 19).

In addition to the production aspect, the authors consider digitalization as a qualitative change in business processes or economic activities (business models) through the introduction of digital technologies, with significant socio-economic repercussions [17] (pp. 217–220).

According to Weigel P. and Fishedick M., digitalization is a process that started decades ago and is constantly accelerating. Three key categories of digital apps have been identified in the energy sector: “System Balance”, “Process Optimization”, and “Customer Orientation”, each containing many individual digital apps [18] (pp. 5350). On this basis, the context of digitalization has been extended from manufacturing to management and trading.

Most energy companies have developed digital strategies and are gradually adopting technologies—digital deposits, cloud technology, big data, artificial intelligence, and remote surveillance. However, the whole process is highly indirectly related to the energy transition and looks more like ordinary industrial automation aimed at reducing costs and improving the efficiency of business processes. The concept of digital energy, including the energy transition, implies the creation of a new business model, with a new structure of interaction between the main actors and new services. The application of digital technologies in the Russian energy sector does not fundamentally change industrial processes but only automates them. Since the application of technologies in the industry is just beginning, there is no information about the effect obtained, even tentatively. The companies have only approximate values of the planned effect upon completion of all stages of the strategy [19].

Regarding the current state of the scientific agenda for energy market development in general and strengthening the role of individual countries as participants in the energy market in particular through digitalization (both in the development of cooperation and in the development of energy independence), there is a lack of unity of approach in the subject area, and the analytical activity is mainly intuitive, but even this allows prioritizing digitalization in the current changes in the external environment. Despite this, the current situation does not allow the accumulation of knowledge about the choice of effective development strategies by individual countries in the energy market in order to make comparisons and to timely identify and correct a development strategy in the presence of advantages both in the field of energy independence and in the field of cooperation. Thus, based on current theoretical bases, the priority role of digitalization is highlighted, which is achieved, according to the authors, by deepening the cooperation between countries, which accelerates the accumulation of financial resources and knowledge, aimed at the development of technological equipment and digitalization of the whole country. This makes it essential, both theoretically and methodologically, to find a preferred methodology for analyzing the development of countries in the energy market under the influence of external and internal environmental factors.

The foregoing leads to the conclusion that the current state of the energy market is now more connected than ever with the geopolitical relations between countries. The protracted nature of the current global crisis has led to a reduction in projections for economic growth and energy consumption, while growth in the share of developing countries has accelerated considerably.

Given that Russia is one of the most significant players in the energy market, the importance of effectively managing the current repercussions of the country's leadership is extremely high. The changes to which the energy market is currently exposed include reductions in energy production as well as in energy consumption, and the accumulation and conservation of energy inputs to countries. In addition, the ever-growing process of energy market transformation plays a significant role in adjusting the patterns of partnerships and changing the partners themselves. In the current situation, digitalization is becoming increasingly important as a driver for new competitive advantages. However, problems more related to Russia, such as the lack of necessary technologies on the basis of which digital transformation would be possible, make the need for cooperation between countries urgent. Accordingly, the chain of reasoning in this article is as follows: The current stage of energy market development under the influence of volatile external factors is in urgent need of digital transformation. The latter is made possible through cooperation between countries in the field of technology transfer.

The development of Russia's energy market towards cooperation seems promising in terms of deepening cooperation with China, a country that is one of the leaders in modern digitalization. Figure 3 shows the dynamics of China's digital economy over the period of 2005–2020, as well as its share in GDP.

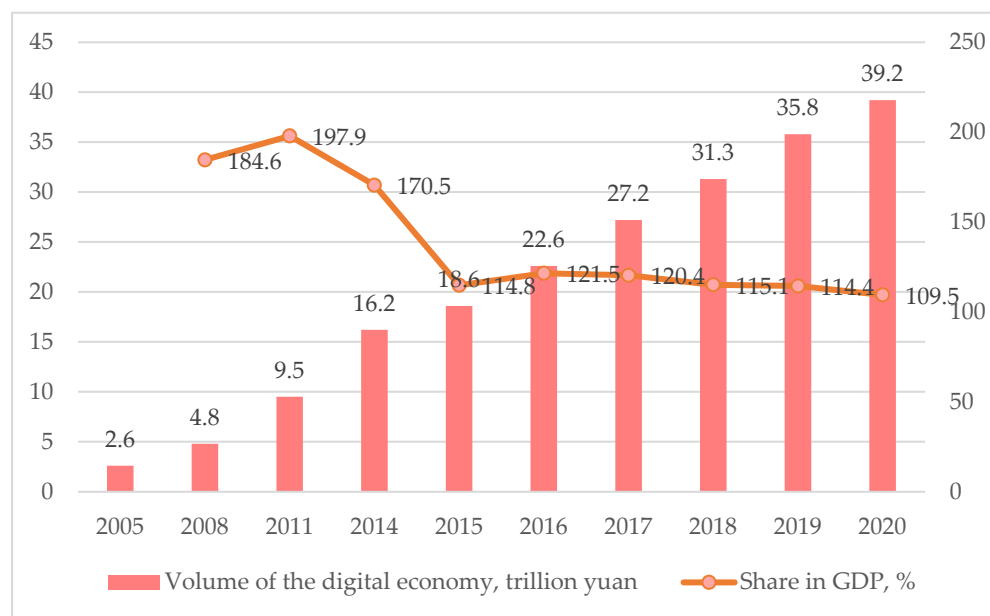


Figure 3. Dynamics of China's digital economy and the digital economy's share in GDP (latest period to previous period), 2005–2020 [20].

China's successful implementation of its digital strategy has been facilitated by high government spending on education and research, and incentives for the private sector to engage in the innovative market. The rapid growth in digital competencies of an overwhelming number of Chinese people influenced by the fast-growing digital supply of services and virtual goods by the BAT ecosystem, including the three Chinese multinational mega-corporations Baidu, Alibaba, and Tencent, should also be taken into account [21] (pp. 11–25).

Cooperation is possible both in the direct import of technology into Russia, with which the latter can improve its own production process, and in the intelligent exchange of information and experience, which will have a positive impact on improving management and trade processes through their digitalization. The synergy of cooperation efforts will mean increased dependence on the one hand and the strengthening of countries on the other, which will lead to a stronger market position and generate additional competitive advantages.

2. Materials and Methods

The scientific rationale for the conceptual features of energy market development in the context of changes in the global economy (under the influence of geopolitical and geoeconomic factors) should be based on a structured and formalized theoretical basis of modern cooperation processes. Thus, this article provides a categorical and conceptual apparatus, which is further used for practical understanding of the topic; provides a number of the authors' definitions aimed at defining the role of digital energy in the process of solving current problems, as well as the reasons for its emergence and the need for it in the modern development of countries; and proposes the scientific ideas of scientists and researchers concerning the role of the cooperation of countries in achieving the need to maintain a place in the energy market under the influence of modern factors.

Based on the stated hypothesis of the research—which is an attempt to prove the necessity of transforming the strategies of modern energy companies in Russia as important participants in the energy market of the country to deepen cooperation under the influence of external and internal environmental factors—an analysis based on “top-down” and “bottom-up” approaches, which differ from each other by the direction of analysis (from macroenvironment to microenvironment and vice versa), was implemented. Application of these approaches will make it possible to realize the hypothesis, proving it as fully and objectively as possible, by applying external and internal environmental factors and assessing them in two ways.

The first approach we apply in this paper is a top-down statistical review of the energy market dynamics in recent years. It captures key energy market trends globally, identifies the structure of the energy market, and identifies the trend that acts as the “keynote” to deepen competition in the market. The analysis of the elements presented shows how strong the need is to maintain the cooperative relations of some countries with others and what role a country can play in pursuing an energy independence strategy.

The second approach we use in this paper is the “bottom-up” approach, which focuses more on the microeconomic factors that shape the dynamic changes. We will break down the hypothesis into a number of parts, the most important of which is to prove the existence of a link between energy companies’ overall financial performance and external and internal environmental factors. The object of the analysis in this case will be energy companies, i.e., energy generation companies, heat and power grid companies, whose main function is to provide consumers with their electricity and heat.

The research methods applied in this approach were:

1. Correlation analysis, by means of which we analyzed the relationship between the indicator “Aggregate financial result (billion RUB)” and external and internal environmental factors, to which we attributed:

- Revenue (billion RUB);
- Number of employees (thousand people);
- GDP (billion RUB);
- Annual average discount rate of Central Bank of Russia;
- RUB/USD exchange rate;
- World natural gas price index;
- World oil prices (RUB/bl);
- Inflation index;
- Advanced production technologies developed (units);
- Share of domestic R&D expenditure (billion RUB);
- Share of domestic R&D expenditure in the ICT sector in total domestic R&D expenditure (billion RUB);
- Number of patents for inventions granted by Rospatent to Russian applicants per 1 million inhabitants;
- Brand-new technologies as a share of the total number of advanced production technologies developed;
- Number of researchers performing R&D per 10,000 people employed in the economy.

These factors were chosen because they reflect the influence of a large number of areas: finance, economic growth, and internal processes, in particular staff numbers and revenue levels, as well as indicators of digitalization as one of the most important trends in the development of the energy market.

The correlation analysis was based on data from Rosstat and the Central Bank of Russia.

The analysis period was 10 years—from 2012 to 2021. This time period was chosen as it allowed us to assess the state of the sector after the financial and economic crisis in Russia (2008–2010); before, during, and after the currency crisis in Russia (2014–2015); and before the current economic crisis in Russia (2022), caused by changes, primarily, in Russia’s relations with foreign countries, which resulted in sanctions on the economy, and the links with permanent partners were damaged.

2. The second method of analysis was regression analysis. To implement the application of this method, the factors that had a correlation weight of 85% or higher in accordance with the previous table (results of correlation analysis) were selected, and a linear regression model was built using them, which can be used as a projection tool. By substituting data for future periods, it is possible to get a projected value of the level of aggregate results of energy companies under the influence of individual factors.

Based on the identified dependencies, a conclusion was made about the priority of the energy independence strategy as the most attractive one for Russia in the current context, or the strategy of cooperation.

Having identified the importance of the role of cooperation as an element of energy market development under current conditions of total tensions and changes in the structure of the energy market, an algorithm was designed to improve the current energy strategy of the Russian Federation by deepening cooperative relations with China.

In terms of the scientific novelty of the study, the following elements were identified:

1. Defining the features of the current stage of energy development in the world;
2. Characteristics of the geopolitical and geoeconomic factors of the energy market development and disclosure of Russia's place in them, taking into account the current reality;
3. Conducting a study of digitalization as a driving force for the development of the energy sector;
4. Assessment of practices applied in developed and developing countries to support and stimulate the digital transformation of the energy sector;
5. Conducting a comparative analysis of measures to support and stimulate the digital transformation of the energy market in the world;
6. Identification of the impact of global challenges within the chosen research area on the energy sector of the Russian Federation;
7. Structuring the key factors affecting the global energy market at the present time and identifying Russia's place in it;
8. By introducing correlation and regression analysis, finding an answer to the question of how much the modern energy market depends on external and internal factors and what role cooperation can play in the process of its improvement;
9. Development of an algorithm for digital transformation of the energy sector as a factor of maintaining stability in the market;
10. Proof of the importance of cooperation between countries in the current energy crisis;
11. Based on the results of the analysis of the best practices for the introduction of digital technologies in the energy sector, as well as the identification of factors that currently have the most impact on the energy market, the formulation of recommendations for the implementation of policies in the field of the digital transformation of the energy market through more active cooperation between countries.

3. The Priority of Choosing a Strategy for the Development of the Russian Energy Market under the Influence of Modern External and Internal Uncertainty Factors

3.1. Analysis of Modern Challenges Affecting the Energy Sector

Global energy markets are changing dramatically. Technological advances create fundamentally new opportunities in the production, transportation, and consumption of energy. Inter-fuel competition is rising, approaches to regulating energy markets are changing, the range of energy resources used is diversifying, and major market participants are reconsidering their strategies. The 21st century has witnessed a huge transformation of the global energy industry.

At the beginning of the century, high energy prices stimulated scientific and technological progress, resulting not only in increased inter-fuel competition but also in greater competition between conventional and unconventional sources of hydrocarbons and intensified energy conservation, thus limiting the growth rate of global energy consumption. In these years, the global community has articulated the need for climate change mitigation, driving efforts to limit the role of fossil fuels. At the same time, the architecture of global energy markets is changing rapidly, with a redistribution of roles between the key market players, with new players emerging and new regional markets forming, and existing markets changing their rules of behavior [22].

The rare confluence of geopolitical, economic, and technological factors the world is now facing will probably affect the lives of generations to come. The shocks may shake social and political stability in some countries and weaken the planet's ability to withstand the most serious long-term problem—climate change [23] (p. 2). The trend of the latter is in

Figure 4 and describes the carbon dioxide emissions resulting from the global combustion of fossil fuels and industrial processes.

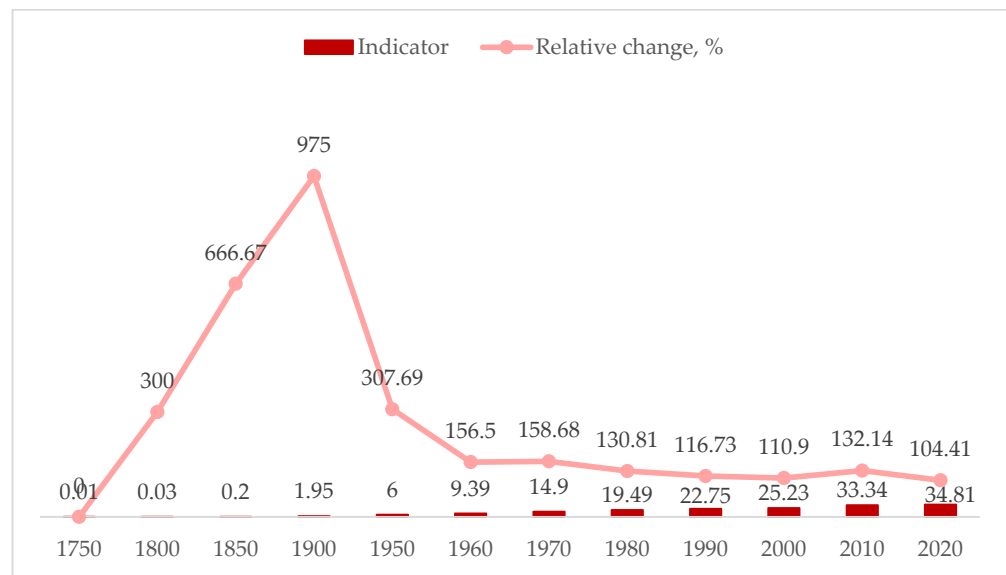


Figure 4. Historical carbon dioxide emissions from global fossil fuel combustion and industrial processes for a 50-year period (from 1750 to 1950) and for a 10-year period (from 1960 to 2020), in billion metric tons [24].

The trend is negative, given that carbon dioxide emissions are decreasing all the time. As a greenhouse gas, the carbon dioxide in the air affects the heat exchange of the planet with the surrounding environment, effectively blocking the re-radiated heat at a range of frequencies, and thus contributes to the formation of the planet's climate [25] (pp. 229–251). Despite this, their levels have risen significantly in recent years, reaching 34.81 billion metric tons in 2020.

Energy-related carbon dioxide (CO₂) emissions from natural gas, liquids, and coal have steadily increased since 1990. Emissions from these fossil fuels are projected to continue rising over the coming decades, reaching record highs by 2050. Natural gas emits about 50 percent less CO₂ emissions than coal, the most polluting fossil fuel. Carbon dioxide emissions by fuel type are shown in Figure 5. CO₂ emissions from the energy sector account for more than 40 percent of global CO₂ emissions from fuel combustion.

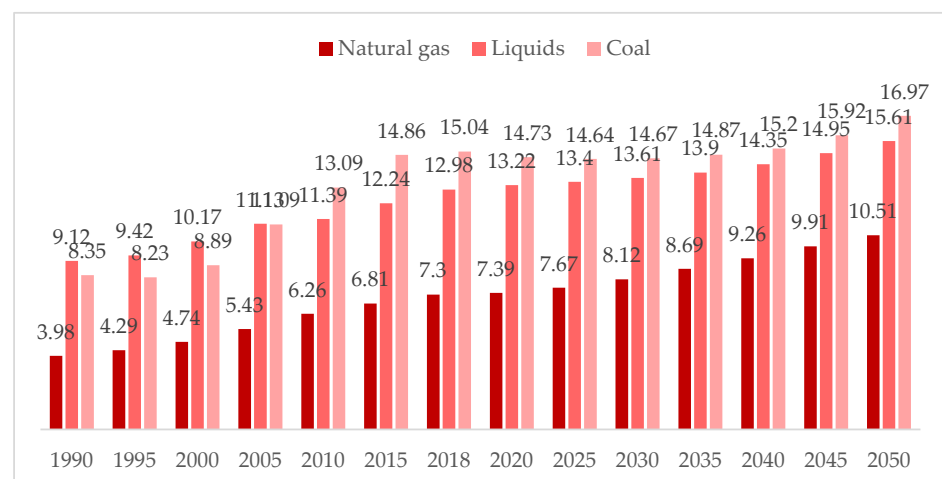


Figure 5. Energy-related carbon dioxide emissions worldwide from 1990 to 2050 (where the forecast data are from 2020) by fuel, in billion metric tons [26].

China is by far the largest source of CO₂ emissions from coal combustion worldwide. China produced about 10 billion metric tons of CO₂ in 2021. Coal consumption in China is significantly higher than elsewhere in the world, which explains the significantly higher emissions from this energy source (Figure 6).

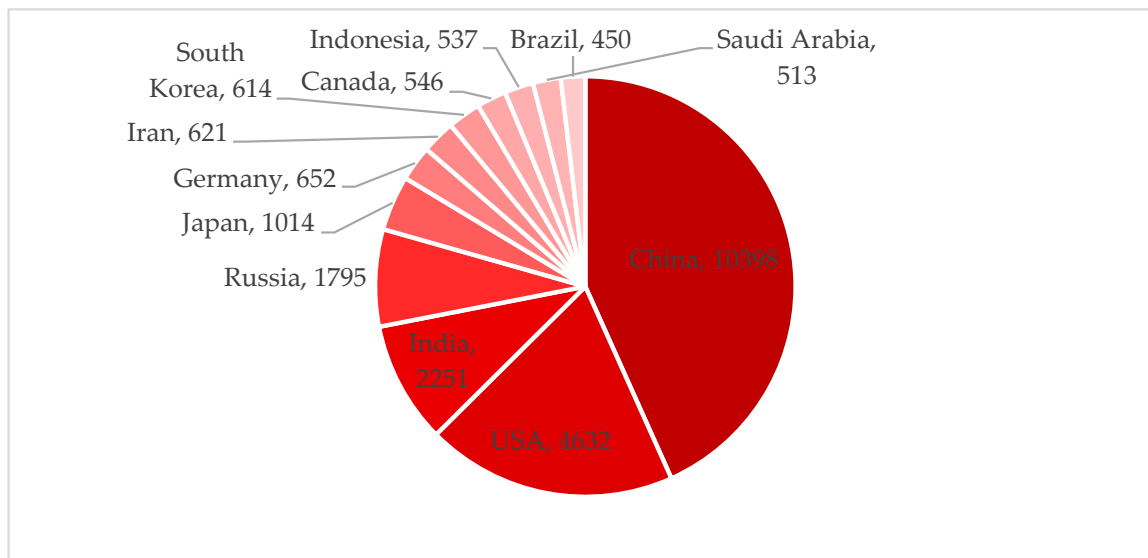


Figure 6. Structure of CO₂ emissions from fuel combustion by country, 2021, billions of metric tons of CO₂ [27].

Among the largest emitters, only Australia's CO₂ emissions are on a downward trend (−3.6%), mainly due to a 4.3% reduction in the energy sector (scaling back the ratio of coal- and gas-fired power plants in favor of solar and wind power). In Japan, the level of CO₂ emissions continues to rise at a controlled pace (+0.8%).

A notable surge in CO₂ emissions can be observed in Brazil (+14%, an increased use of gas power plants, higher consumption, mainly oil, in the transport sector), Russia (+9.5%, record demand for gas, particularly in the power and industrial sectors), and to a lesser extent in the United States (+6.2%). In Russia alone, the level of emissions increased (+156 MtCO₂) by almost as much as in the whole EU, where more than 70% of the increase in CO₂ emissions is accounted for by Germany, France, Italy, and the Netherlands.

Next, the energy developments will be analyzed and the key factors influencing them will be identified. We will also identify the link between global energy developments and climate.

3.2. Statistics of Changes in the Energy Sector

After falling by 4.5% in 2020, global energy consumption has recovered by 5% in 2021. Global energy consumption rebounded with a 5% increase in 2021 after a 4.5% decline in 2020 in the context of a global pandemic. This rebound is 3 points above the annual average of 2% over the period of 2000–2019. In value terms, global energy consumption in 2021 will exceed 2019 levels. Energy consumption increased in most countries: +5.2% in China (after +2.2% in 2020), +4.7% in India (after −5.6% in 2020), +4.7% in the United States (after falling by −8.6% in 2020), +9% in Russia (after −4% in 2020), and +4.5% in the EU (after −6.8% in 2020). Energy consumption also increased in most regions: +9% in the CIS, +5% in Latin America, +7% in Africa, but not in the Middle East (−0.4%) and the Pacific region (−2.5%). Based on the developed research method, Figure 7 shows the dynamic changes in energy consumption by region.

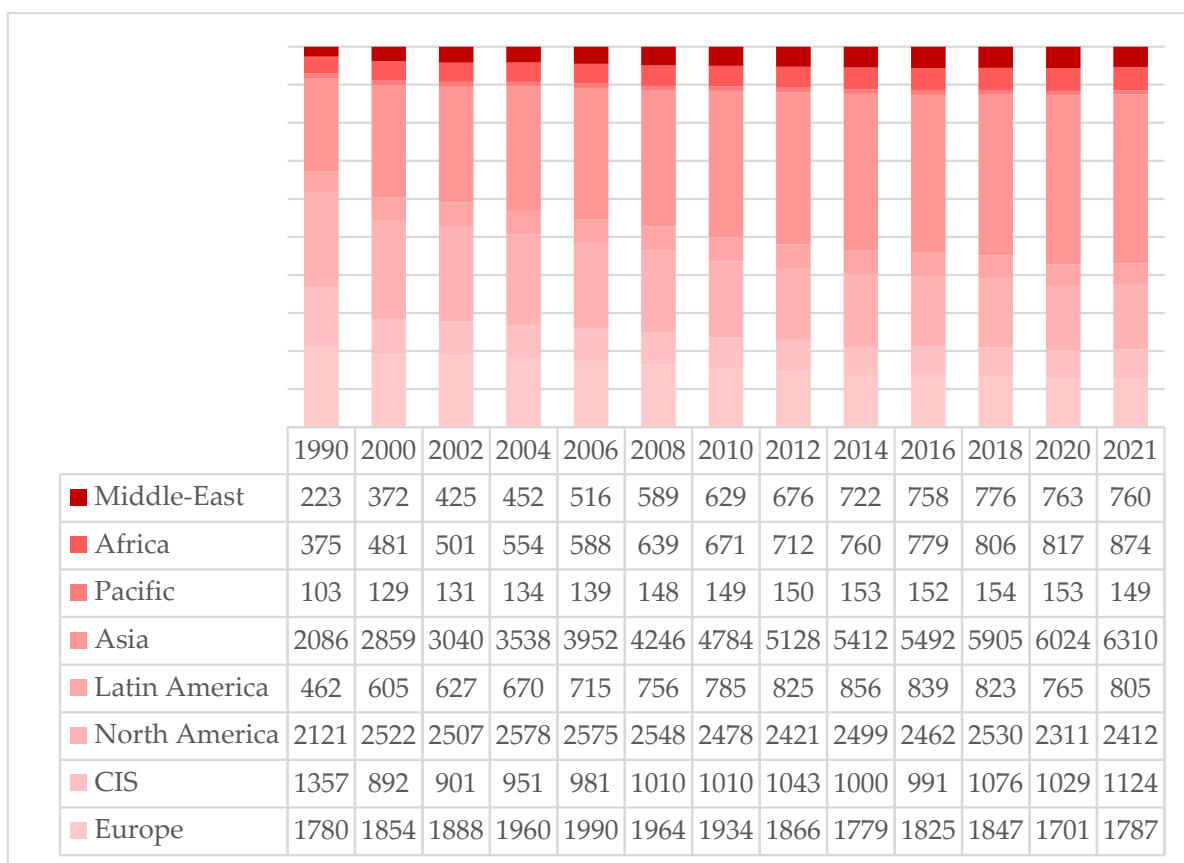


Figure 7. Total energy consumption by region for 1990; 2000–2020 (when analyzed in a 2-year period); 2021, Mtoe [28].

COVID-19 has had a huge impact on global energy demand and energy production chances. The main energy production figures for 2021 are as follows:

- Crude oil: +0.9%, driven by a recovery in demand for petroleum products.
- Gas: +4% with increases in gas production in the USA (2.2%), Russia (+9%), and most producing countries (excluding Australia).
- Coal: +5.7%, with increases in China (+5.1%), India (+9.8%), Indonesia (+7.7%), and most producing countries, except Australia (−7.3%).
- Electricity: +5.5%, with increases in China (+9.7%), the United States (2.7%), India (4.8%), South Korea (4.4%), and most producing countries except Canada, Japan, Thailand, and New Zealand.

Energy production has recovered in Russia, Canada, the United States, and most geographical regions (Europe, North and Latin America, CIS, Asia, Africa, and the Middle East), except the Pacific region (Australia (−6.2%), New Zealand (−4%)). Energy production by region is shown in Figure 8.

Global energy consumption (total energy use per unit of GDP) declines more slowly than its historical trend (−1.5% per year on average between 2000 and 2019), again widening the gap with the 3.5% per year decline needed to reach the 2 °C scenario. This slowdown is mainly due to a recovery in energy consumption in 2021 (+5%), which is close to the global GDP recovery (+6%).

Figure 9 shows the trend of changing energy intensity in the world. Levels and trends of energy intensity vary widely around the world, reflecting differences in economic structure and advances in energy efficiency.

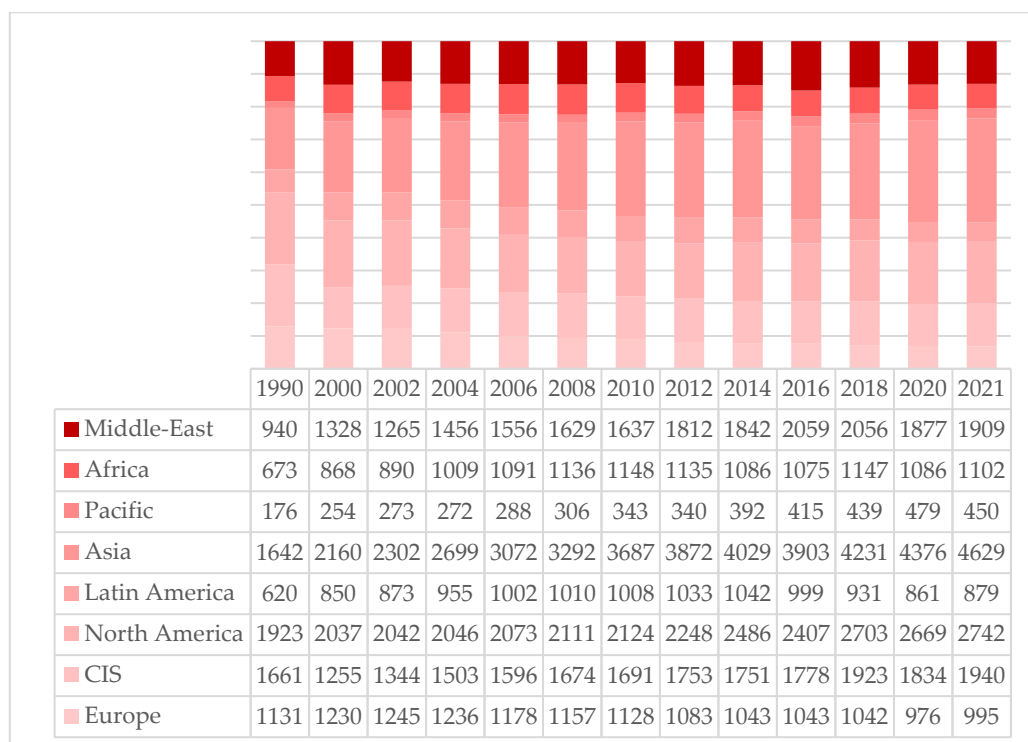


Figure 8. Total energy production by region for 1990; 2000–2020 (when analyzed in a 2-year period); 2021, Mtoe [29].

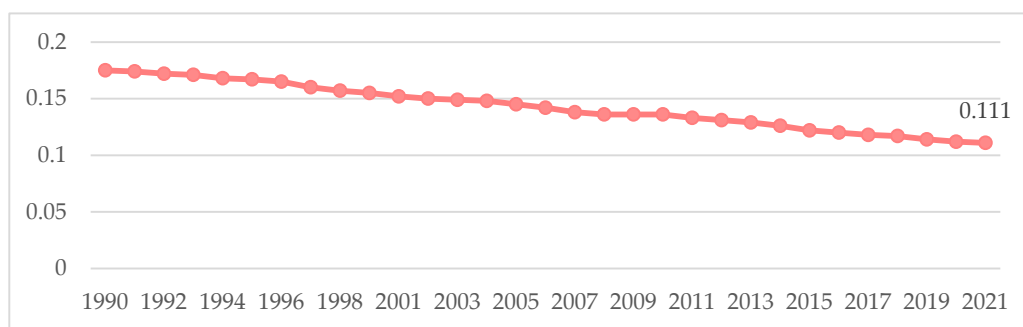


Figure 9. Energy intensity in the world, according to data for 1990–2021, koe/\$15p [30].

Since 2000, the US and EU have been reducing their energy intensity by about 2% per year due to efforts to improve energy efficiency (especially in the energy sector) and, to a lesser extent, due to a structural shift towards less energy-intensive industries and a growing share of services in GDP. In 2021, the improvement was much slower in the EU (−0.8%) and in the United States (−1%).

China’s energy intensity remained stable in 2020 (−0.1% compared with an annual improvement of 2.8% per year over the period of 2000–2019). In 2021, its energy intensity returned to the average of 2000 and 2019). In 2021, its energy intensity returned to the 2000–2019 average with an improvement of 2.7%.

The high energy intensity in the CIS, the Middle East, China, and some Asian countries (Taiwan, South Korea) is explained by the dominance of energy-intensive industries, commodity-based economies, and low-energy carriers, which do not contribute to energy efficiency. In 2021, energy intensity improved in Asia (especially India and China), Australia, the Middle East, and Latin America (improvements in Argentina, Chile, Colombia, and Mexico). Energy intensity has increased in Africa (improvements in Algeria contrast with growth in Nigeria, South Africa, and Egypt).

3.3. Trends in the Development of Global Energy and Their Consequences

The past year has shown the world that hydrocarbons will remain the dominant energy source for the next decade. In addition, the switch to renewable sources on the “green” agenda will not happen as fast as hoped by many of those who have taken up this approach in recent years.

EU leaders seem to realize this as they have recognized nuclear and natural gas as transitional energy sources on the way to a carbon-free economy. In addition, they have allowed investments in nuclear power until 2045 and in natural gas infrastructure until 2030.

Hydrogen has moved to the top of the global economy. Programs for its use and projects for its implementation in the European Union, as well as the development of hydrogen strategies in individual countries and continents by car manufacturing brands, give hope for the emergence of a new generation of cars. It is another breakthrough for humanity, both in terms of the evolution of cars and in terms of nature conservation. Moreover, it cannot fail to be encouraging.

The world has proved unprepared for a rapid recovery in energy demand in China. Global players and leading nations in the economy failed to predict the rapid increase in demand for hydrocarbons and coal. This led to a significant increase in the cost of natural gas and fossil fuels in the first half of 2021.

The imbalance of supply and demand has led to consequences to which our economy and our neighboring economies will have to adapt in the coming years:

A tenfold increase in the price of natural gas and a threefold increase in the cost of coal. The main gas supply operators have taken advantage of the shortages of these energy resources and the benefits of their rise in price. Russia’s Gazprom, for example, has announced that it expects record net profits of RUB 2 trillion in 2021.

Retail gas market players are pulling out of the game. For many energy suppliers, 2021 was a stress test, with dozens of companies from the UK, the Czech Republic, and Germany going out of business. The companies that have survived will reconsider their market behavior.

It has become clear that energy prices are likely to be high for another one to three years. That means that the plans of many production companies are changing. They, as consumers, will seek to lock in prices over the long term. Such natural gas purchasing tactics will enable them to minimize the risks of spot price fluctuations and make their business more sustainable and predictable in terms of profitability. In addition, we, as suppliers, are ready to make such offers to business clients.

The energy crisis will determine the behavior patterns of other energy market participants.

Despite the unstable prices, natural gas will maintain its trend of being a reliable source of power generation and a clean source for balancing the energy systems in the European economy.

Problems with Nord Stream 2 and limited gas supply from the main pipelines will force EU member states to look for ways to diversify and optimize supplies in a long-term cooperative framework [31].

The latter direction is also strongly influenced by the key features of the current geopolitical crisis associated with the situation in Ukraine and Russia’s direct involvement in it. The problems of the functioning of Nord Stream 2 are seen by some analysts as an element of influence on EU countries [32] (pp. 173–181) aimed at reducing the sanctions on the Russian economy.

The current situation has disrupted global energy markets and damaged the global economy. Compared with what took place in the 1970s, the shock has led to a surge in prices across a broader set of energy-related commodities. In energy-importing economies, higher prices will reduce real disposable incomes, raise production costs, tighten financial conditions, and constrain policy space.

Some energy exporters may benefit from improved terms of trade and higher commodity production. However, on net, model-based estimates suggest that the war-driven surge in energy prices could reduce global output by 0.8 percent after two years. The experience

of previous oil price shocks has shown that these shocks can provide an important catalyst for policies to encourage demand reduction, substitution to other fuels, and development of new sources of energy supply [33].

In addition to current geopolitical and geoeconomic issues, which are currently reshaping the energy market, environmental challenges and the problems caused by high CO₂ emissions play a significant role.

Global climate change is one of the most important issues for the global community. For many decades, increases in energy consumption have been inseparably connected with increases in carbon dioxide emissions, which contribute to the warming of the planet's atmosphere. A continuing upward trend in anthropogenic emissions of greenhouse gases will be followed by a rise in sea levels, increased hurricane activity, and melting permafrost, i.e., huge losses for humanity. The COP26 international climate conference in Glasgow in November 2021 demonstrated how difficult it is for the global community to agree on key issues, such as decommissioning coal-fired power stations and reducing methane emissions and deforestation. Nevertheless, significant progress has been made on some important areas of climate policy. Mechanisms for international trade in carbon units have been agreed under Article 6 of the Paris Agreement, which is expected to result in greater collaboration between countries to meet climate goals [34].

Regulations and standards that aim to rapidly deploy proven clean energy technologies, as well as incentives for large-scale investments in infrastructure, including, for example, smart grids for power transmission and distribution, are crucial to achieve significant emission reductions by 2030. However, nearly half of the technologies needed to reach zero emissions by mid-century are still at the prototype stage. In order to accelerate the development of such technologies and bring them to market, the government should leverage its own funds to attract the R&D base of the private sector and promote demonstration projects. Important new industries and employment opportunities must be created over time [35] (p. 7).

3.4. Assessment of the Dependence of the Total Financial Result of Energy Companies on the Factors of the External and Internal Environment

Taking into account the research hypothesis, which is the existence of a correlation between the aggregate financial performance of energy companies and external and internal environmental factors, an analysis of the correlation between the aggregate financial performance of energy companies and these factors was implemented (Table 1).

Table 1. Baseline data for correlation analysis, 2012–2021 (developed by the authors on the basis of [36–39]).

Index	Index Designation	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total financial result (RUB billion)	Y	91.7	76.6	24.1	183.3	738.3	551.1	609.1	707.3	633.9	896.3
Revenue (billion RUB)	x1	6627.4	7187.2	7648.0	8014.8	8438.3	8995.8	9783.9	9985.3	10,055.5	11,826.1
Number of employees (thousand people)	x2	1947.0	1936.0	1914.0	1920.0	1648.0	1633.0	1622.0	1607.0	1588.0	1557.0
GDP (billion RUB)	x3	68,103.45	72,985.70	79,030.04	83,087.36	85,616.08	91,843.15	103,861.65	109,608.31	107,390.33	131,014.99
Average annual discount rate of the CBRF	x4	5.00	5.50	12.00	14.00	10.50	9.35	7.50	7.00	5.50	6.00
USD to RUB Exchange Rate	x5	31.1	31.9	38.4	61.0	67.0	58.4	62.7	64.7	72.2	73.7
Global natural gas price index	x6	209.9	213.2	214.7	139.9	100.0	116.1	146.7	92.8	70.8	256.7
World oil prices (RUB/bl)	x7	3469.6	3458.9	3802.4	3189.4	2927.2	3165.5	4471.2	4162.8	3023.1	5207.1
Inflation index	x8	6.6	6.5	11.4	12.9	5.4	2.5	4.3	3.1	4.9	8.4
Advanced production technologies developed (units)	x9	1323	1429	1409	1398	1534	1402	1565	1620	1989	2186

Table 1. Cont.

Index	Index Designation	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Share of domestic R&D expenditure (billion RUB)	x10	701.5	751.8	845.6	914	941.8	1019.5	1038.6	1139.9	1181.3	1310.1
Share of domestic R&D expenditure in the ICT sector in total domestic R&D expenditure (billion RUB)	x11	20.3	16.5	19.4	33.8	33.9	25.5	24.9	22.8	35.4	31.4
Number of patents for inventions granted by Rospatent to Russian applicants per 1 million inhabitants	x12	156.8	148.8	157.7	153.9	143.2	143.2	139.8	137.1	117.5	103.1
Brand-new technologies in the total number of advanced production technologies developed	x13	135	153	163	175	192	191	182	217	201	260
Number of researchers performing R&D per 10,000 people employed in the economy	x14	54.8	54.3	55.1	52.5	51.4	50.1	48.6	49	49.8	48

Using Excel, the selected data were processed with the Data–Data Analysis–Correlation tool, and a correlation field was generated. The factors (x) that have the strongest correlation with the indicator (y) are highlighted in green. Positive correlation = growth of factor affects growth of indicator; negative correlation = decline of factor affects growth of indicator (and vice versa). The relevant constructed correlation matrix is presented in Table 2.

Table 2. Correlation matrix constructed based on the results of correlation analysis.

Y	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	
Y	1.00														
x1	0.88	1.00													
x2	−0.97	−0.89	1.00												
x3	0.85	1.00	−0.86	1.00											
x4	−0.24	−0.24	0.26	−0.27	1.00										
x5	0.89	0.85	−0.86	0.82	0.08	1.00									
x6	−0.38	−0.15	0.45	−0.11	−0.16	−0.52	1.00								
x7	0.37	0.61	−0.33	0.66	−0.30	0.21	0.54	1.00							
x8	−0.53	−0.28	0.61	−0.25	0.57	−0.23	0.50	0.04	1.00						
x9	0.72	0.87	−0.70	0.88	−0.41	0.70	0.02	0.51	−0.10	1.00					
x10	0.87	0.98	−0.89	0.98	−0.17	0.89	−0.26	0.50	−0.27	0.86	1.00				
x11	0.59	0.51	−0.52	0.47	0.26	0.83	−0.47	−0.17	0.09	0.54	0.58	1.00			
x12	−0.80	−0.91	0.79	−0.91	0.46	−0.73	0.03	−0.50	0.25	−0.98	−0.90	−0.53	1.00		
x13	0.87	0.95	−0.82	0.94	−0.12	0.84	−0.10	0.56	−0.18	0.84	0.95	0.54	−0.87	1.00	
x14	−0.92	−0.93	0.94	−0.91	0.23	−0.88	0.38	−0.47	0.50	−0.69	−0.91	−0.52	0.78	−0.84	1.00

According to the correlation analysis, we can see that the dependence of the aggregate financial result of energy companies is uneven for each of the factors, and three categories can be distinguished:

1. Low correlation: y and x4; x6; x8 is −0.24—correlation is low and negative; y and x7; x11—correlation is low and direct. Based on this, it can be concluded that the annual average discount rate of the Central Bank of Russia, the world price index for natural

- gas, world oil prices (RUB/bl), the inflation index, and the share of domestic R&D expenditure in total domestic R&D expenditure (billion RUB) will not be taken into account in the future model given the weak impact on energy companies' overall financial performance;
2. The average correlation: y and x_9 is 0.72, which is a medium level of direct correlation. The correlation between y and x_{12} is determined by an inverse average correlation, as it is -0.80 . These factors will not be taken into account in the linear regression model, given that the degree of impact is not high enough and cannot be attributed to the most significant factors;
 3. High dependence: A dependence above 0.85 or -0.85 would be considered high for the purposes of our study. The indicators that meet these conditions include revenue, number of employees, GDP, RUB/USD exchange rate, share of domestic R&D expenditure, brand-new technologies in the total number of advanced production technologies, and number of researchers per 10,000 people employed in the economy.

The first ranking of these indicators is the number of employees. This indicator and the aggregate financial result are inversely related. The correlation index value is -0.97 , which allows us to conclude that when the number of employees decreases, the level of the aggregate financial performance of energy companies will increase. This situation is related primarily to a reduction in employee payroll costs, as well as additional costs related to training and other expenses. In addition, the need for a high-quality workforce, rather than a quantitatively dominant one, is important. A reduction in low-skilled workers would have a positive impact. When analyzing this factor in terms of current global factors, it is noted that migration activity in Russia would have only a minor effect on the efficiency of energy companies.

The second place is also occupied by the indicator related to the number of employees—"The number of researchers performing R&D per 10,000 people employed in the economy". This indicator, like the previous one, has an inverse impact equal to -0.92 .

In third place is the RUB/USD exchange rate. The correlation between this factor and the aggregate financial results is 0.89. The volatility of the RUB/USD exchange rate under the current conditions of today's uncertainty and tension is an element in defining the stability of the economy in the country. This indicator affects the activities of energy companies quite seriously, taking into account that the equipment and technologies used in production activities in a rather large volume are foreign. In addition, the price of energy sold by Russian companies on the energy market depends on the exchange rate.

Fourth place in terms of influence is occupied by companies' revenues, the level of correlation with the aggregate financial result being 0.88. This means that 88% of revenues have a positive impact on the total financial result. This can be interpreted as follows: if a company's revenues increase by 1 %, the level of increase in total financial result is 88 %. This factor is due to the fact that the total financial result of energy companies is calculated as revenue minus loss. On this basis, the relevant factors in this calculation are the company's expenses for production, management, trading activities, and taxes. In addition, the amount of revenues generated will be the basis for the expenditure side, which then forms the total financial result of energy companies.

The fifth place is occupied by two factors that have a high impact on the aggregate financial result of energy companies—the share of internal expenses on research and development and brand-new technologies in the total number of developed advanced production technologies.

By analyzing the importance of these factors, the key role of the digitalization, of which they are a part, has been identified. The priority of these factors is obvious for modern energy companies, given that research and development represents the theoretical and methodological basis on which the theoretical and analytical stages of companies' activities can be based, while production technology represents a direct tool by which production activities can be visibly optimized. The correlation between these factors and

overall financial performance is 0.87, suggesting an 87% change in overall energy company financial performance for a 1% change in the factors noted above.

The sixth place is occupied by the level of dependence of the aggregate financial result on GDP—0.86. This indicator assumes that there are financial resources that energy companies can accumulate in their own activities and that they can rely on as subsidy projects from the government. Also interesting is that the correlation between GDP and the indicators of digitalization, such as the share of domestic spending on research and development and new technologies in the total number of developed advanced production technologies, is also high, at 0.98 and 0.94, respectively.

The second method of analysis was regression analysis. In order to implement this method, the factors that have a strength of relationship of 85% or more according to the previous table (results of correlation analysis) were selected. The relevant data for regression analysis is presented in Table 3.

Table 3. Baseline data for regression analysis.

	Total Financial Result (Billion RUB)	Revenue (Billion RUB)	Number of Employees (Thousand People)	GDP (Billion RUB)	USD to RUB Exchange Rate	Share of Domestic R&D Expenditure (Billion RUB)	Brand-New Technologies, in the Total Number of Advanced Production Technologies Developed	Number of Researchers Performing R&D per 10,000 People Employed in the Economy
	Y	x1	x2	x3	x5	x10	x13	x14
2012	91.7	6627.4	1947.0	68,103.45	31.1	701.5	135	54.8
2013	76.6	7187.2	1936.0	72,985.70	31.9	751.8	153	54.3
2014	24.1	7648.0	1914.0	79,030.04	38.4	845.6	163	55.1
2015	183.3	8014.8	1920.0	83,087.36	61.0	914	175	52.5
2016	738.3	8438.3	1648.0	85,616.08	67.0	941.8	192	51.4
2017	551.1	8995.8	1633.0	91,843.15	58.4	1019.5	191	50.1
2018	609.1	9783.9	1622.0	103,861.65	62.7	1038.6	182	48.6
2019	707.3	9985.3	1607.0	109,608.31	64.7	1139.9	217	49
2020	633.9	10,055.5	1588.0	107,390.33	72.2	1181.3	201	49.8
2021	896.3	11,826.1	1557.0	131,014.99	73.7	1310.1	260	48

By performing the calculations using the Excel tool (Data–Data Analysis–Regression), the data were generated and presented in Table 4.

Table 4. Results of the regression analysis.

Regression Statistics		ANOVA							
		df	SS	MS	F	Importance of F			
						Bottoms 95%	Uppers 95%	Bottoms 95.0%	Uppers 95.0%
Multiple R	0.997114								
R-squares	0.994236								
Normalized R-squares	0.974063								
Standard error	51.99617								
Inquiries	10								
Regression		7	932,762.35	133,251.76	49.28				
Excess		2	5407.204	2703.602					
Totals		9	938,169.56						
Y-crossing	3886.04		1588.76	2.45	0.13	−2949.87	10,721.94	−2949.87	10,721.94
Variable X 1	−0.22		0.19	−1.18	0.36	−1.02	0.58	−1.02	0.58
Variable X 2	−1.87		0.36	−5.17	0.04	−3.42	−0.31	−3.42	−0.31
Variable X 3	0.02		0.01	1.74	0.22	−0.03	0.08	−0.03	0.08
Variable X 5	8.83		3.62	2.44	0.14	−6.75	24.40	−6.75	24.40
Variable X 10	−2.01		0.74	−2.71	0.11	−5.21	1.18	−5.21	1.18
Variable X 13	5.01		1.78	2.82	0.11	−2.65	12.66	−2.65	12.66
Variable X 14	2.44		29.71	0.08	0.94	−125.38	130.25	−125.38	130.25

In green, the confirmation that the R-squares are almost equal to 1 is highlighted, which means that there is a high degree of reliability of the model.

Using the linear regression formula, a model based on the implemented analysis was derived:

$$Y = a_0 + a_1 \times x_1 + \dots + a_n \times x_n,$$

where Y—the dependent variable, x—independent variables affecting it, a—regression coefficients.

The model built may be used as a projection tool. By substituting the data from future periods, by means of the built model it becomes possible to obtain a perspective value of the aggregate performance level of the energy companies.

In accordance with the regression analysis that was carried out, the results are described:

The number of observations for which the regression model is built is $n = 10$, which corresponds to 10 years of analysis (2012–2021).

The model has the form:

$$y = 3886.04 + x_1 \times (-0.22) + x_2 \times (-1.87) + x_3 \times 0.02 + x_5 \times 8.83 \\ + x_{10} \times (-2.01) + x_{13} \times 5.01 + x_{14} \times 2.44$$

The coefficient with the variable x means that if x_1 changes by 1 unit, y will increase by -0.22 units on average; x_2 by -1.87 ; x_3 by 0.02 ; x_5 by 8.83 ; x_{10} by -2.01 ; x_{13} by 5.01 ; x_{14} by 2.44 .

The free component of the regression equation (Y-crossing) indicates that at $x=0$ the value of y will be 3886.04 units.

The correlation coefficient $r = 0.997$ between x_n and y indicates that there is a significant direct correlation between the indicators.

The coefficient of determination $R^2 = 0.994$ means that 99.4% of the variation in y is explained by the variation in the factors x. That is, in 99.4% of cases changes in the factors x lead to a change in y. In other words, the fitting accuracy of the regression equation is strong. The remaining 0.006% of changes in y are explained by factors not taken into account in the model (as well as specification errors).

Based on the results of the study, the role of internal environmental factors in the development of an energy company, in particular, revenue, as well as such external factors as the RUB/USD exchange rate and GDP, is significant. By permanently increasing these factors, the level of efficiency of energy companies will increase. Reducing the number of employees and focusing on the quality of their work is also important. In addition, digitalization factors will play a decisive role. Based on the high costs of both research and development and the production of advanced technologies for production, the choice of a cooperation strategy is prioritized, whereby the degree of technology transfer will be more effectively achieved. The synergy effect in this case will depend not only on financial resources but also on the knowledge and experience that will be accumulated by both sides of the cooperative interaction. The presented results allow us to conclude that digitalization is one of the key elements that can positively influence the development of the energy market. Moreover, as part of the development of a cooperation strategy, the degree of digitalization of the industry will be realized even more effectively.

3.5. The Need to Use Digital Technologies as a Driver of Energy Development

To simplify the assessment of technological changes in the sector, namely, the use of digital technologies as a driver for the development of the energy market, five main properties of a digital smart energy system can be identified: adaptability, environmental friendliness, cost-effectiveness, energy security, and energy efficiency. The quantitative relationship established by Mozokhin and An.E. and Al.E. with the challenges to determine mutual influence in modeling and forecasting is presented in Figure 10.

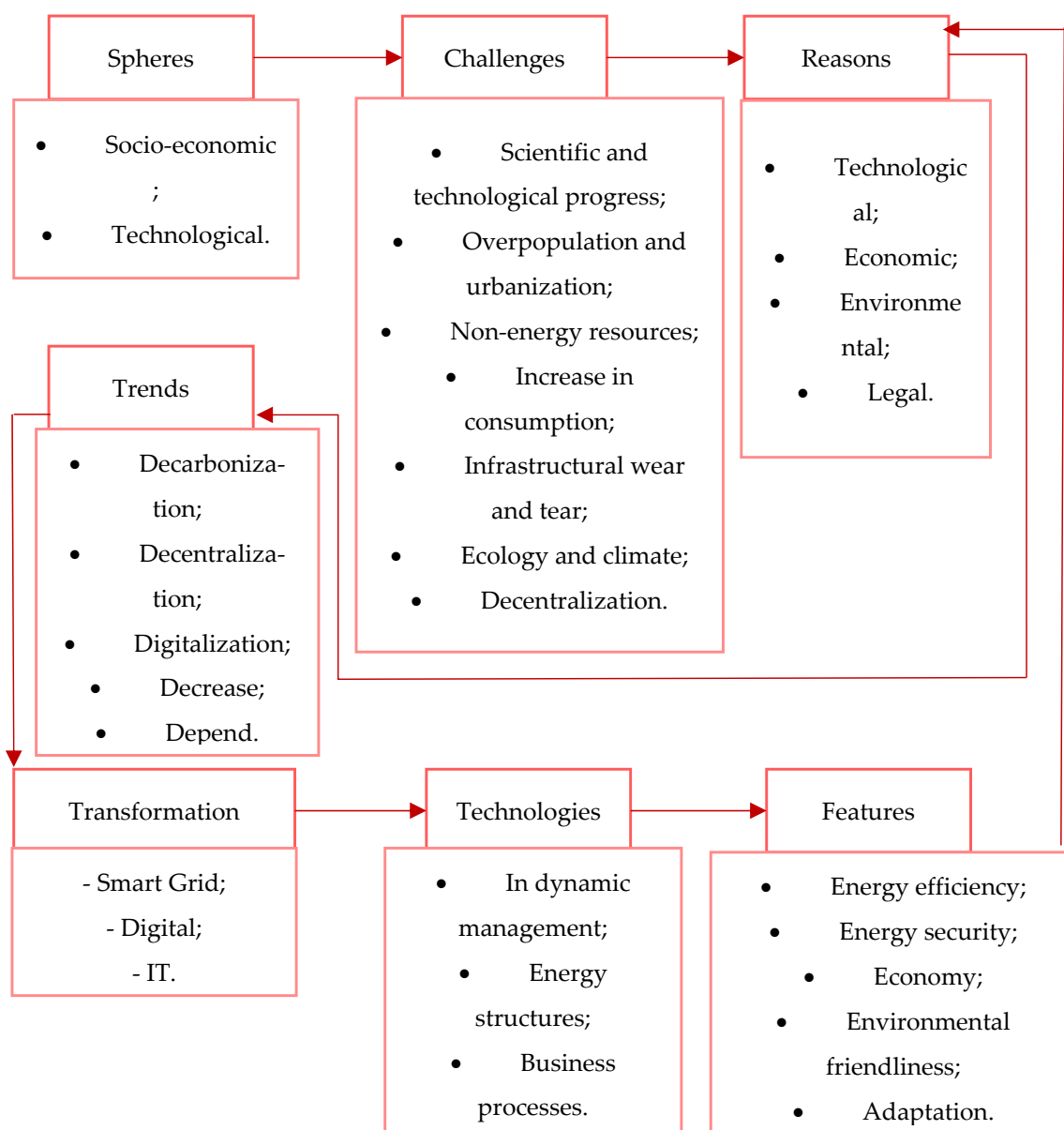


Figure 10. Model for assessing the impact of global challenges on technological development in the field of digital technologies and intelligent energy [40] (pp. 82–86).

The transforming global energy sector is currently in a period of uncertainty and multidirectional change, with multiple bifurcation points in technological, institutional, regulatory, and political decisions, as well as the speed and direction of climate change. In the field of the electric power industry, there are three basic trends that most significantly affect its development and transformation under all scenarios [41]:

- Further electrification (shifting large sectors of the economy, such as transport and heating, to electricity), accompanied in many countries by the development of low-carbon energy;
- Decentralization;
- Digitalization (both the grid elements themselves and the consumption side);
- Under the influence of the current factors presented in Figure 8, the country's policy change in the context of a more active development of its own technology policy aimed at digital transformation seems relevant.

Digital transformation in the electricity sector is the change in and development of a set of production and economic relations in the sector based on digital approaches and tools that are based on big data analysis. Digital transformation of the electric power industry is a change in and development of the set of industrial economic relations in the industry based on digital approaches and tools that are based on the analysis of big data, of which the main directions include [42]:

- Creation of a single information field, including a single conceptual information model of the whole power system; a single metamodel as an interaction language; single object registers; a single identification system; and a set of single task-oriented classifiers and directories;
- Creation of a unified distributed technological interaction environment ensuring transparency and controllability of electric power industry objects, built on the network-centric principle with distributed data storage, which is based on a digital network;
- Creation and implementation of a single trusted sectoral digital platform used by electric power industry entities to transmit technological data in real time and ensure information security;
- Formation of a new electricity architecture—the Internet of Energy—an ecosystem of energy producers and consumers that seamlessly integrate into a common infrastructure and exchange energy, based on consumer-end devices with managed energy consumption and distributed generation and energy storage systems located on the consumer side and/or in low- and medium-voltage distribution networks in close proximity to consumers;
- Transformation of existing management models to maximize positive effects by leveraging digital opportunities, accelerating data exchange, and improving the transparency and reliability of information, thus eliminating territorial imbalances in generation and consumption. Creating new business models, services, and markets based on the possibilities of the digital economy, whose potential is offered by pervasive communications, machine-to-machine interactions, and digital modeling;
- Implementation of risk-based management of the UES; asset lifecycle management: remote management or real-time forecasting through digital and technological solutions; and maintenance to extend the lifecycle or operational efficiency of generation, transmission, or distribution assets;
- Implementation of new digital technologies and platform solutions, building interactions based on them, including customer interactions; integrated customer services: innovative products and services with digital technologies related to energy production and energy management; and high-level customer services.

Considering that a specific feature of the modern stage of energy economy development is the shift to a new technological paradigm in the electric power industry—which represents the organization of energy supply as an ecosystem of energy producers and consumers, which are integrated into the overall information infrastructure—a critical success factor in transforming the energy industry is the willingness of organizations and their employees to adopt digitalization tools and capture digital value—the benefits that new technologies offer [43].

3.6. Theoretical Aspects of Digital Technologies in the Energy Sector

By analyzing the existing digital technologies in the energy sector, their specifics in Russia have been analyzed in detail. On this basis, the key areas of digital transformation actively developed by the country at the moment are highlighted (Table 5): cognitive expert decision support systems in the upstream segment, digital field, integrated value chain management in the downstream segment, digital mine, digital pit, digital logistics, and digital supply chain management.

Table 5. Pilot projects on digitalization of the oil and gas complex and the coal industry of the Russian Federation [44].

The Direction of Digital Transformation	Project Name	The Result Obtained through the Implementation of the Project
Cognitive systems for supporting expert solutions in the upstream segment	Cognitive geologist	Integrated environment for the work of an expert geologist with the ability to automatically develop recommendations and training on new data
	Integrated design	Information system for integrated conceptual design of field development
	Digital borehole double	Information system for optimizing the design and operating modes of wells
Digital deposit	Mining Management Center	Integrated mining enterprise management platform:
	Integrated design and project management environment (6D)	Transport management
Integrated value chain management in the downstream segment	Video analytics tools for decision making	Well repairs
	Digital refinery	Gas and energy
	Digitalization of logistics and sales enterprises	Reservoir
Digital mine	Development of the underground mining dispatching system	Pressure support system
	Robotic cleaning	Liquid lifting
	Transfer of data on key production processes to Rostekhnadzor	Digital reservoir model
Digital career	Monitoring, notification, and search system for people caught in an accident, S8GPS “Granch”	An integrated platform that combines systems of digital modeling, calendar planning, procurement of services and material and technical works, logistics, and construction
	Development of the dispatching system for open-pit mining	Video analytics for HSE
	Unmanned mining dump truck	A new-generation industrial automation platform for integrated optimization of refinery operations
Digital logistics	Robotic drilling rig aerial photography of UAVs. Geomodeling	Digital models of industrial facilities
	Health monitoring of production personnel	Digital models of logistics and sales processes. Platforms for aggregating the supply of goods and services for sales units (Aero, bitumen, bunkering, lubricants). Data exchange platforms with partners and customers throughout the value chain
	Power control room	(based on blockchain). Platforms for providing new services for atypical categories of customers.
Digital supply chain management	The use of blockchain technology with Russian Railways	Platforms for solving typical robotic tasks.
	IT supply chain planning and management system	Platforms for rapid application development tasks in the oil refining industry with an open API and SDK

In addition to the implementation of the presented projects, in order to accelerate the digital transformation in the energy sector, according to E.R. Akhmetshin, a number of activities will be required [45]:

- The intensive implementation of smart sensors, sensor devices, and robotics in the energy sector, and the use of mobile applications and the full extent of all possibilities of cloud computing;

- Providing a modern infrastructure for data processing, storage, and transmission; to provide the right guidance through foresight; and the desire to think and act for future generations;
- Establishing an international, real-time smart grid science center to discuss analytics and standards for digital solutions, predictions and scenarios of future technologies, and for sharing information and experiences;
- Providing incentives for innovation, creating an attractive environment that is likely to involve intellectual resources.

Digital transformation can have a positive effect on energy companies in the near future and strengthen their level of competitiveness in the market. The latter factor is extremely important in the context of the changing structure of the energy market in the world. Based on the need for an adequate response to modern realities, the importance of further cooperation is growing. It is of interest to switch to working with Asian countries both in the field of acquiring technologies that can strengthen the level of digitalization of the Russian energy market and in the field of increasing export–import relations.

3.7. Proposals to Enhance the Use of Digital Technologies in the Energy Sector

At present, Russia’s soft power presence in Central Asia far exceeds that of China. Nevertheless, there seems to be an emerging view that the Chinese presence is likely to increase in the future and that it provides a number of positive economic benefits to a region that has not attracted many investors outside of the natural resource sector, which of course is also of interest to China. China offers not only infrastructure improvements that promise to link Central Asia to the global economy but also opportunities for technology transfer. China’s influence is generally positive and does more good than harm.

Since 2010, China has been Russia’s largest trade partner, apart from the European Union. In 2021, trade between the countries increased by more than a third to more than USD 140 billion (Table 6).

Table 6. The volume of foreign trade of the Russian Federation with China, 2017–2021, billion dollars [46].

Indicator	2017	2018	2019	2020	2021
Import	48	52.2	54.1	54.9	72.7
Absolute change		4.2	1.9	0.8	17.8
Relative change, %		108.8	103.6	101.5	132.4
Export	38.9	56.1	56.8	49.1	68
Absolute change		17.2	0.7	−7.7	18.9
Relative change, %		144.2	101.2	86.4	138.5
Turnover	86.9	108.3	110.9	104	140.7
Absolute change		21.4	2.6	−6.9	36.7
Relative change, %		124.6	102.4	93.8	135.3

In April 2022, the Federal Customs Service stopped publishing imports and exports statistics indefinitely [47].

Data from PRC Customs indicate that the total trade between China and Russia increased by 27.2% over six months to USD 80.7 billion (Table 7). However, when looking at this data in detail, it turns out that deliveries from Russia increased by 48.2% to USD 51 billion. Deliveries from China to Russia increased by only 2.1% over six months to USD 29.55 billion [48].

Table 7. China's Total Export and Import Values by Country/Region, June 2022, millions USD [48].

Import Source	Export and Import		Export		Import		1-to-6 Total Year-on-Year ($\pm\%$)		
	6	1-to-6	6	1-to-6	6	1-to-6	Export and Import	Export	Import
Export Destination									
Total	564,587.1	3,079,124.7	331,264.2	1,732,279.9	233,322.9	1,346,844.8	10.3	14.2	5.7
European Union	75,519.1	420,602.8	50,474.6	277,228.0	25,044.4	143,374.8	8.4	19.1	−7.6
of which: Germany	19,934.7	113,463.6	10,565.9	57,718.2	9368.8	55,745.4	0.6	9.5	−7.2
Netherlands	11,134.7	62,597.1	10,136.0	56,306.6	998.8	6290.5	18.8	23.4	−11.2
France	7115.4	40,274.8	4271.8	23,406.7	2843.6	16,868.2	0.9	11.6	−11.0
Italy	7236.1	40,109.7	4694.2	26,661.5	2542.0	13,448.2	14.8	37.1	−13.2
United States (US)	70,552.4	383,931.0	55,978.8	292,650.8	14,573.5	91,280.3	12.7	15.8	3.6
ASEAN	87,612.0	458,545.2	52,087.1	263,236.1	35,524.9	195,309.1	11.5	16.6	5.3
of which: Vietnam	20,245.3	110,526.9	13,083.1	71,169.3	7162.2	39,357.6	−1.4	3.6	−9.4
Malaysia	19,303.2	96,933.7	9474.6	44,021.4	9828.5	52,912.3	18.2	30.1	9.9
Thailand	13,302.6	67,933.0	7490.2	38,477.6	5812.4	29,455.5	8.5	18.7	−2.3
Singapore	9332.2	47,521.8	6585.7	29,984.8	2746.5	17,537.0	7.0	17.6	−7.2
Indonesia	12,673.7	69,708.5	6542.3	34,303.2	6131.4	35,405.3	29.9	25.7	34.2
Philippines	8357.7	41,816.2	6208.1	29,857.7	2149.5	11,958.5	11.4	12.5	8.7
Japan	30,687.0	177,138.1	14,804.6	83,546.1	15,882.4	93,592.0	−2.1	4.4	−7.3
Hong Kong, China	28,524.4	146,321.4	27,844.0	143,094.4	680.4	3227.0	−9.4	−8.6	−32.6
R. O. Korea	32,230.2	184,246.0	15,733.1	81,333.1	16,497.1	102,912.9	9.4	18.3	3.3
Taiwan, China	27,840.2	165,235.7	7620.9	42,720.0	20,219.3	122,515.7	9.5	16.4	7.3
Australia	19,202.3	106,467.8	6732.7	36,086.3	12,469.6	70,381.4	−3.1	21.8	−12.3
Russian Federation	14,750.8	80,675.1	5002.5	29,550.0	9748.3	51,125.1	27.2	2.1	48.2
India	13,099.8	67,088.9	11,306.9	57,513.8	1792.9	9575.0	16.5	34.5	−35.3
United Kingdom (UK)	8798.1	50,466.9	7068.0	38,777.0	1730.1	11,689.9	−4.0	−2.2	−9.5
Canada	8337.0	41,767.9	5384.7	27,410.4	2952.3	14,357.5	11.3	21.5	−4.0
New Zealand	2039.6	12,925.3	744.4	4270.5	1295.2	8654.9	7.6	16.8	3.5
Latin America	47,771.5	236,631.7	24,564.3	120,473.6	23,207.2	116,158.1	14.8	20.1	9.8
Africa	26,430.4	137,383.6	16,198.7	76,771.0	10,231.7	60,612.6	16.6	14.7	19.1

Oil accounted for the major increase in the total trade turnover: in May, Russia ranked first in terms of the volume of its delivery to China [49].

The volume of exports was 8.42 million tons or 1.98 million barrels per day, which is 55% more than in May 2021. This is due to large discounts for Chinese buyers. In particular, state-owned Sinopec and Zhenhua Oil bought oil at a discount.

Sophia Donets, chief economist of Renaissance Capital for Russia and CIS, believes that the Asian market—including the Chinese one—may receive up to 45% of oil and oil products that normally go to the European Union [50].

For Russia, the Asian market will definitely remain key and significant as the largest energy consumption market in terms of advantages and prospects for exporting countries. Russian–Chinese relations are seen as quite far-reaching and require constant interaction, taking into account the growing competition with other countries and their activity in the region. Demand is increasing, which creates new corridors of opportunities for Russia and China [51–54].

As the oil and gas sector remains the cornerstone of Russia's economy and Western sanctions begin to intensify, the Russian Federation will have to look eastwards for export opportunities. Pivoting exports to Asia will take time and require large-scale investment in infrastructure.

Russia's capacity to divert all unwanted cargoes from the West to Asia is limited, which means that if an embargo is imposed Russia will have to further reduce production because it does not have enough capacity to store additional volumes of crude oil. Crude oil production in Russia has already started to fall, as demand for oil and domestic refinery capacity has declined [55].

Russia will need some time to recalibrate its supply chain and find enough buyers for its oil outside Europe and the US. It will also take some time for the Russian economy to overcome sanctions and create additional demand for oil domestically. Thus, crude oil production will not start to recover until mid-2023 at the earliest. However, many stranded wells may not return to production, which means that some of Russia's spare capacity could become redundant [56].

The situation will be aggravated by the lack of investments and foreign technologies, which will lead to a decrease in drilling activity [57]. Russia is pinning its hopes on China to diversify its gas markets, as Europe intends to reduce its energy dependence on Russia as quickly as possible. At the moment, Central Asia is definitely a region of strategic importance for both Russia and China, and each of the parties is striving to create its own sphere of influence. In this regard, it is worth noting the overwhelming dependence of the efficiency of the development of the Russian energy market on the vector of cooperation with other countries and the speed of the retransformation of its own activities from the western to the eastern path.

The key features of this activity for Russia are the expansion of cooperation with Chinese partners in various energy sectors: oil and gas, nuclear, hydrogen, solar, and wind. Russia continues to advocate the need to strike a balance between addressing climate change on the one hand and socio-economic development on the other [58].

International experience shows that digital transformation requires coordinated efforts in five interdependent directions [59]:

- The framework conditions for the digital transformation of the industry include such aspects as: human capital, availability of basic infrastructure for digitalization, availability of funding sources, etc.
- Digital transformation of companies (culture, attitudes, and personnel competencies) implies a change in the organizational model of companies, a transition to flexible business models, a greater interaction with external sources of innovation, etc.
- Implementation of digital solutions for current operations implies implementation of digital solutions aimed at increasing the efficiency of current operational and investment activities (e.g., implementation of predictive analytics, optimization of equipment operation modes, etc.).
- Institutional support for digital transformation in the industry includes a range of actions by government associations and professional associations, universities, and research organizations.
- The implementation of digital solutions for the development of new businesses implies the introduction of solutions aimed at launching new products or services by traditional energy companies or companies from related industries.

In selected pilots, companies have seen reductions in operating and investment costs and increases in revenues for traditional businesses (Figure 11).

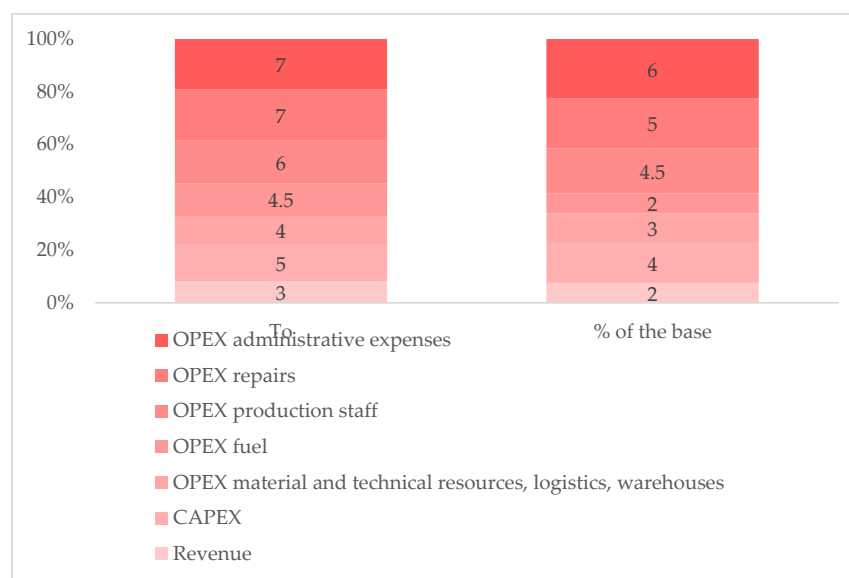


Figure 11. Estimated economic effect of the introduction of digital solutions (on the example of some enterprises), with the indicator before implementation and the indicator “% of the base” [59].

Based on the presented data, there is an increasing need to create a fully digitalized energy company that operates as a “smart enterprise” under the principle of “systemic digitalization”. The authors define this term as the process of functioning of an energy enterprise as a single digital ecosystem, whose activities will be based on the permanent development of “smart” areas of activity and implemented with their help. The algorithm of the activity of an energy enterprise based on the principle of “system digitalization” is shown in Figure 12.

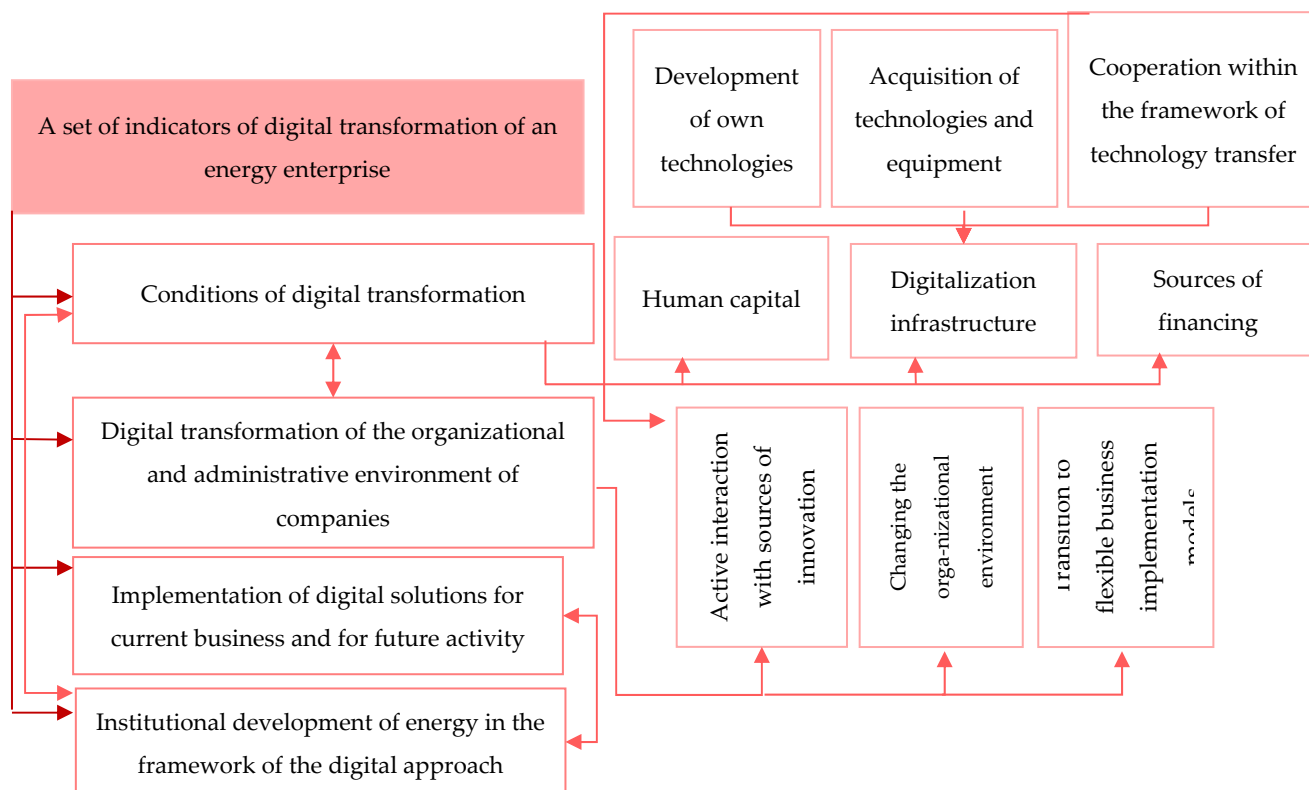


Figure 12. Elements of the energy enterprise activity algorithm based on the principle of “system digitalization” (developed by the authors on the basis of [59]).

In accordance with the developed algorithm, it seems obvious to implement a more active cooperative strategy for the development of Russia’s energy complex, which will strengthen the basic element of energy enterprise transformation within the application of the principle of “systemic digitalization”.

4. Concluding Remarks

We have formed a conceptual basis that determines the relevance of the transformation of the existing energy development strategy in the world within the application of existing digital solutions and the production of new ones. Based on the research conducted in this article, we have made several definite conclusions:

1. Cooperation is an evolutionary and forced process in the development of the global energy market and is implemented under the influence of geopolitical and geoeconomic factors of increasing tension between partners;
2. The consequences of modern forced cooperation are both positive and negative. The former includes creating opportunities for further export–import activities and expanding the range of a country’s own technological capabilities, which in general is the main competitive factor in the current conditions. The latter, negative consequence is the appearance of economic dependence often on a weaker partner due to the lack of options;

3. Given the priority of digital development, the efficiency and competitiveness of a country in the global energy market increasingly depends on the effectiveness of cooperation in the field of technology transfer;
4. The current stage of development of the energy market is realized through the active use of digital technologies, which determines their leading role in the process of countries achieving competitive advantages. In addition to improving the manufacturability of production, which leads to a reduction in the negative climate impact, digitalization also has a positive impact on the internal processes of enterprise development, which will allow countries in the future to significantly reduce the costs of their activities.

We came to these conclusions by a detailed analysis of the current situation of changes in the structure of the energy market and its dynamic changes. In addition, the comparison conducted between countries and regions, according to criteria such as energy production and consumption, as well as the level of CO₂ emissions, revealed the key difficulties faced by the countries participating in the energy market. As for the level of CO₂ emissions in different countries, it was concluded that China is by far the largest source of CO₂ emissions from coal burning worldwide. In 2021, China produced about 10 billion metric tons of CO₂.

Among the largest emitters of CO₂, only in Australia the level of CO₂ emissions adheres to a downward trend (−3.6%), mainly due to a 4.3% reduction in the energy sector (a decrease in the share of coal and gas power plants in energy generation in favor of solar and wind energy). In Japan, the level of CO₂ emissions continues to grow at a controlled pace (+0.8%). In Russia, the level of emissions has increased (+156 Mt CO₂) by almost the same amount as in the whole EU.

Levels and trends of energy intensity vary greatly in different regions of the world, reflecting differences in the structure of the economy and achievements in the field of energy efficiency.

Global energy intensity (total energy consumption per unit of GDP) is declining more slowly than its historical trend (−1.5% per year on average between 2000 and 2019), which again widens the gap with a decrease of 3.5% per year required to achieve the 2 °C scenario. This slowdown is mainly due to the recovery of energy consumption in 2021 (+5%), which is close to the recovery of global GDP (+6%).

The main solution for effective development in modern conditions was digitalization, for which, due to the level of required financing as well as intellectual support, cooperation was identified as one of the important elements of strategic development. This thesis was also confirmed by the second part of the study, in which a correlation and regression analysis of the dependence of the aggregate financial result of energy companies on factors of the external and internal environment was implemented.

In accordance with this analysis, we note that the dependence of the total financial result of energy companies on these factors is uneven, and three categories can be distinguished:

1. Low dependence: The average annual discount rate of the Central Bank of the Russian Federation, the world natural gas price index, world oil prices (rubles per barrel), the inflation index, as well as the share of domestic research and development costs of the ICT sector in the total domestic research and development costs (billion rubles) will not be taken into account in the further model they will develop, given the weak nature of the impact on the overall financial result of energy companies;
2. Average dependence: Factors such as advanced production technologies developed (units), the share of domestic R&D expenditure in the ICT sector in the total domestic R&D expenditure (billion RUB), and the number of patents for inventions granted by Rospatent to Russian applicants per 1 million tenants will not be taken into account in the linear model regression, given that the degree of influence is not high enough and cannot be attributed to the most significant factors;
3. High dependence: High in the framework of our study is considered a dependence above 0.85 or −0.85. Indicators that meet these conditions include revenue, the number of employees, GDP, the ruble–dollar exchange rate, the share of internal

research and development costs, fundamentally new technologies in the total number of advanced production technologies developed, and the number of researchers who performed research and development per 10 thousand employed in the economy.

The correlation coefficient $r = 0.997$ between cp and y indicates the presence of a noticeable direct relationship between the indicators.

The coefficient of determination $R^2 = 0.994$ means that 99.4% of the variation in y is explained by the variation in factors x . That is, in 99.4% of cases, changes in the presented factors x lead to a change in y .

Based on this study, the significant role of the factors of the internal environment in the development of the energy company is noted.

Based on the conducted analysis, we conclude that the dependence of modern energy companies on the digitalization factor is quite high and requires expanding their own capabilities in the field of research and development as well as the introduction of advanced technologies into the production process. Prospects for further research include the possibility of quantitative and qualitative assessment of the transformation of the structure of the world energy market both for individual countries and for groups of countries. Also of interest is an in-depth study of the effects of the digitalization of energy enterprises, in particular Russian ones after the country's more active cooperation with China. In addition, it is of interest to deepen the study of the dependence of changes in the aggregate financial result—which we accepted in this article as one of the indicators of the development of the Russian energy market—on the factors of the external and internal environment that are continuously changing.

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