

# Energy Transition to Renewable Energy Sources and Its Consequences for Russia

Valeriy M. Tumin <sup>1</sup>\*[ORCID 0000-0003-4651-0359],  
Maksim M. Novikov <sup>2</sup>[ORCID 0000-0002-7233-1680],  
Shen Wenhao <sup>3</sup>[ORCID 0000-0001-9667-0110],  
Petr A. Kostromin <sup>4</sup>[ORCID 0000-0003-4161-3244],  
Yury V. Daneykin <sup>5</sup>[ORCID 0000-0001-7181-2557]

<sup>1</sup> Moscow Polytechnic University, Moscow, Russia

<sup>2</sup> Diplomatic Academy of the Ministry of Foreign Affairs of the Russian Federation, Moscow, Russia

<sup>3</sup> Saint Petersburg State University of Economics, Saint Petersburg, Russia

<sup>4</sup> Russian State University for the Humanities, Moscow, Russia

<sup>5</sup> Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia

vm@tumin.net

## ABSTRACT

Russia, as a key exporter of energy resources, may face the problem of disrupting socio-economic well-being, given the high dependence of the budget on oil revenues. In this context, the country is faced with a strategic dilemma: to try to risky transition to carbon-free technologies, thereby going beyond its priority industry, or to focus on maximizing the benefits of the hydrocarbon industry. Therefore, the digitalization of the industry will help a more balanced and will help to correctly distribute the financial and debt burden, assess industry risks and volatility of global commodity markets. The article discusses the concept of energy transition from traditional non-renewable to environmentally friendly renewable resources to overcome the "Dutch disease" of countries dependent on oil and gas. A review of approaches to the future energy market in 2040-2050 was carried out, based on which two trends can be distinguished: the impossibility of completely abandoning oil and gas and an increase in demand for deep oil refined products for the needs of the chemical industry. The authors conducted a study of the current state of the energy sector in Russia: the production and export of oil, gas and coal – as the main sources of energy in the country. The geographic structure of Russian hydrocarbon exports is estimated and the shift in foreign trade supplies towards the Asia-Pacific region (primarily China) is highlighted. The forecasts of changes in the structure of energy consumption in Europe, as the main importer of Russian oil and gas so far, are presented. It was noted that the production of electric vehicles and, in general, the electrification of industries, together with the support of renewable energy at the state level in the countries of the European Union, creates external economic and foreign policy threats for the Russian Federation. The key problems that complicate the energy transition in the Russian Federation and the reasons for the emergence of these problems are highlighted. The consequences of the country's lag behind the leading energy powers of the world in the field of innovative energy are characterized.

**Keywords:** forecast of world energy consumption, market of non-renewable energy resources, export of traditional energy resources, energy transition

## 1. INTRODUCTION

The development of industry and, as a consequence, the growth in the use of various types of fuel, accompany the entire anthropogenic history

of mankind. Fuel and resources have tended to be the cause of most of the wars and conflicts in world history. And with the advent of oil on the market, it became both an instrument of war and a goal of conquest [1]. Scientific and technological progress

contributed to evolutionary or revolutionary energy transitions: from biomass to oil, from oil to gas, from gas to nuclear and then to new types of energy. Of course, there is competition between different types of fuel, both in terms of manufacturability and environmental friendliness, and in terms of economic use. The modern variety of applications has made possible the interchangeability of different fuels, but there are still consumption sectors where the proportion of fossil fuels remains high. For example, the production of automotive and aviation fuel [2].

The oil and gas industry is characterized by high demand for refined products and high profitability. But here are also destructive mechanisms – the growth of dependence on one type of fuel, which brings most of the budget revenues. This is the so-called “Dutch disease”, when the country's dependence on fossil fuels first brings super profits, and in the event of a fall in world prices leads to a deep crisis.

We are currently witnessing a profound transformation in the energy sector. The principles of energy use, its storage, transmission, and environmental standards are changing. And most importantly, one type of fuel is being replaced by another. In the transport sector, the electrification of trucks and cars is changing the entire supply chain and pricing. In addition, manufacturers producing cars with solar panels and hydrogen fuel receive competitive advantages in the form of government support (orders, subsidies, etc.). Interestingly, biofuels, whose share has been declining over the past 200 years due to low efficiency, are now “in vogue” again, largely due to technological breakthroughs in energy recovery.

E.G. Carayannis et al. believe that oil will lead the energy consumption of the transport sector until about 2040 [3]. Oil and gas account for about 60% of all energy consumption in the world. Therefore, the “energy revolution”, i.e. a massive transition to renewable energy sources in the shortest possible time, in the context of the technological dependence of machines and mechanisms on fossil fuels, is impossible in the coming years. But a gradual transition to more environmentally friendly fuel is already underway and this process cannot be stopped [4].

On the other hand, according to L.V. Eder et al., the demand for oil and gas processing products will grow: polymers, fabrics, medicines – therefore, it is still impossible to abandon these types of fuel completely [5]. Moreover, tax revenues from the oil

and gas sector are the most important source of budget revenues for the Russian Federation, and in the structure of exports they amount to about 2/3 [6].

Digital transformation in Europe and Asia is changing the sales markets for Russian energy carriers, which are controlled by the country's largest transnational companies (TNCs), which actually determine the state of the economy of the entire country [7]. Consequently, it is necessary to adjust the strategic development goals in favor of increasing the share of renewable energy, but while maintaining the same rates of economic development [8].

The issue of the place and role of the oil and gas sector in the Russian economy, especially after the country's exit from OPEC, and the ways of its development, is extremely relevant for both Russian and foreign authors, since the economic well-being of neighboring states is also dependent on Russian energy resources.

L.A. Chaldaeava et al. rightly emphasize the economic efficiency of energy recovery and conversion technologies. In this interpretation, the return on sales and the return on capital (investment) become, on the one hand, the constraints, and on the other, the guides of the development of modern energy. When the cost of innovations in solar and wind energy falls, companies in a certain area can even compete with traditional energy suppliers to make good profits [9].

A.M. Atris and M. Goto conclude that assessing the energy efficiency of companies is the first step towards sustainable development. The authors use unified performance metrics using non-radial DEA (data coverage analysis) models and the Kruskal-Wallis rank model. The results showed that large integrated holdings are better at ensuring environmental efficiency in the medium and long term than independent companies due to strategic environmental branding, high costs for compliance with environmental standards and the development of human capital aimed at sustainable development [10]. This means that in Russia, large companies are quite capable of developing new areas of activity through diversification, engaging in R&D research, development of artificial intelligence for renewable energy [11].

C. Lim and J. Lee studied the efficiency of oil refineries in terms of the theory of portfolio optimization by H. Markowitz for more than 30 OECD countries, for the period from 2005 to 2016. The conclusions showed a direct relationship

between the economic efficiency of companies and world prices for their products. Consequently, the development of deep oil refining simultaneously with an increase in the environmental friendliness of this process can be an excellent intermediate link between the existing practices of oil and gas production and the renewable energy of the future. In support of this thesis, the authors cite calculations in which it can be seen that oil production damages the industry of the countries under consideration as a whole, while investments in R&D and consumption of renewable energy sources are, on the contrary, positive [12].

The crisis in oil consumption and changes in sales markets can positively affect the development of oil corporations. In their article, C. Sun et al. analyzed the performance indicators of the largest oil companies in the world in 2003-2013. The conclusion was largely paradoxical: the energy transition to renewable energy sources and the crisis in the oil market ultimately had a positive effect on companies, because they were able to adapt and adopt strategies for introducing energy innovations [13].

The efficiency of the introduction of renewable energy sources varies greatly depending on the region and the size of the actually available market. In particular, low- and middle-income countries such as an energy transition are going faster due to the high cost of oil and the availability of solar and water energy. For example, African countries, where energy corporations are investing in order to obtain cheap renewable energy.

Such initiatives contribute to the achievement of the UN's global sustainable development goals, in particular Goal 7 – ensuring access to reliable energy for all of humanity. Indeed, in modern energy markets, access to clean energy is extremely limited by intermediaries and unfair [14]. Therefore, many countries are trying to implement similar initiatives for the diffusion of renewable energy technologies and cross-border supply of electricity [15].

Clean energy contributes to increasing household income, improving the health of the nation, and developing the country's brand. Therefore, in this study, we tried to update this topic for Russia, to assess the prospects for the introduction of such technologies in the country.

## 2. MATERIALS AND METHODS

The aim of the study is to characterize the current state of the energy sector of the Russian

Federation related to oil and gas production and its prospects in the context of the global energy transition to renewable energy sources.

The research objectives are:

- analysis of the oil and gas sector in Russia;
- identifying key trends in the development of alternative energy and Russia's place in these processes;
- identification of key threats to the Russian energy sector and directions of its development.

The research is based on the theory of energy transitions. The data of domestic and foreign statistics, practical examples of companies are used. Electric vehicle sales are seen as the main driving force behind the change in the energy mix in favor of green electricity.

Elements of scientific novelty lie in the conclusions formulated by the authors on changes in international politics and law in the context of countries and territories striving for equitable access to clean energy.

The limitations of the study lie in possible changes in the energy structure under the influence of new technologies, as well as the “oil lobby” – a deliberate slowdown in the pace of scientific and technological development on the part of the largest players in the oil and gas market. In addition, the above examples of growth in sales of electric vehicles do not always mean an increase in environmental friendliness. For example, lithium-ion batteries require the extraction of large reserves of natural lithium, which is harmful to the environment.

## 3. RESULTS

After the famous article “World Energy at a Crossroads” presented at PEF-2021 by I. Sechin it became clear that the head of Rosneft Oil Company is confident that the world is in an oil trap for a long time and Russia plays an important role in the world markets of traditional energy sources [16].

*Table 1* shows the share of Russian production of crude oil, natural gas and coal on a global scale for 2000-2020.

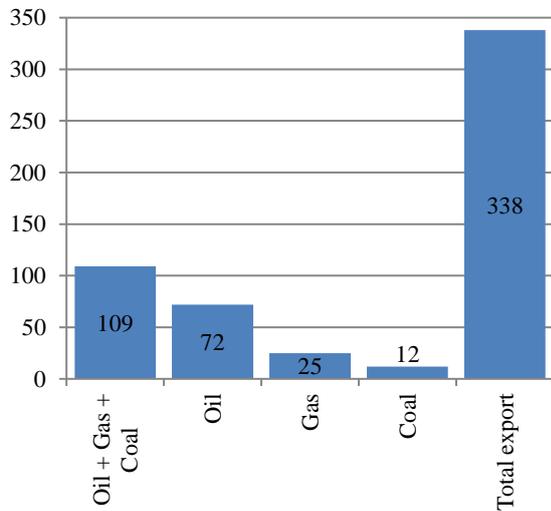
According to [17], in 2018 Russia became the largest exporter of natural gas, the second largest exporter of crude oil and the third largest exporter of coal. Thus, the total value of Russian exports in 2020 amounted to \$338 billion, where fossil fuels

accounted for \$109 billion. In 2020, Russia exported \$72 billion in oil, \$25 billion in gas, and \$12 billion in coal. These three types of fossil fuels account for about 1/3 of the total volume of Russian exports (Figure 1).

**Table 1.** Energy production in Russia (% of world production), 2000-2020, %

Energy source	2000	2005	2010	2015	2020
Oil	8.83	11.73	12.46	12.02	12.1
Gas	22.4	21.39	18.99	16.69	16.6
Coal	5.54	4.91	4.31	4.68	5.2

Source: compiled by the authors based on data [17]



**Figure 1.** Russian exports in 2020, bln USD

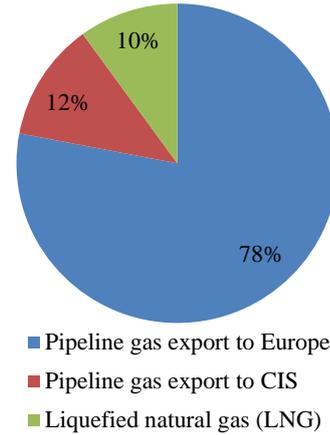
Source: compiled by the authors based on data [18]

In this regard, the growing targets for renewable energy sources around the world and the transition to the decarbonization paradigm are for Russia a significant threat to income from hydrocarbon exports, and, consequently, to the economic security of Russia [19].

But since it was mentioned earlier that the speed of the energy transition depends on the region, in order to determine the stability of demand, one should consider the main export flows of energy resources from Russia.

Due to the geographical proximity, European consumers have always been the main sales market for Russia. After deteriorating political relations with Western countries, Russia has accelerated the diversification of its market and strengthened ties with Asian countries. This policy is called the “turn to the East”. China has become an important partner for cooperation and Russia's main target market for

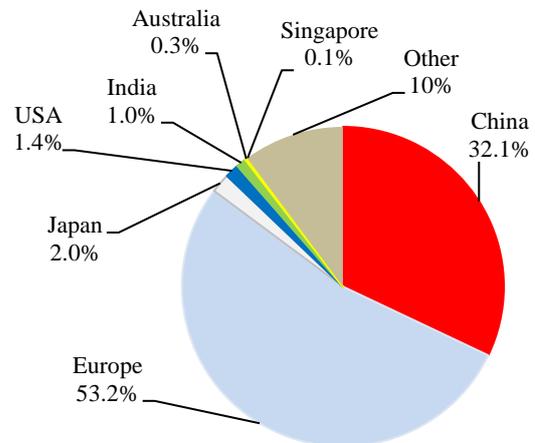
demand diversification. This led to the conclusion of a long-term gas supply agreement between the two countries, the first pipeline gas export project to Asia, launched in December 2019, Power of Siberia (Sila Sibiri). Before the start of the project, in 2018, Russia exported 247 billion cubic meters of gas, and almost 80% of gas was exported to the European market by pipeline, 12% fell on the CIS countries and 10% of the total gas exports fell on LNG (liquefied natural gas) (Figure 2).



**Figure 2.** Structure of Russian gas export volume in 2018

Source: [20]

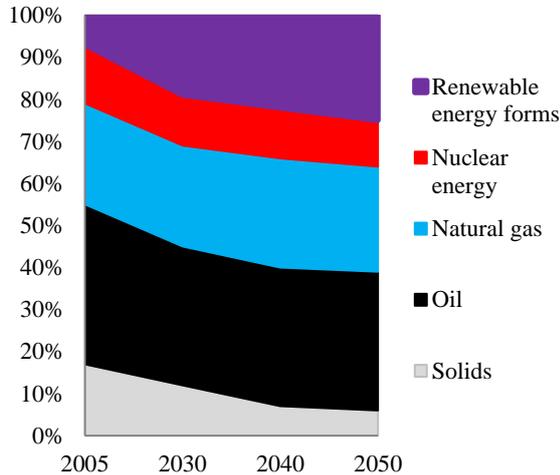
The situation with the export of Russian oil is somewhat different. Oil supplies are easier to diversify than gas supplies due to the relative ease of transportation and storage. China is the leading importer of Russian oil, accounting for 32% of the country's oil export revenues. And yet, in the aggregate, the European region remains the largest buyer of Russian oil (Figure 3).



**Figure 3.** Structure of Russian oil exports by flow directions in 2020

Source: compiled by the authors based on [17]

It can be concluded that the markets of Europe and China are key for the export of Russian energy. And if, according to the most optimistic estimates, the global demand for hydrocarbons peaks between 2030 and 2040, after which a sharp decline in oil and gas demand is expected, then in Europe the peak demand for fossil fuels is already behind (Figure 4).



**Figure 4.** Gross domestic energy consumption in the EU 2005-2050

Source: [21]

As mentioned earlier, further demand in Europe for hydrocarbons will be determined by the decline in the cost of renewable energy sources, government policies, new technologies and changes in the strategies of companies to prepare for the new energy stage.

We should also highlight the development of the electric vehicle market. Combustion vehicles, which account for over 50% of global oil demand, lose market share to electric vehicles every year. According to the Bloomberg Electric Vehicle Outlook 2020, the share of electric vehicles will reach 10% of global passenger car sales by 2025, increasing to 28% in 2030 and 58% in 2040 [22].

China and Europe, which are currently the priority destinations for Russian energy exports, are projected to account for 72% of all passenger electric vehicle sales by 2030, driven by European restrictions on vehicle emissions, China's electric vehicle credit system, economy rules fuel and government policies restricting the sale of new internal combustion vehicles.

For Russia, all this means one thing: its share of energy exports to Europe and China will inevitably decline. And since the revenues of the oil and gas sector are the main source of the Russian economy, the reduction in financial revenues from the sale of

oil and gas can seriously affect various sectors of the Russian economy. In addition, when the oil and gas sector falls out of the general economic field, the foreign exchange income of the state will sharply decrease, which may lead to the fact that the country will actually be unable to purchase imported goods [23].

However, according to F. Veselov, Head of the Department of Scientific Foundations for the Development of Energy Systems at ERI RAS, in Russia itself, "scientific and technological progress cannot be realized due to the cheapness of fuel and the high cost of capital". In case of active development and implementation of renewable energy around the world and adherence to its traditional energy policy on the part of Russia, it is predicted that Russian exports will decrease by 15%, and revenue by 17%. "All this will take place in the context of increasing production costs as the transition to more complex stocks", also noted in the ERI RAS report [24].

The reduction in supplies will primarily affect Russian oil, oil products and coal. In addition, unfavorable conditions for the country will be created due to the weakening of the market situation. So even with the most favorable forecasts, oil prices in 2040 will not exceed the levels of 2007-2012. If, at the same time, the sanctions against Russia remain in effect, then an additional negative impact will be exerted by restricting the access of Russian energy companies to borrowed capital, the latest technologies and sales markets. This outcome of events is confirmed in the report of T. Mitrova, Director of the Energy Center of the Moscow School of Management SKOLKOVO: "The unfavorable investment climate and the institutional structure of the fuel and energy complex, which impedes the development of energy efficiency and the introduction of any low-carbon technologies, will slow down the Russian economy, taking away all opportunities for increasing GDP growth" [25]. It is predicted that the average annual GDP growth rate will be 1.7% at best, and 0.6% at worst.

The recent IMF forecast for Russia for 2021 confirmed a possible and other growth bar of 4.4%.

But, despite the listed threats to the further development of the national economy, Russian regulators do not intend to adjust the energy policy and, contrary to global trends, are betting on the development of the coal industry. Back in early 2019, it was said about the intention to invest in the coal industry in the amount of one and a half trillion rubles. In addition, there is an active development of

large oil and gas and pipeline projects. Moreover, despite the fact that, according to experts, the gas industry will be the most promising in terms of liquefied natural gas, the emphasis is on projects such as the Nord Stream 2 and the Power of Siberia gas pipeline [26].

It turns out that instead of developing a strategy for a smooth move away from the raw materials orientation of exports and the dependence of the entire domestic economy on this category, Russia, investing tens of billions of dollars, decides on the planned development of the raw materials infrastructure [27, 28].

#### 4. DISCUSSION

The country independently drives itself into a hostage state, because there are no guarantees for the return of the invested investment and cannot be. According to T. Mitrova, ignoring global trends creates a threat of possible investment death. Thus, adherence to traditional energy megaprojects in an environment when the energy industry is on the verge of a new era can turn out to be a very big risk for Russia, a startup where the ultimate beneficiaries will be of international origin, and the victory may turn out to be either Pyrrhic or a new offshore boom.

There is another rational explanation in the digitalization of all world resources, and this vision is in the accelerated construction of a new pre-war infrastructure of a global nature. But with the index of transnationalization of the national economy of Russia, the model of which A. Kudrin called "obsolete", constituting over 80% and having an energy-dependent and fuel-saturated oriented character, it will be extremely difficult to turn again the aircraft over the Atlantic. Because in this case, the ocean will be associated with the emerging union of the global oligarchy and the emerging cryptocurrency technocratic bloc, which is forced to yield to the powers that be, because everything that is on Earth for a long time and legally belongs to the corresponding aristocratic families of the Anglo-Saxon and Asian elites.

At the same time, one should understand that the deal on Nord Stream 2, which has already been completed by 99%, between the United States and Germany will still be reduced to the transit of Russian gas through Ukraine and the prevention of Russia's dominance in the European energy market. This means that the Americans will continue to oppose the influence of fuel and energy projects between the countries of the Old World and the

EAEU. And the national interests of the United States, as you know, according to their strategies and doctrines, are manifested everywhere, which in Europe will lead to a balancing of foreign policy levers for the post-COVID elite and the introduction of mechanisms of targeted and sectoral sanctions, retorts and reprisals for end consumers and suppliers involved in non-American fuel supplies. Of course, this will lead to a drop in the volume of electricity, which had a good effect on the leading economy of the European Union (EU) Germany, which closed all nuclear power plants on its territory under pressure from the green party. And this immediately led to an increase in the cost of German products and to a decrease in the competitiveness of Europe as a whole. This event after Brexit and COVID-19 will certainly create political imbalances and lead to new infrastructure and fuel alliances between the Old and New Worlds through a further dilution of the powers of the EU supranational governing bodies and the creeping Americanization of the Marshall type in the key positions of the sovereignty of all countries of the European continent.

#### 5. CONCLUSION

Based on the results of the study, the following conclusions can be drawn:

- 1) The rift of the modern world will not consist in the adoption of an ideological or democratic paradigm of the further coexistence of the countries of the "golden billion" and the impoverished countries of Africa and credited to the level of several GDP of Asian countries, it will take place at the level of a technological self-identification code capable of autonomously conducting independent policies from leading players in the global international division of labor, intrafirm and country specialization and cooperation, along the lines of combining or opposing global value chains with the dominance of TNCs of those countries that are still able to maintain parity in economic sovereignty and not fall under the general global governance of corporatocracy. The times are coming when the enemy of my enemy is not only my friend, but also a competitive advantage in more flexible participation in integration communities such as the WTO and BRICS, the EAEU and ASEAN. Each state must learn to grope for its own trend of non-prescription involvement in international economic relations, according

to the ideas of T. Hobbes, when “everyone is against everyone” being friends and enemies at the same time. This will lead not only to the isolation of the technological leaders of Industry 4.0., but also to the disintegration of a single world into a number of currency, innovation and technological zones, will reduce the reformatting of environmental standards to a new migration of peoples, so actively moving from Africa and the Middle East to Europe after the fall of the M. Gaddafi’s regime.

- 2) International law will not only face the emergence of new mandated territories, but it will also have to create an institution of law and give an appropriate legal assessment to the concepts of “somalization” and “post-Yugoslavian syndrome”, local conflicts of a continental scale on the bayonets of PMCs of great powers and countries that have not forgotten bonuses the colonial heritage of its past. The ongoing reformatting of the world of insufficient digital redistribution of natural resources and hypertrophied bubbles in commodity markets from futures to swaps, hiding behind global concern for the planet in the imposition of building a “green”, carbon-free economy (according to this scheme, Russia is already planning to pay an annual carbon tax – the EU fine of 1.1 billion euros) is just a trick by the richer countries to stop the pursuit of the poor. The attempt of the rich West not to share its portion of calories with anyone for each member of civilized society to the detriment of all catching up countries, and from this even more losing from the introduction of the environmental agenda, from the philanthropy of Bill Gates to the imposition of overwhelming eco-standards that finally put an end to the concept of competitiveness, and technological independence from such global giants as Cisco, Oracle, Microsoft, IBM, Huawei and Xiome.
- 3) That is why the digital transformation of the oil and gas industry in Russia, capable not only of calculating the costs and risks of each industry project, but also of predicting the expected trends in the global energy sector (more than 5 trillion US dollars annually makes up the turnover of the global industry), which is significantly inferior to in the development of digital and cloud services, banking and payment platforms,

communication systems and growing space tourism, biotechnology and the pharmaceutical market, oriented towards the coming waves of vaccinations against the emerging host of new strains and mutations of COVID-19 and other man-made infections.

## **AUTHORS’ CONTRIBUTIONS**

The study was prepared by a team of five authors. Valeriy M. Tumin and Yury V. Daneykin analyzed the current state and development dynamics of the Russian oil and gas sector. Maksim M. Novikov and Shen Wenhao described the directions of development of the Russian energy sector in the context of global trends, including the production of electric vehicles. We examined the results obtained in the context of domestic realities and formulated conclusions. Petr A. Kostromin prepared a literature review of the foresight approaches of Russian and foreign authors to the energy of the future, the place of oil and gas in the structure of sales in the market, the economic efficiency of oil and gas processing in comparison with renewable energy sources.

## **REFERENCES**

- [1] P. Johnstone, C. McLeish, “World wars and the age of oil: Exploring directionality in deep energy transitions”, *Energy Research and Social Science*, 2020, vol. 69, p. 101732. DOI: 10.1016/j.erss.2020.101732
- [2] I.V. Filimonova, A.V. Komarova, I.V. Provornaya, Y.A. Dzyuba, A.E. Link, “Efficiency of oil companies in Russia in the context of energy and sustainable development”, *Energy Reports*, 2020, vol. 6(6), pp. 498-504. DOI: 10.1016/j.egyr.2020.09.027
- [3] E.G. Carayannis, A.E. Cherepovitsyn, A.A. Ilinova, “Sustainable Development of the Russian Arctic zone energy shelf: the Role of the Quintuple Innovation Helix Model”, *Journal of the Knowledge Economy*, 2017, vol. 8, pp. 456-470. DOI: 10.1007/s13132-017-0478-9
- [4] A. Cherepovitsyn, D. Metkin, A. Gladilin, “An Algorithm of Management Decision-Making Regarding the Feasibility of Investing in Geological Studies of Forecasted Hydrocarbon Resources”, *Resources*, 2018, vol. 7(3), p. 47. DOI: 10.3390/resources7030047
- [5] L.V. Eder, I.V. Filimonova, I.V. Provornaya,

- A.V. Komarova, S.M. Nikitenko, “New directions for sustainable development of oil and gas industry of Russia: Innovative strategies, regional smart specializations, public-private partnership”, In Proceedings of the International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, 2017, vol. 17(15), pp. 365-372. DOI: 10.5593/sgem2017H/15/S06.046
- [6] I.V. Filimonova, A.V. Komarova, M.V. Mishenin, “Technical, economic and fiscal aspects of increasing the efficiency of development of oil and gas regions in the east of Russia”, In Proceedings of the 14th International Scientific-Technical Conference on Actual problems of electronic instrument engineering, APEIE, 2018, pp. 374-378. DOI: 10.1109/APEIE.2018.8545393
- [7] L.S. Valinurova, E.A. Sulimova, T.G. Guseva, E.A. Bolotina, V.M. Tumin, “Post-crisis modeling of economic development trends in an on-going recession of national economies”, Montenegrin Journal of Economics, 2021, vol. 17(2), pp. 75-82. DOI: 10.14254/1800-5845/2021.17-2.6
- [8] O.Y. Myasnikova, I.I. Shatalova, E.V. Zenkina, T.V. Bogacheva, N.I. Illeritsky, G.M. Kutlyeva, “Promising directions of cooperation among Eurasian Economic Union countries”, International Journal of Engineering and Technology, 2018, vol. 7(3.14), pp. 386-391. DOI: 10.14419/ijet.v7i3.14.17031
- [9] L.A. Chaldaeava, T.I. Chinaeva, A.S. Bogopolskiy, “Analysis of financial and economic indicators, characterizing the activities of organizations in the oil and gas industry”, Statistics and Economics, 2020, vol. 17(1), pp. 69-78. (In Russ.). DOI: 10.21686/2500-3925-2020-1-69-78
- [10] A.M. Atris, M. Goto, “Vertical structure and efficiency assessment of the US oil and gas companies”, Resources Policy, 2019, vol. 63. DOI: 10.1016/j.resourpol.2019.101437
- [11] B.S. Vasyakin, D.N. Mednikov, E.A. Karelina, A.S. Kharlanov, “Marketing model of distribution of intellectual machines as new subjects of socio-economic relations in emerging economies”, International Journal of Economic Policy in Emerging Economies, Forthcoming and Online First Articles, 2021. DOI: 10.1504/IJEPEE.2021.10038315
- [12] C. Lim, J. Lee, “An analysis of the efficiency of the oil refining industry in the OECD countries”, Energy Policy, 2020, vol. 142, p. 111491. DOI: 10.1016/j.enpol.2020.111491
- [13] C. Sun, Y. Luo, Y. Huang, X. Ouyang, “A comparative study on the production efficiencies of China's oil companies: A true fixed effect model considering the unobserved heterogeneity”, Journal of Cleaner Production, 2017, vol. 154, pp. 341-352. DOI: 10.1016/j.jclepro.2017.03.222
- [14] C. Barrington-Leigh, J. Baumgartner, E. Carter, B.E. Robinson, S. Tao, Y. Zhang, “An evaluation of air quality, home heating and well-being under Beijing's programme to eliminate household coal use”, Nature Energy, 2019, vol. 4, pp. 416-423. DOI: 10.1038/s41560-019-0386-2
- [15] B.K. Sovacool, R.J. Heffron, D. McCauley, A. Goldthau, “Energy decisions reframed as justice and ethical concerns”, Nature Energy, 2016, vol. 1, p. 16024. DOI: 10.1038/nenergy.2016.24
- [16] I.I. Sechin, “The world energy industry is at a crossroads” [Mirovaya energetika na rasput'e], St. Petersburg International Economic Forum, 2021. (In Russ.). Retrieved from [https://www.rosneft.ru/upload/site1/attach/0/14/02/SPIEF\\_slides\\_2021.pdf](https://www.rosneft.ru/upload/site1/attach/0/14/02/SPIEF_slides_2021.pdf)
- [17] “BP Statistical Review of World Energy”, 2021. Retrieved from <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf>
- [18] “Russia's export of the most important goods” [Eksport Rossii vazhneishikh tovarov], Federal customs service, 2020. (In Russ.). Retrieved from [https://customs.gov.ru/storage/document/document\\_statistics\\_file/2021-02/08/gJrQ/WEB\\_UTSA\\_01.xlsx](https://customs.gov.ru/storage/document/document_statistics_file/2021-02/08/gJrQ/WEB_UTSA_01.xlsx)
- [19] I. Slav, “Why the Clean Energy Revolution Isn't Taking Off in Russia”, Oilprice, 2019, July 01. Retrieved from <https://oilprice.com/Alternative-Energy/Renewable-Energy/Why-The-Clean-Energy-Revolution-Isnt-Taking-Off-In-Russia.html>
- [20] E. Rasoulizhad, F. Taghizadeh-Hesary, J. Sung, N. Panthamit, “Geopolitical Risk and Energy Transition in Russia: Evidence from

- ARDL Bounds Testing Method”, *Sustainability*, 2020, vol. 12(7), p. 2689. DOI: 10.3390/su12072689
- [21] A. Cohen, “Will Russia Survive the Coming Energy Transition?”, *Forbes*, 2019, June 27. Retrieved from <https://www.forbes.com/sites/arielcohen/2019/06/27/will-russia-survive-the-coming-energy-transition/?sh=50acfdbe5577>
- [22] “Electric Vehicle Outlook”, Bloomberg NEF, 2021. Retrieved from <https://about.bnef.com/electric-vehicle-outlook/>
- [23] A. Koshkina, “What prevents Russia from switching to renewable energy sources” [Chto meshaet Rossii pereiti na vozobnovlyaemye istochniki energii], *Profile Journal [Zhurnal Profil]*, 2020, April 21. (In Russ.). Retrieved from <https://profile.ru/scitech/chto-meshaet-rossii-perejti-na-vozobnovlyaemye-istochniki-energii-285031/>
- [24] E. Samedova, “Oil is inferior to solar and wind energy, but not in Russia” [Nefit' ustupaet energii solntsa i vetra, no ne v Rossii], *DW*, 2019, July 08. (In Russ.). Retrieved from <https://www.dw.com/ru/нефть-уступает-энергии-солнца-и-ветра-но-не-в-россии/a-49454791>
- [25] T. Mitrova, V. Yermakov, “Russia’s energy strategy 2035”, *Russie.Nei.Reports*, 2019, vol. 28. Retrieved from [https://www.ifri.org/sites/default/files/atoms/files/mitrova\\_yermakov\\_russias\\_energy\\_strategy\\_2019.pdf](https://www.ifri.org/sites/default/files/atoms/files/mitrova_yermakov_russias_energy_strategy_2019.pdf)
- [26] E. Vavina, “Cheap gas and expensive equipment are slowing down the green energy sector in Russia” [Zelenuyu energetiku v Rossii tormozyat deshevyi gaz i dorogoe oborudovanie], *Vedomosti*, 2019, May 30. (In Russ.). Retrieved from <https://www.vedomosti.ru/business/articles/2019/05/29/802812-zelenuyu-energetiku>
- [27] A. Sobko, “Greta Thunberg's World: What will happen when Green Energy wins” [Mir Greta Tunberg: chto budet, kogda “zelenaya energiya” pobedit], *RIA News [RIA Novosti]*, 2019, October 20. (In Russ.). Retrieved from <https://ria.ru/20191020/1559971478.html>
- [28] A. Tarasova, “What will happen to Russia when the world abandons oil?” [Chto budet s Rossiei, kogda mir otkazhetsya ot nefiti?], *Vyberu.ru*, 2019, December 20. (In Russ.). Retrieved from <https://www.vbr.ru/banki/novosti/2019/12/20/kogda-alternativnie-istochniki-energii-podorvyt-ekonomiky-rossii/>