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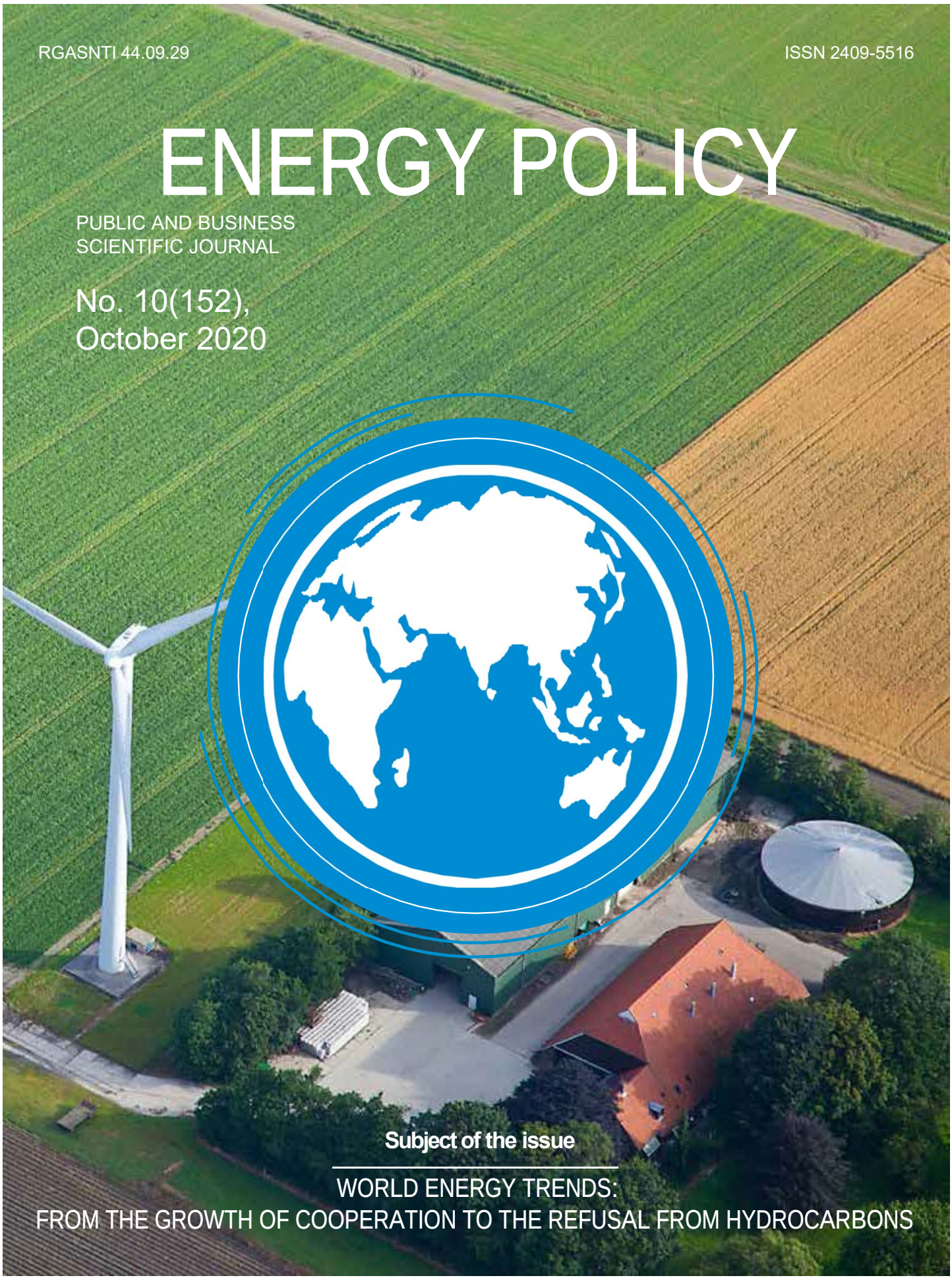
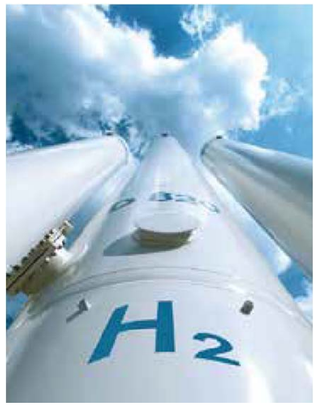


Subject of the issue

WORLD ENERGY TRENDS:
FROM THE GROWTH OF COOPERATION TO THE REFUSAL FROM HYDROCARBONS

Содержание



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Polar Trends: from Complete Rejection to Plentiful Growth of Hydrocarbon Production

World events and trends are becoming an integral part of the national energy policies. Against that background, the international cooperation and collaboration for achievement of common interests acquires primary importance. This is confirmed by the long-term successful cooperation of Russia with the OPEC and the GECF countries, the work of the “Group of Twenty” energy ministers to stabilize the world oil market, the progress in creating a common market space with the EAEU countries, and so on. Recently, the world agenda has been supplemented with a new complex and painful topic of transition of the European Union to the carbon-free economy. In the new issue of the “Energy Policy” magazine, we tried to outline the main features and assess the risks of this transition for the Russian fuel and energy sector.

In contrast to Europe which aims to refuse from oil and gas, the African continent continues to develop hydrocarbon production. Moreover, Africa is rightfully considered as one of the fastest growing energy markets, in which the supply of energy resources does not keep pace with the demand. In the new issue, we tried to “play on contrast” and show two oppositely directed trends in the global development of the fuel and energy sector.

Much attention in this issue was paid to the situation in the domestic fuel market. It has grown significantly after the 2020 crisis spring, when the demand for petroleum products fell by about 40 %, but continues to require constant monitoring and analysis from the regulators such as the Federal Antimonopoly Service.

Alexander NOVAK
Minister of Energy of the Russian Federation

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International Cooperation is the Way to Energy Security of the Planet

Humanity faced the beginning of the globalization processes several centuries ago, but over the past century the pace of integration has accelerated significantly, and since the beginning of the 21st century has become truly galloping. First of all, this is facilitated by the development of telecommunication technologies, communications and transport, as well as the presence of an increasing number of common problems, tasks and challenges for the world community, including the fight against the epidemic of coronavirus infection in the recent months, as well as the fight against the economic consequences of the pandemic. This experience has once again demonstrated the necessity and even inevitability of the international cooperation in various sectors of the economy to achieve the stability.

Energy is one of the most important areas for the international community, which is one of the main guarantors of global security in the modern world. The fuel and energy sectors provide the comfortable existence for the world's population and the opportunities for development of the world economy. Therefore, in the conditions of global challenges and the constantly changing world, it is extremely important to combine the efforts of countries to keep the balance in this industry. In this regard, the Russian energy policy over the past few years has been invariably aimed at developing and deepening the international cooperation which every year reaches ever higher levels of communication.

OPEC+

A prerequisite for cooperation in the OPEC+ format was the protracted crisis in the ‘black gold’ market that began in 2014. Within two years, oil prices had fallen on average by half. There were several reasons for this. First, the significant increase in production in almost all oil-producing countries due to the previous period of ultra-high prices and significant investments in the sector. Secondly, against the backdrop of a favorable market environment, there was a sharp jump in shale oil production in the United States. And thirdly, Iran has returned into the list of the key suppliers. Russia, which is not a member of OPEC, nevertheless appeared to be one of the first countries in the world

which came to the conclusion about the need for cooperation between the oil-producing countries and took the initiative to start negotiations with the countries — key oil producers. This path wasn't easy. Finding a compromise was preceded by a series of difficult negotiations. It was necessary to take into account the interests of each country. And at the end of 2016 it has been successful. As a result, on December 1 — even before the the effectiveness of the Agreement (January 1, 2017) — for the first time since June 2016, the cost of barrel of Brent crude exceeded the level of $ 50 per barrel.

in 2018 — $ 71.2, in 2019 — $ 64.7.

By the beginning of this year, the expected effect had been achieved, and the parties of the agreement were preparing for further easing of the restrictions, however, the sharp reduction in energy demand in connection with the coronavirus pandemic required the adoption of unplanned, more stringent measures. If in 2019 the oil demand reached about 100 million barrels per day, in April 2020 it has dropped sharply to about 72–75 million barrels per day. To stabilize the situation, the new agreement was signed in April of this year, from May 1, 2020 to May 1, 2022.

The negotiations of the G20 Energy Ministers

Source: RF Ministry of Energy

The agreement for reduction of oil production by OPEC and non-OPEC countries has become the most significant example of the international multilateral cooperation in the energy sector in the recent years. Saudi Arabia, along with Russia, played a key role in the successful conclusion and subsequent implementation of the deal, demonstrating its commitment to the agreement and active participation in the negotiations with other countries. During 2017–2020, thanks to the OPEC+ agreement, the oil market was significantly stabilized. In 2017, the average price of Brent in the market reached $ 54.1,

In addition, the list of participants has significantly expanded. In addition to the 24 OPEC+ countries, the deal was supported by a number of G20 states, including the United States, which, due to the peculiarities of the legislation, although did not formally enter into cooperation, but expressed their readiness to help stabilize the situation on a voluntary basis. This was an unprecedented signal for the market.

With effectiveness of the agreement on May 1, the market started balancing and around July-August, according to the estimates of the analytical agencies, the demand exceeded the supply.

Despite the beginning of the second wave of the epidemic in a number of countries, my colleagues and I continue to look at the situation with optimism and expect that we will be able to gradually increase production in the framework of the deal

In July, the commercial oil reserves showed a decline for the first time, whereas the oil demand recovered to 90 % of the pre-pandemic level, and the oil quotes stabilized above $ 40 per barrel. At the moment, despite the beginning of the second wave of the epidemic in a number of countries, my colleagues and I continue to look at the situation with optimism and expect that we will be able to gradually increase the production, according to the terms of the deal, without harm for the market.

In addition to the agreement, interaction with the OPEC countries is developing under the auspices of the Charter for Cooperation of Oil-Producing Countries which was unanimously approved and signed in July 2019. It is a strategic document with no validity time limits. The Charter is aimed at developing the dialogue, the technological cooperation, and mutual support of the energy policy of the oil-producing countries. And this is a very important, milestone agreement, since oil will remain the leading source of energy for more than one decade.

GECF

Our country was one of the initiators of founding the Gas Exporting Countries Forum (GECF) in 2008. Today, the GECF is an international government organization whose mission is to protect the interests and sovereignty of the energy policy of the member countries and coordinate the efforts to promote natural gas on the global stage. During its existence, the gas coalition has united 20 countries — the leading natural gas producers which control 72 % of proven reserves, 46 % of production, 55 % of pipeline gas export and 61 % of LNG supplies.

The most important today's event of the association was signing in 2019 of the unanimously approved Malaba Declaration of the GECF, which confirmed the importance of the role of natural gas in achieving the UN sustainable development goals, as well as the irreplaceable contribution of the 'blue fuel' to environmental protection, in particular to mitigating the effects of climate change. A milestone event for the world gas community was the introduction of the wording on inadmissibility of the use of unilateral economic and political sanctions, into the document.

One of the key activities of the GECF is also monitoring the current state and forecasting the development of the situation

GECF Headquarters

Source: canyalcin / Depositphotos.com

in the gas markets, which is necessary for planning the energy policy of all the players and is especially important for assessing the economic consequences of the coronavirus pandemic. According to the GECF forecasts, the drop in global gas demand may range from 2.8 % to 6 % in 2020. The global economic recovery in 2021 will not be able to compensate for the losses incurred by the gas industry, and gas demand will only reach the 2019 level in 2022. At the same time, in the future, natural gas will remain an integral part of the energy transformation, and the share of gas in the global energy balance by 2050 will exceed 27 %.

In 2020, the growth rate of LNG trading will be slower and will amount to 3–3.5 %, with a decrease in the rate of commissioning of new capacities for production of liquefied gas and a decrease in its supply on the market. In 2021, LNG trade volumes may grow by 7–7.5 % due to a possible revival of demand and the launch of new projects. In the future, the pace of its annual growth is expected to accelerate to 3.5–5.5 %, caused by the emerging of new crude importers, capable increase the world consumption to 2025. In this regard, in the future, the situation may arise again with oversupply of LNG, which re-raises the question of effective mechanisms to stabilize markets.

Against this background, the GECF acquires special significance. This is a very important institution for the market in the context of a steady excess of the global gas supply over the demand due to the slowdown in economic growth and the launch of new liquefied natural gas capacities.

The drop in global gas demand may amount to 2.8–6 % in 2020. Economic recovery in 2021 will not compensate for the losses of the industry , and gas demand will reach the 2019 level only in 2022.

The GECF must anticipate the future trends, set the pace for innovation and be an example of effective cooperation in the gas industry. The leading experts today compare the gas alliance with OPEC in terms of influence and authority. And this is quite fair.

LNG will remain a part of the global energy transformation *Source: Altinosmanaj / Depositphotos.com*

Today, on the basis of the GECF, there are opportunities similar to OPEC to create coalitions and agreements to balance the industry market. And these levers can be used when needed.

EAEU

The Eurasian Economic Union is a strategic cooperation of the participating countries, which is aimed at increasing the competitiveness of national economies and the standard of living of the population. The energy cooperation with the CIS countries within the EAEU is one of the priority areas of activity for Russia. Since 2014, the work has been underway to create the common energy markets for the EAEU countries, i.e., Russia, Belarus, Kazakhstan, Kyrgyzstan and Armenia.

The integration of energy systems will increase the energy security of our countries and will contribute to a more rational use of energy resources of the Union states. In July 2019, the formation of a common electricity market had been completed, which allows to use the existing advantages of parallel operation of the energy systems of the EAEU member states at a qualitatively new level. The document provides for adoption of uniform rules for access to services for the interstate transmission of electrical energy and mutual trading in electrical energy in the common EAEU market by 2022. By 2025, the EAEU member states will conclude international agreements for formation of common markets for gas, oil and oil products. To ensure uninterrupted interstate transportation of oil, oil products and gas, with participation of the Russian Ministry of Energy, the exchange of technological information was organized between the pipeline companies of the EAEU member states, as well as the gas transportation systems of the EAEU member states and exchange trading operators.

BRICS

Another international organization — the BRICS — unites the five countries from different parts of the world — Russia, Brazil, India, China, South Africa, each of which has unique resources for the planet. Initially, the community was supposed to be an advisory authority, but almost immediately the organization began to transform into an economic and even geopolitical club of international importance. The BRICS member countries account for more than a quarter of the Earth's territory, 42 % of the world's population and about 40 % of global energy consumption. Therefore, energy has become one of the key elements of cooperation, the main goal of which is to solve the problems of ensuring access to affordable, reliable, sustainable and modern energy. Here, a special role is played by our country, which is one of the leaders in terms of hydrocarbon reserves, the level of technologies, including those in nuclear energy.

The meeting of the Eurasian Inter-government Board
Source: government.ru

The BRICS Energy Research Platform, created by the initiative of the Russian side, has been operating since 2019. Russia is chairing the BRICS association this year, and we see that the request for an assessment of global energy development comes not only from the BRICS countries, but also from other major economies. The energy platform is exactly the tool that allows to assess the structure of energy consumption, the trends of production, cost, investments, infrastructure development not only in the countries of the community, but also in the global scale. The forecasts are based on a medium-term perspective and help the BRICS countries to formulate a competent energy policy based on the data obtained.

It is important that the study covers not only traditional coal, oil, gas (including LNG), electric power industries, but also renewable energy sources and the use of environmentally friendly fuels in the transport sector, in particular, natural gas. The sustainable energy system will be an excellent foundation for the BRICS, which, according to experts, has every chance of becoming a political competitor to the G7 countries in the future.

"The Group of Twenty"

During the pandemic, the G20 countries showed a new level of cooperation. In April, the G20 energy ministers met amid an unprecedented slowdown in the economic activity, which seriously affected the energy sector and reduced oil demand. A short-term energy focus group was created, within the framework of which an effective mechanism for monitoring and developing the necessary response measures to balance the energy market was established.

During the G20 Sustainable Energy Working Group, we took a closer look at the circular carbon economy, universal access to energy with a focus on environment-friendly cooking techniques, security and stability of energy markets. As a result, based on the results of the September ministerial meeting, its participants expressed their intentions of further cooperation to develop the principles of security and stability of energy markets, to continue collective efforts to eradicate the energy poverty, promoting access to reliable and sustainable energy. There was also presented the mechanism of operation of the circular carbon economy (CCE) platform with the so-called base "4R", which implies reducing carbon emissions, using the produced CO_2, its capturing and processing. The increased use of a closed carbon economy could provide up to 40 % reductions in industrial emissions. In general, we support the approach proposed by our colleagues, while it is advisable to consider the mechanism in a broad aspect.

Since the "circular carbon economy" principle is based on the circular economy model of four measures "4R" (reduction, reuse, recycling, removal), each component is important and each country is free to choose the most optimal solution based on national conditions, priorities, needs and energy balance. I would like to note that fossil energy sources, in particular natural gas, can be environmentally neutral, taking into account the development and application of modern technologies for the capture and disposal of harmful emissions.

As planned in the roadmap, by 2050 we will reach the formation of a pan-European energy space with an integrated network infrastructure, with transparent markets

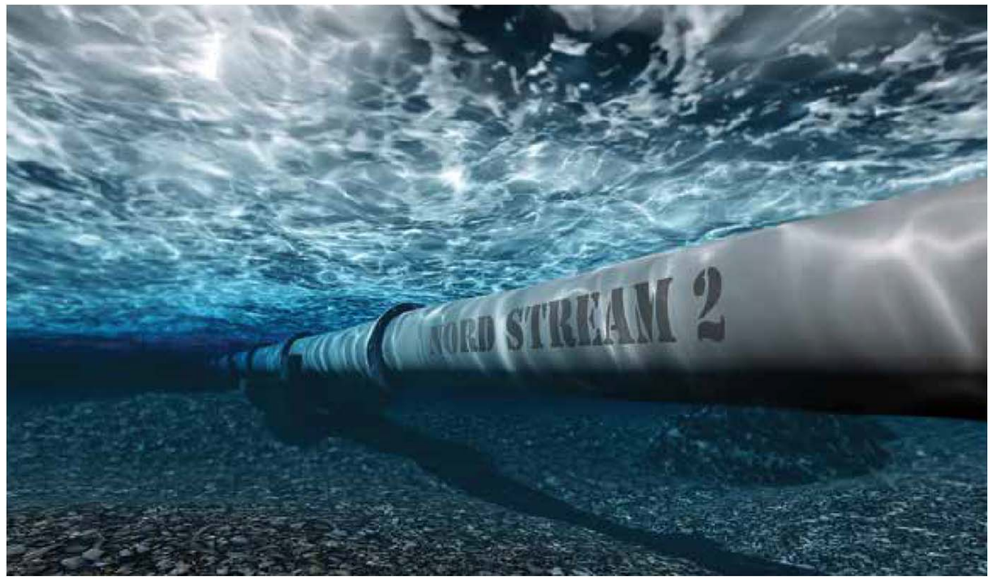
Today, the most important thing is to ensure the availability of energy sources for every inhabitant of the Earth, the availability of scientific research for widespread use, to comply with the interests of all the market participants

Russia — European Union

Russia has been the largest supplier of energy resources to the European market for the past 50 years. The document on the approval of the Russia-EU energy dialogue in 2000 became the first for the European Union energy dialogue with an external partner. It was a unique agreement among other sectoral dialogues in bilateral relations, which brought communication on energy issues with European partners to a new level. The establishment of energy dialogue made it possible to promptly consider the topical issues of energy cooperation, including the rationalization of industrial and transport infrastructures, the opportunities for European investments, the relations between the producer and consumer countries, and the development of cooperation in the field of energy saving.

In subsequent years, a number of joint documents were signed regulating the actions of the parties for prevention and prompt response in the event of emergency situations in supplies of gas, oil and electricity from Russia to the EU. This has undoubtedly significantly increased the energy security of the continent. In March 2013, we approved the Roadmap for Russia-EU Energy Cooperation until 2050, which is aimed at mutually beneficial development of EU-Russia energy relations and covers all sectors of the fuel and energy sector. Despite the fact that in 2014 the energy dialogue was formally frozen at the initiative of the EU, the Gas Advisory Council continues its work, in which framework the volume of production and demand for Russian gas in the European market is assessed, and recommendations for long-term cooperation between Russia and the European Union in the gas sector are formed. As we see today, the European countries are interested in the supply of Russian 'blue fuel'. We have made sure of this once again, in particular, by the unprecedented support of our European partners for our joint project of the Nord Stream — 2 gas pipeline. It is already obvious to everyone that this is a commercial project that does not in any way affect the gas supply route through Ukraine. The latter, according to the agreements reached at the end of 2019, will operate at least till 2024.

We are sure that over time, and in a fairly short term, the energy dialogue with the EU will resume in other sectors of the fuel and energy sector. As planned in the current roadmap, by 2050 we will reach "the formation of a pan-European energy space with a functioning integrated network infrastructure, with open, transparent,



The Nord Stream — 2 Gas Pipeline *Source: YurikswO / Depositphotos.com*

LNG tanker “Christophe de Margerie” delivers Russian liquefied gas to China

Source: sabetta-yanao.ru

efficient and competitive markets, which will contribute to ensuring energy security and achieving the goals of sustainable development of the EU and Russia”. This is important, first of all, for consumers.

WEC

Since 2000, we have been actively cooperating at the WEC platform. The World Energy Council established in 1923 on the initiative of business and energy circles of a number of countries in Europe and North America, is the largest energy international non-governmental organization, which includes 92 countries. One of the main activities in the framework of the WEC was the International Energy Congress (IEC) which is held once every three years and is a platform for world energy leaders and experts to discuss all the aspects of functioning of the energy sector, the search for the most optimal ways to develop the energy system, prevent the risks and formation of responses to existing challenges.

In 2018, based on voting by the representatives of the national committees of the WEC countries, Russia obtained the right to host the 25th IEC in 2022 in St. Petersburg. WEC today plays an exceptional role in the global energy balance, therefore the IEC-2022 theme was chosen with a focus on the needs of the world's population — “Energy to Humanity”. In our opinion, today it is most important to ensure the availability of energy sources for every inhabitant of the Earth, the availability of scientific research for wide practical application, and to meet the interests of all market participants. All this is necessary to achieve the goals of socio-economic prosperity and the maximum possible balance of interests.

The leadership of the Russian Ministry of Energy heads the eight intergovernmental commissions — with Spain, Iran, Pakistan, Qatar, Turkey, Saudi Arabia, Congo, Bolivia and Afghanistan

From East to West

In addition to the international structures mentioned above, Russia is also a member of the Organization of the Black Sea Economic Cooperation (BSEC) which unites 12 states of the Black Sea and the Southern Balkans, whose priority is to promote multilateral cooperation in the field of industry and trade, energy, transport, agriculture, science and in other areas. The International Energy Forum (IEF), established in 1991, is another independent institution of world energy policy, designed to provide a global dialogue between consumers and producers of energy resources. At the IEF platform, where our country regularly takes part as well, for about 20 years an effective dialogue has been established between consumers, producers and transit countries of energy resources, the critical issues are discussed, such as increasing market transparency, overcoming “bottlenecks” in development of infrastructure and the legal framework of the energy sector, formation of common approaches to development of the world energy sector. Since 2015, Russia has become a full member of the International Renewable Energy Agency (IRENA) which was formed by the initiative of Germany in 2009 and unites 145 states. For more than 10 years now, IRENA has been promoting the distribution and sustainable use of all types of renewable energy, which are actively developing in Russia today.

The cooperation on the energy track has also been established on the basis of the CIS Electric Power Council, the Association of Southeast Asian Nations (ASEAN), the UN Economic Commission for Europe, the UN Economic and Social Commission for Asia and the Pacific (ESCAP) and other organizations. The work is ongoing on the projects of energy bridges “Russia — Armenia — Georgia — Iran” and “Russia — Azerbaijan — Iran”.

Coal supplies to India almost doubled in 2019 – to 8.41 million tons. Coal supplies from Russia to Japan had increased by 10 % compared to 2018, exceeding 20 million tons

In addition to cooperation with countries in multilateral formats, we pay considerable attention to development of mutually beneficial bilateral business contacts that link our country with numerous energy partner countries on all the continents

Oil supplies to China by the ESPO in 2019 amounted to 40 million tons

Source: magazine.neftegaz.ru

of the planet. Today, the cooperation in the fuel and energy sector has been established with more than 100 countries. The management of the Russian Ministry of Energy heads the eight intergovernmental commissions — with Spain, Iran, Pakistan, Qatar, Turkey, Saudi Arabia, Congo, Bolivia and Afghanistan. In addition, in 2019 alone, representatives of the Ministry of Energy took part in 51 meetings of the IGC on trade and economic cooperation with foreign countries, 15 international treaties and 3 memorandums were signed, a number of large-scale international projects were implemented.

We are actively working on the European market, traditional for Russia,

Gas production at the Zohr field
Source: phillytrib.com

developing the projects with the countries of the continent in the field of supply of hydrocarbons, their storage and deep processing, as well as participate in the renovation of power generating facilities. In January 2020, gas supplies had been started via the Turkish Stream gas pipeline, the capacity of the first and second lines of which is 15.75 billion cubic meters each. Gazprom and the German company VNG are implementing on pari passu basis the joint project of the UGS
"Katarina" in Germany, LUKOIL owns the Isab refinery in Sicily, which is the third largest refinery in Europe, and "Power Machines" is participating in the modernization of the Serbian HPP Djerdap-1, having fulfilled its obligations to supply equipment ahead of schedule.

At the same time, diversification of energy exports is the basis of Russia's new energy policy, therefore we are expanding the bilateral energy cooperation with the countries of the Asia-Pacific region, the Middle East, Africa and America. In particular, the volumes of coal supplies to the APR countries have significantly increased, the export of oil and oil products to the region is maintained at a consistently high level.

Oil supplies to China in 2019 amounted to 40 million tons, in the first half of 2020 — 19.48 million tons. In the end of 2019, Transneft brought the Eastern Siberia–Pacific Ocean pipeline to a maximum capacity of 80 million tons per year. Coal exports to China increased by 19 %, reaching 32.8 million tons in 2019. The Power of Siberia gas pipeline was put into operation, which supplies gas to China in the amount of 38 billion cubic meters of gas per year.

As regards the supply of coal to India, there has been an almost two times increase, in 2019 — up to 8.41 million tons. Coal supplies from Russia to Japan had increased by 10 % compared to 2018, exceeding 20 million tons. We are implementing joint projects with Asian companies in the field of hydrocarbon production both abroad and in the Russian Federation. In particular, this is about the projects of Zarubezhneft and PetroVietnam — Vietsovpetro and Rusvietpetro, as well as the joint projects with the Chinese, Indian and Japanese partners in the field of LNG production (Yamal LNG, Arctic LNG-2).

I would like to note that the favorable climate for interaction of Russian companies with the region of the Middle East and North Africa was formed, among other things, by cooperation within the framework of OPEC+. I am confident that we need to maintain the reached pace and extend the experience gained to other possible areas of our cooperation. In the bilateral energy cooperation with the countries of the region, there are many opportunities for expanding the cooperation. In particular, to promote the interests of Russian business in the Middle East and North Africa region, the mechanism of intergovernmental commissions on trade and economic cooperation (IGC) is actively used,

Boca de Jaruco super-viscous oil production project in Cuba *Source: Zarubezhneft*

as well as bilateral working groups functioning within the framework of the IGC for development of cooperation in the energy sector. As the examples of successful interaction, I will cite the recent entry of NOVATEK into the Lebanese exploration and production project on the shelf blocks of the eastern Mediterranean, the joint work of Gazpromneft and Saudi Aramco in the framework of the project on the use of artificial intelligence in geological and hydrodynamic modeling, as well as participation Rosneft in the project for development of the Egyptian gas field "Zohr" and joining of LUKOIL to the concession for the development of the Gasha field in the UAE.

In Latin America, special attention is paid to the cooperation with the Republic of Cuba. The main efforts in this area are focused on modernizing the country's energy system, producing superviscous oil using innovative methods developed by the Russian companies.

The favorable climate for interaction of Russian companies with the region of the Middle East and North Africa was formed by the cooperation within the framework of OPEC+. We need to keep the achieved pace.

As we can see, to date, significant successes have already been achieved in Russia's foreign energy policy. At the same time, the immediate plans include expanding Russian participation in the work of the specialized international organizations and structures, as well as in specialized subgroups on energy cooperation as part of bilateral intergovernmental commissions. In addition, further work is to be done in terms of the development and transfer of innovative energy technologies, including that in the field of hydrogen energy.

I emphasize once again: our country is always ready to discuss the possibilities of establishing and expanding cooperation with partners in the fuel and energy sector, and exclusively on mutually beneficial terms. We are sure that only such an approach will help reduce the risks in the energy sector, increase the efficiency of foreign economic activity of fuel and energy organizations and, ultimately, will significantly increase the level of energy security of the planet for the benefit of all the countries and peoples.

Igor ARTEMYEV
Head of the Federal Antimonopoly Service of Russia

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Now the Economy of Oil Product Supplies is Moving in Normal Course

The restrictions imposed by the coronavirus pandemic have strongly hit the fuel market. In the spring of 2020, oil prices had dropped to $ 10–15 per barrel, and the population's transport activity dropped to its lowest levels. The companies were forced to shut down the oil refineries for unscheduled repairs in order to prevent their complete closure. Nevertheless, fuel prices at the Russian filling stations remained at pre-crisis high values. How the Russian fuel market survived the pandemic, how badly the independent filling stations suffered, what actions were taken by the government to support the industry, what is the situation in the Far East and how the process of recovering the demand for oil products is going on, — told the head of the Federal Antimonopoly Service Igor Artemyev in an interview with the magazine “Energy Policy”.

– How did the fuel market survive the coronavirus epidemic, due to which the demand for fuel fell sharply in March-May, and also began to grow sharply in June-August? Were there any problems with lack of fuel, when the refineries did not have time to deliver the required volumes on time?

– In fact, the epidemic of coronavirus infection and measures aimed at limiting its spread (including the introduction of self-isolation regime) have led to an imbalance in the supply and demand of motor fuel on the market. Sharp price fluctuations occurred in the wholesale and small-scale wholesale segment.

To support the oil industry and ensure the country's energy security, the Russian government has implemented a number of measures. This included temporary reduction in the regulatory amounts for exchange sales of motor fuel, a temporary ban on import, which made it possible to stabilize the situation to a certain extent.

In order to prevent overstocking of the tanks and a complete suspension in the production of petroleum products, the oil companies were forced to reduce the production, including by carrying out preventive, unscheduled works at the factories. After the abolition of the self-isolation regime, demand immediately recovered to 90 % of the pre-pandemic level. In these conditions, the supply of fuel in a short period of time did not keep up with the demand. As a result, the prices began to rise in May 2020, which slowed down in June 2020, when there was a surplus balance in the production and sale of fuel in the domestic market.

Currently, the economy of supplying oil products to the domestic market and exporting have leveled off.

– How did the disparity between retail and wholesale prices for fuel in the domestic market as a whole in Russia develop in the last months of summer? Did anyone manage to solve this problem?

– Against the background of strong price volatility in the wholesale and small-scale wholesale segment caused by the coronavirus epidemic, the retail price fluctuated within inflation, without any price jumps. Due to such multidirectional dynamics in all segments of the oil product market, the disparity between retail and wholesale prices has formed in the short term. In order to stabilize the situation, on a daily basis, based on data received from various sources, including from our territorial offices, within the framework of meetings of the Exchange Committee under the FAS, the Headquarters under the Ministry of Energy, we developed the recommendations and made decisions on increasing the supply of oil products at the proper level. And this work has brought its positive results.

– How did the vertically integrated oil companies and independent gas stations go through this period? Were there any complaints about the work of large oil

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and gas companies, which were balancing between the drop in oil demand, closure of refineries for repairs, the social function of fuel supply and the need to maintain economically efficient operation, the profitability of fuel supplies for export, etc.?

– Of course, this period affected all market participants. We constantly monitor the current situation on the oil products market, interact with federal executive authorities and conduct a dialogue with large companies, stock exchanges, expert organizations and independent participants in the oil products market. The necessary decisions, as I already said, were taken as quickly as possible to keep the situation in the controlled area. And I think we succeeded. The measures taken made it possible to stabilize fuel prices in the wholesale segment. As a result, the growth of retail prices also restrained.

– How difficult was the situation for independent gasoline filling stations? Were the RTS complaints reasonable? How many independent chains have left the market? How did this affect the fuel supply to the regions where vertically integrated oil companies are not present? Were the measures proposed by the Federal Antimonopoly Service and the Ministry of Energy sufficient for this segment (increase in sales on the stock exchange, proposals for sales standards for non-dominants, import ban)? How will the independent gasoline filling stations market develop in the future?

– For the independent gas station chains, 2020 was a test for strength and professionalism. In 2019 and during the period of the sharp decline in wholesale prices, the marginal profitability of gas filling station chains was at a fairly premium level, which allowed the independent market participants to accumulate a margin of safety, including filling all tank farms and oil storage facilities with fuel purchased at prices that are comfortable for the market. During the period of sharp increase in wholesale prices, this “safety cushion” had worked well and allowed them to make up for the corresponding losses.

We have been discussing the need to increase sale rates for oil product exchange for long time now. Now we have come to the common opinion with our colleagues from the Ministry of Energy about their progressive increase, but with the obligatory extension to all market participants and the introduction of clear criteria for regularity and uniformity. All of this is intended to ensure a sufficient supply of fuel on the exchange, smooth out price fluctuations in the auctions, restrain the price growth, and prevent a rush of demand in the oil products market. I should note that there are no prerequisites for a fuel shortage in the country.

In March and April, the transport activity reduced to minimum

Source: hansenn / Depositphotos.com

FAS is working on the new National Plan for the Development of Competition for 2021–2025. It provides for development of the futures market and the financial derivatives market

Currently, the FAS is working to create the new National Plan for the Development of Competition in the Russian Federation for 2021–2025. It provides for measures aimed at developing the futures market and the financial derivatives market. This tool allows you to buy fuel not only for the coming month, but also in advance, say, 2–3 months or six months in advance. Thus, to hedge the risks and reduce losses from fluctuations in prices for oil products.

– The crisis on the market in the spring and summer again exacerbated the problem of supplying fuel to the Russian Far East. What is the reason for such high prices in the entire region (not only, for example, in Kamchatka, but also in the Khabarovsk Territory, where there is an oil refinery)? How necessary is a new refinery, for example, Eastern Petroleum Company, in this region and will it help to solve the problem of overprices? Why didn't the Far East damper regime begin to work?

– The Far Eastern market of petroleum products has certain features in comparison with other federal districts.

The main large-scale wholesale supplies of petroleum products to the territory of the Far Eastern Federal District are carried out from four oil refineries. Two refineries are located directly in the FEFD. These are the Komsomolsk Oil Refinery owned by Rosneft, and the Khabarovsk Oil Refinery owned by NNK. There are two more refineries in other regions — Angarsk and Achinsk — the both also owned by Rosneft.

The capacities of two refineries located in the FEFD do not allow providing the district's domestic market with sufficient volumes of oil products. The cost of missing volumes of oil products supplied by railway from the Siberian refineries also includes additional transportation costs.

According to our constant monitoring of prices for oil products, historically the Far Eastern Federal District is the price leader in all segments of the oil products market among the other federal districts of Russia. The formation of prices in the small-scale wholesale segment of the Far Eastern market of oil products is also influenced by the presence of excessive intermediary structures in the systems for the sale of oil products and underdeveloped competition.

Khabarovsk Oil Refinery
Source: chemtech.ru

The additional transport costs for the supply of oil products directly to the regions of the Far East, and the lack of capacities (oil depots, storage warehouses) for oil products in order to create a reserve in case of stopping the nearest refineries for modernization or scheduled/unscheduled repairs, make their contribution. The formation of market prices in the small-scale wholesale and retail market segments and the development of competition in the Far East are negatively affected by the insufficient supply of motor fuel at exchange auctions. These problems, unfortunately, are typical for all the regions of the Far Eastern Federal District.

The oil companies according to rough estimates, oil companies replenished the budget for July 2020 by about 44 billion RUB. For August 2020, it is planned to receive in the budget about 29.7 billion RUB

Of course, the presence of one more refinery in the Far Eastern Federal District will have a significant positive impact on the balance of supply and demand, and, accordingly, on prices. The construction of the Eastern Petroleum Company was proposed by Rosneft. However, according to the information we have,
Rosneft refused to implement this investment project due to a change in the tax maneuver. In order to increase the efficiency of fuel supplies to the Far East, as well as in order to reduce the prices for petroleum products in proportion to the amount of the subsidy provided at the rate of 4000 RUB per ton, the Ministry of Energy, together with us, developed the draft government decree “On approving the rules for granting subsidies from the federal budget to Russian Railways” The essence of the decree is to compensate for the lost income arising from preferential tariffs for transportation of fuel on the domestic Russian railways, intended for sale in the Far East. Now this document is undergoing interdepartmental agreement.

Also, the FAS, together with the Ministry of Energy, are working out the amendments aimed at increasing the standards for sales of oil products on the exchange, clarifying the criteria for the regularity and uniformity of such sales, and also extending this to all participants in the oil products market (of course, including companies that do not occupy the dominant position).

– To what extent, from the point of view of the FAS, were the claims of car owners about high prices for gasoline reasonable in the face of the drop of oil prices? If we take oil prices at this moment, they fell to $ 40–45, while gasoline prices rose to 44 RUB per liter of AI-92 and to 47–48 RUB per liter of AI-95. Is there any sign of collusion between the major oil companies?

– Currently, the prices for petroleum products are formed on competitive conditions. There is no government regulation in this market.

As you know, many factors affect the wholesale price. These are, of course, the economic factors, resource endowments, the conjuncture of domestic and foreign markets, including the tax burden on the oil sector, and changes in duties.

Starting from March 2020, there was a decrease in world prices for Brent crude oil from $ 52.46 per barrel (02.03.2020) to $ 19.93 per barrel (27.04.2020), which amounted to about 62 %. World prices for petroleum products decreased by 63 % (from 44,466 RUB/t
to 16,077 RUB/t).

Against the backdrop of the concluded OPEC+ deal and the gradual return of demand, the world oil price increased to $ 39.88 per barrel (September 14, 2020), for oil products to 41,602 RUB per ton.

The prices at filling stations in April-July remained stable
Source: gutaper / Depositphotos.com

In July, the demand for fuel recovered to 90 % of the pre-crisis level

Source: Krivosheevv / Depositphotos.com

Since the beginning of 2020, the increase in excise rates on motor gasoline and diesel fuel was 3.5 %.

In order to smooth out the impact of sudden changes in external prices for domestic consumers, the government approved a reverse excise tax on oil with a damping component. According to the damper, companies receive compensation from the budget if export prices for fuel are higher than the notional domestic price. If export prices are formed below this level, companies already pay extra to the budget. In the current market conditions, the oil companies, according to approximate calculations (within the framework of paragraph 27 of Article 200 of the Tax Code of the Russian Federation), replenished the budget for July 2020 in the amount of about 44 billion RUB. For August 2020, it is planned to receive funds to the budget in the amount of about 29.7 billion RUB. In such a situation in the oil product market, retail prices for motor fuels are assessed as stable.

– From the point of view of the FAS, is it necessary to change the indicative prices to exchange prices in the formula of the damper for gasoline, as suggested by Rosneft? What will the market benefit from this?

– The damper became a necessary measure that helped stabilize the situation associated with sharp price surges in the oil product market. But at the present time it may need a small adjustment to its values, which, in my opinion, should be as close as possible to current market prices.

– What is happening on the jet fuel market now? Are the airlines’ complaints about the multiple rise in fuel prices at Russia's main airports justified, why are airlines reluctant to buy fuel on the exchange, why are the exchange trading volumes at such a low level? What measures are needed to stabilize the fuel market?

– At present, the jet fuel market can be assessed as stable, both in terms of sales volumes, and in terms of pricing and cost. Today's prices for aviation kerosene refineries are significantly lower than prices recorded in the same period last year.

A huge impact on the final cost of jet fuel at airports is exerted by logistics and

We propose to expedite the adoption of the rules for granting subsidies from the Russian Railways budget, to work out the issue of using exchange and OTC price indicators by airlines when making purchases

other services (transportation, storage, aircraft refueling). In order to reduce them, we propose to accelerate the adoption of the rules for granting subsidies from the federal budget to Russian Railways, to work out the issue of using exchange and over-the-counter indicators of prices for aviation kerosene by airlines during procurement procedures. Companies supplying aviation kerosene at airports consider it necessary to work out the issue of reducing the transport component in the final price of aviation kerosene. For example, to optimize the number and cost of logistics services for the delivery of aviation kerosene, to reduce the number of intermediary organizations

The lion's share of the price of aviation kerosene is accounted for transportation, storage services, aircraft refueling, etc.
Source: aapsky / Depositphotos.com

(if the delivery of kerosene can be carried out by one company).

It is also important to work out the issue of increasing the liquidity of exchange trading in aviation kerosene, including by attracting airlines to purchase aviation kerosene at exchange trading.

I would also recommend that aviation fuel producing companies develop draft trading policies aimed at selling aviation kerosene in Russia in order to prevent violations of antimonopoly legislation.

Realization of these proposals will help stabilize the price situation on the aviation fuel market in the regions of the Far East and will contribute to the formation of fair and transparent price indicators for aviation kerosene.

– Independent participants in the fuel market have repeatedly spoken about the need to increase the liquidity of exchange trading. From the point of view of the FAS, do the indicators of exchange prices correspond to the real ones? Are oil companies willing to go to the stock exchange? Are the proposed recommendations to increase the share of gasoline and diesel fuel sales on the exchange to 11 % and 7.5 %, respectively, sufficient? Are such recommendations generally needed if companies go to the stock exchange themselves?

– Exchange trading as an effective pro-competitive instrument was used by the FAS in the oil products market for the first time in 2008 in the framework of the instructions issued by the antimonopoly authorities in relation to oil companies. Currently, the exchange sells oil, oil products, natural gas, mineral fertilizers, wood and timber, petrochemicals, sugar, grain.

The issues of development of exchange trading are among the priorities of the state competition policy, which are enshrined in Decree No. 618, as well as in the National Plan approved by it.

As a systemic measure, exchange trading contributes to the development of competition in commodity markets, primarily in commodity markets, as well as financial markets, taking into account the synergistic effect. In particular, the transparency of pricing is increasing. Price indicators, regularly published by the exchange, are used by companies in their business activities, as well as by the authorities in the performance of their functions. In order to increase the liquidity of exchange trading, together with the Ministry of Energy, we have developed draft regulatory legal acts providing for an increase in the minimum standards for sales on the exchange for gasoline to 11 % and 7.5 % for diesel fuel. The obligation to sell oil products in the specified volumes will apply to all oil refiners, including those who do not occupy a dominant position in the oil products market. I also consider it necessary to introduce responsibility for non-observance of regularity and uniformity in the sale of oil products at the exchange and prohibit

The damper has become a necessary measure. At the present time, it may require a small adjustment to its values, which should be as close as possible to current market prices

traders to buy oil products in the interests of oil companies.

Now drafts of these documents have been published at regulation.gov.ru and are undergoing regulatory effect assessment. Acts will be adopted upon the completion of all the necessary measures provided for by the current legislation.

Their implementation will help stabilize the situation on the oil product market, ensure a sufficient supply of motor fuel at exchange auctions, and restrain price increases. I hope that this will also serve to prevent rush demand in the oil products market.

– How will the Russian fuel market develop in the future? Will prices continue to rise, will it be possible to keep it within inflation limits? What should be done for that? Should we impose restrictions on fuel exports for large oil companies, as suggested by the RTS? How balanced is the domestic market, are new support measures required?

– This year a rather difficult situation has developed in the oil product market. The exchange mechanism has shown itself to be a verified market instrument that helps stabilize the situation. It allowed to ensure a delicate balance between supply and demand. Its further development is absolutely natural and timely.

As I said, we are constantly monitoring the current situation on the oil product market. We are in constant interaction with other authorities and in dialogue with vertically integrated oil companies, stock exchanges, expert organizations and independent participants in the oil products market.

In the framework of the meetings of the exchange committee under the FAS, the headquarters under the Ministry of Energy, we discuss the current situation on the oil products market and make decisions aimed at maintaining stability there. Currently, the economy of supplying oil products to the domestic market and export have leveled off and is in its normal course.

Aviation kerosene is mainly transported by railway *Source: Alex-VN / Depositphotos.com*

Iron and steel plant in Birmingham

Source: ftadviser.com

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«Зеленый» протекционизм Европы

Green protectionism in Europe

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OMV Refinery in Schwechat

Source: BAYERNOIL.de

Аннотация. Авторы статьи рассматривают возможность введения углеводородного налога в Европе. В статье проведен анализ последствий и рисков такого шага для экономики России, как основного поставщика энергоресурсов в Европу. Авторы также предлагают комплекс мер по снижению негативного влияния углеводородного налога на российскую экономику.
Ключевые слова: Европа, климатическая повестка, углеводородный налог, выбросы парниковых газов.

Abstract. The authors of the article are considering the possibility of introducing a hydrocarbon tax in Europe. The article analyzes the consequences and risks of such a step for the Russian economy, as the main supplier of energy resources to Europe. The authors also propose a set of measures to reduce the negative impact of the hydrocarbon tax on the Russian economy.
Keywords: Europe, climate agenda, hydrocarbon tax, greenhouse gas emissions.

Essentially, cross-border carbon regulation is an element of pressure on economic sovereignty of countries – trade partners of the EU.

Closing of the Auguste Victoria mine
Source: techkee.com

This year, plans of the EU to introduce cross-border carbon regulation have become one of the hottest economic news even coronavirus pandemic hasn't managed to suppress. A noble cause of taking care about the climate of the planet can be easily reduced to protectionist measures aimed to support European enterprises. Even at first sight mechanisms under discussions contradict a whole series of international norms and rules. Europe's largest importing partners have argued against the 'carbon tax'. As for the Russian enterprises, plans of the European Union can result in hundred billion dollar fees every year which in turn will affect safety of the Russian FES.

Green Deal

The National Security Strategy and the Energy Security Doctrine ratified by the President of Russia pay special attention to economic development and provision of economic safety for Russia. Building up international efforts to implement the climate policy and accelerate the transition to a green economy is directly called the foreign challenge for energy security in these document.

In the framework of the climate agenda related to implementation of the Paris Agreement, the European Union announces extremely ambitious goals for reduction of the volume of greenhouse gas emissions.

In 2019, the European Commission introduced the Green Deal, a set of measures that, according to its developers, would allow Europe achieving carbon neutrality, i.e. a balance between emissions and greenhouse gases, by 2050. Essentially, it's about a new largescale growth area of the EU and significant changes in the structure of its economy that involve not European enterprises only, but importing partners from abroad as well, since one of the most debatable mechanisms of the Green Deal is introduction of cross-border carbon regulation.

For example, the cost of a hydrogen iron reduction technology is 5 times as high as the cost of a traditional one, but it allows European countries avoiding dependence on imported coal that can't be extracted on the territory of the EU in a cost-efficient way.

Essentially, introduction of cross-border carbon regulation is an element of pressure on economic sovereignty of countries – trade partners of the EU, since it forces them to accelerate introduction of similar carbon regulation models using fiscal and restrictive mechanisms.

Oil extraction in the Scottish part of the North Sea *Source: thescottishsun.co.uk*

The 'carbon tax' on products imported to the European Union is designed to support European producers and increase the competitiveness of their products that have lost their price appeal because of refusal to use traditional energy carriers. At the same time, a decision on turning to more expensive energy sources and reducing material intensity of the EU's economy was determined with a political objective to stop using resources, production of which was becoming economically unprofitable on the territory of the EU, because critical dependency and a need to import those resources from competing jurisdictions arose. Such an approach can result in a loss of price advantages of products made with the use of traditional energy sources. These measures will be a priori discriminatory by their nature for Russian export-oriented economic sectors, such as (heavy machine building, metallurgy) and oil and gas industry causing significant financial losses. Therefore, to ensure stability of our economy in general and to provide certain economic conditions for FES operation in the context of the EU's plans for a 'carbon tax' are a priority now.

Cross-border carbon regulation can be integrated into the European Climate Law which is to be adopted in summer 2021. Regulation is expected to start in 2025–2030

It should be noted that at the moment there is a system of quantifying greenhouse gas emissions and the Emissions Trading System (EU ETS) in place on the territory of the European Union which is extended to the most energy-consuming industries to drive reduction of carbon intensity of the economy.

Parameters for introduction of cross-border carbon regulation are still worked out. At the moment, official public consultations are held that are to be over by October 28, 2020. The European Commission is expected to make a decision on introduction of carbon regulation in Q2 next year. Cross-border carbon regulation is supposed to be integrated into the European Climate Law which is to be adopted in summer 2021. Regulation might come into force to the full extent in 2025–2030.

Possible forms of cross-border carbon regulation that are currently discussed on international venues are application of EU ETS requirements to importers, introduction of a custom duty with a rate to be applied to the volume of greenhouse gas emissions caused by production of goods, or a consumption tax for foreign products. Meanwhile, two latter forms are the most likely to be used. It is worth noting individually that the volume of greenhouse gas emissions to be considered can include both direct industrial emissions and indirect energy-related emissions (emissions caused by generation of energy used to produce goods delivered to the territory of the European Union). The projected price of these emissions is supposed to be based on a level of the current prices at the EU ETS (currently about 20-30 euros per a ton of CO_2e).

Positions of Stakeholders

Preliminary consultations held by the European Commission have shown dissimilarity of stakeholders' positions on all aspects of cross-border carbon regulation, including forms and terms of its introduction, as well as goals, regulation mechanism, industrial coverage, and areas where collected money should be used.

Refinery in Schwechat
Source: OMV Aktiengesellschaft

The suggested initiative also serves the economic interests of some member states of the European Union which complicates the search of a consolidated solution.

Even before official consultations some controversies appeared on the international level. Opinions on potentially protectionist and unilateral nature of approach were expressed by government officials from the USA and China. In particular, Wilbur Ross, Minister of Trade of the USA, warned that the country would take countermeasures against the European Union in case the suggested cross-border 'carbon tax' was protectionist by nature.

According to Russian experts, carbon regulation mechanisms can't be called anything but protectionist ones. Suggested focus on fiscal measures will mean that the EU's importing partners will have to pay for carbon, and the price will be comparable with one in the European market. Under circumstances where international financial institutes restricts the access of Russian companies to low interest credits and long term investments, while there are no tax concessions in the internal market to drive large-scale 'climatic' investments, to calculate the carbon footprint of exported products correctly is a vitally important issue for Russia. Such a calculation should take into account to the fullest extent possible not only greenhouse gas emissions caused by the process of production of exported goods, but also related projects on compensation of CO_2 emissions implemented on the territory of our country.

The volume of greenhouse gas emissions can include both direct industrial emissions and indirect energy-related emissions.
Their cost can be based on the price at EU ETS (20-30 euros per a ton of CO_2e).

Tesla at a charge station near the channel, Amsterdam
Source: areadeposit / Depositphotos.com

It's required to ensure 'climatic neutrality' of our products.

Compensatory projects can be an important business area for Russia considering the global nature of climatic issues and Russia's potential in field of forest restoration and preservation of boreal forests. Meanwhile, a relevant draft of the European Climate Law doesn't imply using cross-border offset projects to compensate for emissions in the EU. These projects must be implemented on the territory of the EU. It means, nowadays federal authorities involved in shaping the Russian climate policy, those who represent it on international venues, have to increase efforts on adoption of branch-wise methods of calculating the carbon footprint of products considering both direct and indirect emissions, as well as results of implementation of compensatory projects. Besides, it's getting more and more important to ensure introduction of the Russian verification and validation system aimed at calculating the reduction of greenhouse gas emissions integrated into the international system as soon as possible. It's necessary to advocate the interests of Russia at negotiation venues in the framework of the Paris Agreement for the result of Russian compensatory projects to be fully subtracted from the carbon footprint of domestic products.

Introduction of cross-border carbon regulation should be considered in a general context of the Green Deal program aimed not only at reduction of greenhouse gas emissions, but at decreasing the EU's dependency on supply of energy resources from non-member states. A particularly unfortunate format of carbon regulation mechanism for energy carriers can cause additional pressure on consumers in the European Union, especially in combimnation with other elements of the Green Deal (primarily, with climate regulation). In its turn, it will affect all levels of consumption of Russian energy resources in European markets. Also, it should be taken into account that the Green Deal pays much attention to the growth of 'environmentally friendly gases' in the EU. According to some forecasts by ENTSOG (the most aggressive though), a share of gas imported to Europe will be reduced by 10–20% due to the transfer of the European energy to 'green' hydrogen received from water electrolysis when using wind and solar power. Negative effects for countries that export traditional energy carriers are obvious.

Financial consequences

The European Commission expects to receive €5-14 bln annually in 2021–2027 from application of cross-border carbon regulation. The 'carbon tax' is stated as one of sources to fund a large-scale (about €750 bln) plan of financial aid to steer the European Union out of economic crisis caused by the coronavirus pandemic.

The draft of the European Climate Law doesn't imply using cross-border offset projects to compensate for emissions in the EU. These projects must be implemented in the EU

According to the Institute of Economic Forecasting of the RAS, financial losses of Russian exporters will amount to €2.8-3.6 bln per year (with a price of 20–25 euros for a ton of CO_2e considering direct emissions only) as a result of the cross-border carbon regulation introduced by the European Union. However, it should be taken into account that this analysis includes a wide range of goods, including those within the scope of providing free quotas in the European Union. Introduction of cross-border carbon regulation for a narrow line of products seems the most realistic option.

Wind turbine at the wind power plant in Galicia (Spain)

Source: jorisvo / Depositphotos.com

Thus, cumulative annual costs of Russian exporters will be about 1 bln euros. It will significantly change the current level of actual fiscal load for sectors that have fallen under this regulation (metallurgy, energetics, chemical industry).

If the basis for calculation of fee in the framework of the cross-border carbon regulation includes indirect energy-related emissions as well, the discriminatory nature of the regulation toward Russian products can be reinforced because of structural specificities of the Russian power supply system.

FINSIDER iron and steel plant in Italy
Source: warosu.org

Compliance with standards of international law

According to some experts, introduction of a 'carbon tax' in the EU doesn't comply with the WTO rules and creates a threat of double taxation. It's critical to note that the European Commission considers possible introduction of cross-border carbon regulation based on point 2, Article II of the General Agreement on Tariffs and Trade (GATT) of 1947, according to which import duties equivalent to an internal tax may be imposed.

Meanwhile, the European Union ignores the fact that a part of point 5, Article 3, of the UN Framework Convention on Climate Change directly states the norm that doesn't allow using any measures aimed at combating climate change to restrict international trade. We can also see a contradiction to point 1, Article XI of GATT (1947) in accordance to which protectionist tariffs may not be imposed, and discrimination for imported goods unlike domestic goods is prohibited, as well as application of any other hidden restrictions of international trade.

On the part of the EU, there can be attempts to rationalize introduction of the cross-border carbon regulation with statements of Article XX of GATT that allows a contracting party to take measures related to exhaustible natural resources if these measures are taken at the same time with restriction of internal production or consumption.

In this regard, it should be noted that Article XX of GATT is unique by its nature in terms of its application (it's actually called General Exceptions), because it's determined with two-tier restrictions in the framework of which the following conditions need to be fulfilled:

1) a necessity to take exclusive measures, including those related to conservation of exhaustible natural resources, if these measures are taken simultaneously with restriction of internal production or consumption;
2) these measures should not become means of random or unjustified discrimination between countries where the same conditions prevail, or a hidden restriction of international trade.

Thus, the order of applying exceptions provided for with Article XX of GATT is a complicated, highly elaborate procedure that requires preparation of a significant evidential base to prove that the suggested measure is aimed at conservation of an exhaustible natural resource (in the context of this discussion the term can be used by the EU to refer to climate) and enables protection of human life and health, as well as protection of animals and plants from a negative effect of the climate change.

OEMK, Stary Oskol
Source: metalloinvest.com

Countermeasures

On the level of international interaction it is necessary to challenge introduction of cross-border carbon regulation in the framework of bilateral negotiations with the European Union, as well as in the format of respective international and supranational structures (WTO, Paris Agreement, etc.) Also, possible coordination of efforts on preventing introduction of cross-border carbon regulation with states that express their negative positions regarding adoption of the measure (UAE, Qatar, Saudi Arabia and others).

We consider it important for participants of international negotiation venues to promote consistently a thesis about significance of climate change policy mechanisms, discussed in the framework of Article 6 of the Paris Agreement that serve as a basis of international cooperation in field of climate change prevention. Article 6 of the Paris Agreement regulates issues of financial and non-financial interaction between countries when implementing projects to reduce wastes and increase greenhouse gas absorption.

In case cross-border carbon regulation the cross-border carbon regulation is implemented, the Russian industry will face the following key challenges to protect its interests:

- world-scale recognition of data provided by Russian manufacturers about carbon intensity of their products (the volume of greenhouse gases emitted during production calculated per unit of output while compulsorily consideration to compensatory events);
- an opportunity to implement projects on reduction and absorption of greenhouse gas emissions to compensate for carbon intensity of products;
- defining and recording carbon intensity by kinds of products for each certain supplier;
- exemption from payment in case products meet the EU benchmark set for greenhouse gas emissions of goods of a similar category;

The European Commission expects to receive 5–14 bln euros per year from carbon regulation.
The carbon tax is stated as one of sources to fund the plan on steering the EU out of coronavirus crisis

To minimize consequences of introduction of the carbon tax by the EU, it's necessary to analyze all the national projects to design a set of measures aimed at adaptation of the Russian FES to its application

- adjustment of the fee for products that don't reach a benchmark level, but reach average indicators of greenhouse gas emissions in the European Union for a similar category of goods;
- establishment of a transition period for the carbon tax in respect to importing partners;
- providing equal conditions for Russian suppliers and European manufacturers in terms of providing free quotas for greenhouse gas emissions.

To solve the abovementioned problems it's required to work out Russian branch-wise methods of assessment of the product carbon intensity and ensure their recognition on the international level, as well as to accelerate adoption of the draft of legislation 'On State Regulation of Greenhouse Gas Emissions and Introduction of Amendments to Certain Legal Acts of the Russian Federation'. These actions will allow shaping a necessary regulatory framework to implement projects on reduction of emissions and increasing absorption of greenhouse gases. In the framework of this work the Ministry of Energy of the Russian Federation is currently designing a method to allocate electrical energy from the electric power system all suppliers (producers) deliver it to, which allows defining indirect greenhouse gas emissions of any production facility.

Another key issue is to design Russian methodological instructions for determination of the volume of greenhouse gas absorption. Our country still doesn't have a unified method that could estimate the existing potential of the absorption capacity all ecosystems of the country have credibly enough. The existing methodological instructions serve as guidelines and take into account only absorption of 'controlled forests' (i.e. the forests with immediate forestry management) without considering the capability of forests located on agricultural lands, lands of the Ministry of Defense of the Russian Federation and lands of settlements to absorb carbon as well. Also, the abovementioned document doesn't take into account a capability of other biomes, such as meadows, farm lands and water bodies to absorb carbon.

Solar panels near the Catholic church

Source: GoneWithTheWind / Depositphotos.com

According to the Ministry of Energy of the Russian Federation, to minimize potential consequences of introduction of cross-border carbon regulation it's worth analyzing all the national projects to design a set of measures aimed at adaptation of the Russian economy and FES in particular to the application of cross-border carbon regulation by the EU.

It's critical to note that performance of related sectors of the economy, particularly, industry, health care service, defense and others, directly depends on stable performance of FES. Another fact to consider is that 51.8% of the total greenhouse gas emissions falls to FES in Russia. Thus, it's worth considering the idea of creating a Competence Center based on the Ministry of Energy of the Russian Federation to design unified approaches for regulation of greenhouse gas emissions. Operations od such a center should involve the Ministry of Industry and Trade, the Ministry of Construction, the Ministry of Transport and the Ministry of Agriculture.

A special emphasis should be made on the following. A special role in the Climate Doctrine of the Russian Federation is given to increasing energy efficiency in all sectors of economy as a measure to ensure reduction of greenhouse gas emissions and increased absorption with absorbers and accumulators. In FES it is achieved, among others, through increasing production efficiency and consumption of heat and electrical energy.

Considering EU's plans for introduction of cross-border carbon regulation, the work on optimization of FES performance the Ministry of Energy of the Russian Federation started as early as in 2014 to reduce fuel consumption for electrical supply is getting more and more relevant. It allows reducing a negative effect of electrical power plants on the environment, including reduction of greenhouse gas emissions. Optimization of the load of generation equipment with an increased share of electrical energy production in a combined cycle; support of modernization of fixed assets at electrical power plants and improvement of FES energy efficiency have already resulted in establishment of stable dynamics for reduction of emissions. Thus, a level of pollutant emissions caused by FES decreased by 19.6% in Russia in 2019 against 2014, and a level greenhouse gas emissions decreased by 6.48%. Special attention should be paid to the fact that it happened in the context of growing volumes of heat and electrical energy production while keeping a share of coal consumption in the fuel balance of the Russian energetics the same.

In conclusion, it should be noted that the unfolding geopolitical situation is a new challenge for the economic safety of FES and, therefore, for the national security of our country. We need to implement some events, including ones on international venues paying special attention to increasing energy efficiency and environmental friendliness of FES. Then such a challenge will not be a threat, but a possibility that enables to develop new areas. We'd like to note that for implementation of suggested initiatives joint efforts of all federal bodies of executive authority are required with active involvement of industrial, expert and academic communities. The Ministry of Economic Development, the Ministry of Energy, the Ministry of Industry and Trade, the Ministry of Natural Resources, the Ministry of Agriculture and the Ministry of Foreign Affairs must synchronize their efforts to respond to challenges and threats the Russian Federation currently faces in field of climate.

Hydrogen production

Source: versiya.info

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«Зеленая сделка» – реальность, в которой надо жить

The Green Deal is a reality to live in

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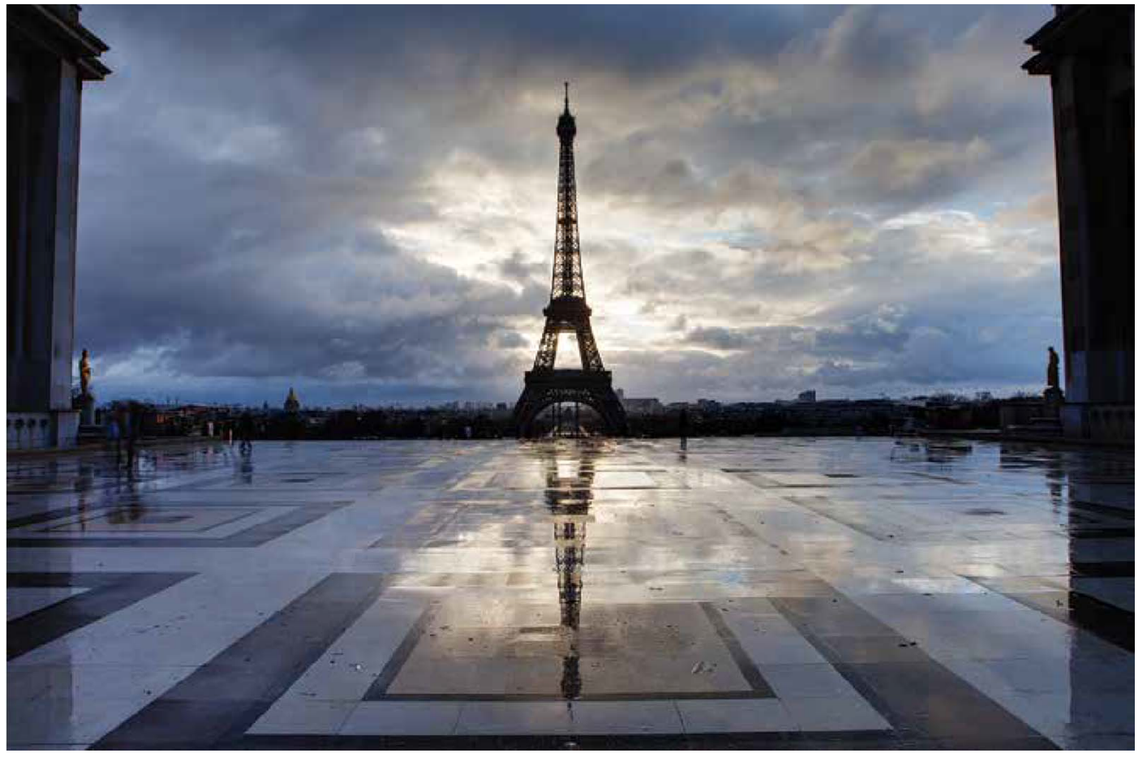
EU accelerate works on implementation of the Paris Agreement



Source: danmir12 / Depositphotos.com

Аннотация. Статья представляет собой обзор дискуссии о переходе Европы на безуглеродную экономику, которая состоялась на полях Тюменского нефтегазового форума. В ней собраны высказывания чиновников и топ-менеджеров нефтегазовых компаний, анализирующих риски такого перехода для российской экономики.

Ключевые слова: «Зеленая сделка», безуглеродная экономика, выбросы углекислого газа.

Abstract. The article is an overview of the discussion on Europe's transition to a carbon-free economy, which took place on the sidelines of the Tyumen Oil and Gas Forum. It contains the statements of officials and top managers of oil and gas companies, analyzing the risks of such a transition for the Russian economy.

Keywords: Green Deal, carbon-free economy, carbon dioxide emissions.

> **The European Commission announced its plans to accelerate CO_2 emissions reduction by 55% of the volume of 1999 instead of previously expected 40%**

In December 2019, the European Union has demonstrated the first plan/presentation on transition to carbonless economy - so-called Green Deal - by 2050. It suggested reduction of greenhouse gas emissions in major energy-intensive sectors of the European economy at the expense of using energy from renewable sources, increasing energy efficiency, developing technologies for use and storage of electrical and heating energy.

Implementation of such a transition requires a faster shift away from greenhouse gas emissions. Ursula von der Leyen, Head of the European Commission, has already announced that the volume of CO_2 emissions is to be reduced by 55% against 1999 by 2030 instead of previously planned 40%. According to experts, to implement this plan, a share of RES in the structure of electrical energy now should grow from the current 32% to 65% to reach 38–40% in the overall demand for electrical energy in comparison to the current 33%. According to data by Reuters, it will require additional investments in the amount of 300 bln euros in 2021–2023.

At the same time, the idea of introducing a carbon tax for goods imported to the European Union from other countries is in the works. Russia is one of the main suppliers of energy resources and metallurgy products to Europe. As per the expert calculations, introduction of such a tax can cost the Russian economy 3-5 bln dollars every year. Such prospects make Russian companies look for opportunities to optimize production even now and adjust with a view of European plans. Introduction of the carbon tax on imported products has become one of key topics at the Tyumen Oil and Gas Forum.

Pig in a Poke

Russia has been moving toward increasing energy efficiency and reducing the environmental impact for a long time already. The process of enabling companies to turn to the best technologies available started several years ago has played a pivotal role. However, it's still unknown to what extent they will comply with new initiatives of the European Union. The problem of compensatory approaches when calculating the volume of greenhouse gas emissions still remains unresolved.

"All companies of the oil and gas sector, heavy equipment industry and other enterprises of Category 1 Environmental Impact face the objective to turn to the best technologies available and get all the necessary environmental clearances by 2024.

All companies should have programs on increasing energy efficiency and reducing greenhouse gas emissions... International legislation is to be made yet. The Green Deal, for example, practically doesn't provide for compensatory events aimed at reducing the carbon footprint. The existing methods connected with forest restoration, conservation of biodiversity, a possibility of storing CO_2 are not covered with the EU's legislation," Denis Kharlamov, Deputy Minister of Natural Resources and Environment of the Russian Federation, said. "Nowadays the method takes into account the absorption capacity of controlled forests only, while we have huge uncontrolled forest areas," he added.

"The biggest risk now is uncertainty of the (taxation) mechanism itself, it's a true 'pig in a poke'. We don't know what to focus on," Mikhail Ivanov, Deputy Minister of Industry and Trade of the Russian Federation, added.

Giants Put a Stake on Zero

European oil and gas giants such as Shell, BP, Total, Eni and others could have become reference points for preparations to the global carbonless economy. Each of them has already announced its commitment to gradually shift from oil extraction and build up clean energy production based on RES and gas, so that by 2050 carbon emissions would be equal to zero.

BP has come further than others announcing the end of the oil era. The company intends on investing 5 bln euros annually to increase its RES-based capacities more than 20 times – up to 50 GW. At the same time BP plans to create a comprehensive portfolio of low-carbon technologies, including RES, bioenergy and hydrogen. Oil and gas extraction will decrease by 1 mln barrels of oil equivalent per day against 2019 by that time, and emissions caused by extraction – by 30–40%. BP will not participate in new geological prospecting projects anymore. Total announced that it would invest 2-3 bln euros annually to increase electrical energy production by one third through LNG and energy from renewable sources.

European oil and gas giants such as Shell, BP, Total and Eni have announced that they would build up production of clean energy and reduce carbon emissions up to zero by 2050.

However, for now such statements of European giants pose more questions for their colleagues than aspirations to take note of their methods. "We have studied all public statements of our peer companies from Europe: Shell, Total (SPB: TOT), BP, Eni – they have been made over the last 6–8 months. These are long statements, quite vague for now, without any certain details and any actual content. The companies state that most of them turn to renewable energy sources and development of this area. Corporations split into two: one half is involved in natural resources, hydrocarbons; another half focuses on forest cultivation, as well as renewable, environmentally friendly, 'green' or 'blue' hydrogen," Azat Shamsuarov, Dirst Vice President of LUKOIL, said.

"It's a challenge as well. As we witnessed ourselves, just recently the cost of energy from RES was 3–4 times more expensive than energy from traditional sources. Now these prices are comparable. We estimate the consequences of carbon initiatives for the company both in Russia and abroad. Obviously, we'd like to take part in protection of the country's interests and its budget," he added.

However, the aspiration of European oil and gas giant companies to turn to clean energy can have dirty implications. According to Alexander Dyukov, Head of Gazprom Neft, they are driven not with a care of the environment, but rather with a struggle for preservation of leading positions in energy markets.

"Speaking about why it's primarily about Europe, in my opinion, it's not because of concerns about the climate, though the climate is important, of course. The matter is, there's a certain market situation. It's not a secret that reserves have been dwindling for a long time in Europe. And other countries that possess the resource are not as glad to see European companies in their projects as before. The access to investments is no longer a problem, it's become much easier to get investments now. In terms of technologies, service companies are ready to build a well and conduct other service works without participation in the project. This market situation drives European countries out to new sectors of energetics: RES, projects of 'green' hydrogen, biofuel," he said.

"European governments discuss new goals for reduction of greenhouse gases by 55% against 1990, introduction of the carbon tax and other measures. These are protectionist measures in an effort to protect domestic energy sector while recognizing that it's extremely difficult for them now to compete in a traditional sector. They have chosen the path of building a new branch of the climate energetics where European companies will prevail," Dyukov emphasized.

"First of all, this all is about Europe. Let's take the Unites States - they have an entirely different opinion about the issue (building carbonless economy). There are no loud statements. And one of the reasons is that they have what to work with in terms of reserves. That's why the largest oil and gas companies of the USA don't follow the example of their European colleagues, though they experience massive pressure of public opinion as well," Head of Gazprom Neft added.

BASF – the largest chemical concern and gas emitter with HQ in Ludwigshafen (Germany)
Source: rupec.ru

Global Injustice

The fact that plans on carbon footprint exclusion by 2050 suggested by European regulators were immediately caught up by European oil and gas companies provided reasons to think that the energy policy of the EU is based on protectionism.

"A carbon fee should bee seen as a certain element of protectionist policy pursued by the EU. Essentially, it's

The EU is ready to go for introduction of a tax for CO_2 emissions in the framework of combating climate change

Source: Imaginechina-Tuchong / Depositphotos.com

an attempt to make opportunities of the European companies with manufacturing sites in the EU where they have to pay to emissions match opportunities of the global companies that import their products to Europe. Based on estimated carbon fees that amount to 3–5 bln dollars per year, it's almost 3% of our export. We'll face the situation when competitiveness of our products will be endangered with a carbon fee," M. Ivanov said.

"When we start looking at how the European Green Deal is arranged, when we start looking at the approach of European regulators and European policy makers we start feeling that they might be interested not only and not so much in CO_2 emissions as such, since the situation seemingly turns into protectionism. For example, when talks about hydrogen start, the Europeans claim that they are interested in 'green' hydrogen only. 'Blue' hydrogen disposal is anathema for Europe," Sergey Vakulenko, Head of Strategy and Innovations Department, Gazprom Neft, added.

Such an approach is painful for energy supply partner companies of the European Union. It's not a business reasoning, but moral and ethical that starts playing center stage.

"The topic of carbon, CO_2 emissions started expanding faster than massive regulation and attitude to companies in other aspects. A question of justice arises: who needs to change something? The European Union is one of leaders in field of clean energy that enables itself and others to turn to carbonless energetics. Here are countries that have been accumulating its economic potential for many years developing industry and emitting CO_2. Now they have achieved a high standard of living and wish to live comfortably in a carbonless

The fact that plans on carbon footprint exclusion by 2050 suggested by European regulators were caught up by oil and gas companies provided reasons to think that these plans are protectionist by nature

Qatar is one of LNG suppliers to Europe
Source: Courrierinternational.com

world. However, there are many countries that have not made this way yet, though they want to live in better conditions. This way is easier and cheaper to make at the expense of hydrocarbons. Is it fare that those who have already made this way to start living better and now strive for carbonless economy make others follow the example at the expense of high costs and possible damage for industry and standards of living of citizens?" Dmitry Konov, Chairman of Board, SIBUR Holding, asked.

As in his turn Pavel Sorokin, Deputy Minister of Energy, noted, such policy of the EU is based on favorable credit climate. The European Union has sponsored renewable energy projects for many years.

"Unfortunately, when you hear about the 'climate agenda' the first thing that comes to mind, as we've seen today, is cynicism and hypocrisy. It's so easy to reflect, so easy to dictate conditions when you are actually an emitter of free money, so you can prolong any project, no matter how unreasonable it is from the economic point of view, for as long as you like," he said.

Besides, the European Union actively imposes the policy of taking brownfields outside Europe, to less developed countries. If a brownfield is taken from the EU to China, it doesn't mean the EU stopped being an emitter, just the center of emissions has been relocated to another place. The same applies to the hydrogen agenda we actively discuss: if you look at the strategy of the European Union, you'll see ho 'blue' hydrogen is shifted beyond the borders of the EU, i.e. the emission center is shifted. So, officially, the European Union will remain clean and 'green'," the official added.

According to him, such an approach puts population of these countries in a position which is not even in comparison with the Europeans. "Many countries want to develop as well. Not only people in the United States of America, the European Union and Japan want to live well, but also 1.5 billion people in China, as well as India Africa and Latin America. And we also want to become people with a prospect of development," P. Sorokin said.

Carbonless Reality

However, despite all the injustice of the EU's policy, its outlines are getting more and more real. The Green Deal have been enshrined in two strategic documents already – the EU Strategy for Energy System Integration and the EU Hydrogen Strategy for a Climate-Neutral Europe. In the middle of the next year a roadmap of measures for a transition to the carbonless economy should be prepared. So Europe's refusal to use oil and gas is getting more and more real.

"We are operating in more than thirty countries of the world, and it's already the reality to live in for us. We used to set a strategic goal of 95% recovery of associated petroleum gas, while today we have achieved 97.6%. Today we speak about zero emissions for 2030 already, while before it was suggested for 2050," A. Shamsuarov said. "A special committee will be created in the Board of Directors of the Company, organizational and structural changes will take place within the company in order to study and formulate pointedly our own development strategy (in this area – IF). I hope, during the spring session in LUKOIL we will consider the vision of the company's further development with clear references for investment flows, corporate development in Russia and beyond," he added.

"We accept the challenge and hope to overcome it without any significant losses," LUKOIL top manager emphasized.

According to Segey Vakulenko, Russia must insist on follow-on revision of the Green Deal regarding introduction of compensatory measures, for example, from absorption capacities of forests to the use of systems for CO_2 recovery and storage. "CO_2 recovery and storage could be a way out for Russia," he said. "The biggest problem for application of carbon dioxide recovery technologies however is that CO_2 is not expensive. Economy of these processes is limited. As soon as CO_2 recovery gets a positive price, the economy of projects will be completely different," Vakulenko noted.

However, Russia must strive for adjustments to the Green Deal together with partners from other oil-producing countries.
"It would be a right thing to start a serious and sincere conversation with the European Union. And to attract OPEC, USA China and others to our side, so that the fight against CO_2 reduction in the atmosphere would be fare and based on principles of technological neutrality. Then the could appear more room to work for Russian companies," S. Vakulenko emphasized.

The European Union actively pursued the policy of taking brownfields outside Europe, to less developed countries. As a result the center of CO_2 emissions was removed to other regions

Until the moment when the Green Deal starts functioning, Russia needs to make as much effort as possible to optimize and increase efficiency of hydrocarbon production and processing.
"It should be understood that hydrocarbons don't have much time left, while they are still profitable, only about 30–40 years. We must do our best not to leave these resources underground, to extract them and use in favor of economy. We must be very careful; one the one hand, recognizing that climate regulation is unavoidable all across the world, we need to deal with it somehow; on the other hand, we must make the most of our industry," P. Sorokin noted.

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Проблемы изменения и прогнозирования климата

Problems of forecasting and climate change

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Over 40 years the area of sea ice has reduced by 20%

Source: Iurii / Depositphotos.com

Ocean is a complicated dynamic system which is much less studied than atmosphere

Source: mimadeo / Depositphotos.com

Аннотация. В статье обсуждаются проблемы изменения климата в течение последних десятилетий. В ней даны некоторые прогнозы изменения климата. Исследование основано на трехмерной гидродинамической модели глобального климата. В работе приведены расчеты прогнозирования климата до 2100 года с использованием сценариев роста CO_2. Обсуждаются важные последствия глобального потепления для России.

Ключевые слова: моделирование глобального климата, потепление климата, прогнозирование.

Abstract. The article discusses the problems of climate change over the past decades. It gives some projections of climate change. The study is based on a three-dimensional hydrodynamic model of the global climate. The article presents calculations of climate prediction up to 2100 using CO_2 growth scenarios. The important consequences of global warming for Russia are being discussed.

Keywords: global climate modelling, climate warming, forecasting.

Results of ice core analyses show that currently the concentration of CO_2 exceeds the value of previous 650,000 years

Introduction

Climate is one of the main natural resources with a determined effect on economy, agriculture, energetics and so on. As results of climate researches show, human activities have a serious if not catastrophic impact on climate. Today's situation is unprecedented in the history of Earth. Greenhouse gas emissions can increase average global temperature in a few decades, while it took at least a few thousand years for the temperature to change by one and the same value because of natural reasons. It's not absolute values of the future changes, but their growth rates that are unprecedented [1, 2].

Paleoclimate data proves unusual nature of the current climate changes, in particular for the period of the last 1,300 years. Results of ice core analyses show that today's atmospheric abundance of the main greenhouse gas (CO2) exceeds by far respective values of the previous 650,000 years. By 2015 CO2 concentration reached 440 ppm (particles per million) against 280 ppm in the pre-industrial period, while its growth in 1995–2015 amounted to 1.9 ppm per year. Today's global concentration of other important greenhouse gases, such as methane and nitrogen oxide, their values have also exceeded pre-industrial ones over many dozens of thousands years.

Uncertainty regarding these changes largely remain, particularly on the regional level. Besides, extremely unfavorable social and economic consequences of local and global nature can be caused even by natural climate changes.

To hold fundamental researches on this issue, one need to use respective mathematic models. General circulation models are the most complicated climate models [3]. In a full version for examination of the greenhouse effect they need to include models of atmosphere and ocean. Besides, there's a need for models to describe the evolution of sea ice and various process that occur on the earth surface, such as accumulation and change of snow; soil humidity and evapotranspiration.

The structure of climate changes actually observed turns out more complicated than one received from modelling. In some regions, in certain seasons changes are opposite to the model's results

Glacier ablation in Greenland
Source: Denis Burdin / Depositphotos.com

To improve computer capacity is one of the most important requirements to get more reliable climate forecasts [4]. Increased number of atmosphere and ocean climate observations; organization of continuous monitoring of climate change factors such as greenhouse gas concentration, the solar constant, a level of atmosphere transparency tied with volcanic explosions and other natural and man-made effects are equally important [2].

Another significant nuance is large-scale observations of water convection in the atmosphere that determine the amount and types of clouds. These small-scale processes in the atmosphere are not thoroughly studied yes, nor is microphysics of clouds [2].

Adequate description of the interaction between the atmosphere and the geological substrate is another problem of climate change modelling. In particular, it's important to have a description of soil filtration processes and evaporations from the surface in the presence of various types of plants.

The ocean is a much more complicated dynamic system than the atmosphere, though the observations are much poorer here. More complete data on variations of temperature, salinity and currents depending on the depth of the ocean are required. The ocean surface temperature is defined by a balance between intensity of heating the surface and numerous dynamic processes where redistribution of heating energy occurs. Major processes are small-scale turbulent exchange in large-scale vertical and horizontal transfer of energy with sea flows. There are still no general ocean circulation models with appropriate spatial resolution to have an opportunity to describe the eddying flows that are important from the point of energy. Parameterization of subgrid-scale processes using semi-empirical theory of turbulent diffusion is present even in the most complicated models which has a powerful influence on the results. The structure of climate changes actually observed turns out more complicated than changes received from models. In some regions, in certain seasons changes are opposite to the modelling results, which proves the importance of other climate forcing factors or imperfection of models.

Calculations based on atmospheric general circulation models (GAC) give well-coordinated global results, but vary a lot on the regional level.

Regional climate changes can differ significantly from global trends. Analysis of temperature over 20 years shows that in general the climate has become warmer, while in England and Western Europe it got colder

Forecasting the atmospheric temperature of Earth based on GAC models some challenges and uncertainties arise depending on CO_2 concentration. The reason is a human-induced rise in temperature will occur in the context of natural effects of climate warming and cooling that can be compared to the greenhouse effect by their intensity. To calculate these man-made changes one need to be able to model natural climate changes with great precision. Besides, two major challenges arise – how to describe oceans and claudage adequately.

Icebergs in Antarctica

Source: AchimHB / Depositphotos.com

The thing is a value of greenhouse effect is largely determined with ocean currents that transfer large masses of water from one region to another. Considering this factor in calculations leads to weakening of the greenhouse effect. Claudage modelling faces significant challenges, since natural cooling effect of clouds is ten times stronger than the forecasted total anthropogenic warming. The warming effect of claudage (natural greenhouse effect) is also much larger than the anthropogenic one. It means small changes in cloud types and amounts can either weaken greenhouse effect (in case of increased claudage) or reinforce it (in case of decreased claudage) depending on negative or positive feedback. However, small changes of claudage are extremely difficult to model correctly and, therefore, to guess how it will be changed.

When considering greenhouse effect one should have an opportunity to forecast not global tendencies only, but regional changes of the climate as well - let's say, in the European part of Russia or in Siberia. These regional changes can differ from global climate trends significantly. For example, analysis of temperature over 20 years shows that in general the climate has become warmer, while in England and Western Europe it got colder.

Analysis and forecast of climate change

On the one hand, climate change is a a complex long-term problem, but on the other hand, this problem requires an urgent solution considering the speed and value of accumulation of greenhouse gases in the atmosphere, not to mention possible increase of temperature by 2°C.

Since 1990, the Intergovernmental Panel on Climate Change (IPCC) as an international structure established in 1988 together with the World Meteorological Organization and the United Nations Environment Program regularly publishes detailed and objective scientific-technical assessments and forecasts. These sets of assessment reports, special issues, technical documents, methodologic researches and other developments of IPCC have become generally recognized reference materials.

The last IPCC report [2] contains a conclusion that human activities are the main reason of warming that has been noted since the middle of the 20th century. The report enshrines that increasing temperature of the climate system is an indisputable phenomenon accompanied with a large number of significant changes observed in the realm of time, from decades to thousands of years: increased temperature of the atmosphere and the ocean; reduced mass of snow and ice; a sea level rise and a growth of greenhouse

Communications room of the Russian meteorological service

Source: meteorf.ru

gas concentration. Over three last decades surface temperatures observed have been consecutively higher than any temperatures of the previous decades after 1850.

The influence of human beings on the climate system is obvious, and anthropogenic greenhouse gas emissions observed reach the highest level in the entire post-industrial period. Today's climate changes have extensively affected anthropogenic and natural systems. Since the beginning of the industrial period the growth of anthropogenic greenhouse gas emissions was mainly driven by growing economy and population; now they are larger than ever. As a result, the

Antarctic Weather Station

Source: info.sibnet.ru

concentration of carbon dioxide, methane and nitrogen oxide in the atmosphere has reached the highest values, at least over the last 800,000 years. Their influence in combination with the impact of other anthropogenic factors can be seen across the entire climate system, and it's highly possible that they are a key reson of warming that has been noted since the middle of the 20th century. Over the last 40 years temperature has increased by about 0.6 °C; the area of sea ice has reduced by about 20%, and a sea level rose by about 19 cm.

Over the last decased climate changes have influenced natural and anthropogenic systems on the surface and in seas.

Over the last 40 years air temperature has increased by about 0.6 °C; the reduction of sea ice area has reached about 20%, and a sea level rose by about 19 cm

These impacts are resulted from noted climate change despite its reason and point on susceptibility of these systems to characteristics of the climate.

Over the time since 1950, changes in various extreme weather conditions and climatic conditions have been observed. It has been established that some of these changes depend on the anthropogenic effect, including decrease of extremely low temperatures and increase of extremely high ones; a growing number of times when an extremely high sea level was noted, and a growing number of storm rainfalls in some regions.

Constant greenhouse gas emissions will result in further warming and long-term shifts in all components of the climate system increasing possible dangerous, global and irreversible impacts on people and ecosystems of the Earth. To scale down climate changes significant reduction of greenhouse gas emissions will be required which, along with adaptation measures, might limit risks associated with climate change.

The total carbon dioxide emissions largely define the increase of the average global surface temperature by the end of

the 21st century and in the future. Possible forecasts of greenhouse gas emissions vary in a wide range depending on both social and economic level of states and the policy in field of climate. According to all suggested emission scenarios, a growth of air temperature and related effects is expected in the 21st century. It's quite possible that waves of increased temperature will repeat more frequently and become more prolonged, while maximum precipitation will be more intense and frequent in many regions. Processes of warming, ocean acidification and sea level rise still continue. The climate change will strengthen existing and create new risks for natural and anthropogenic systems. These risks are distributed in an uneven manner and, as a rule, they are more substantial for the least protected people and communities in the country of any level of development.

Many climate change factors and related consequences will still be relevant for a few centuries even if man-made greenhouse gas emissions cease to exist. Risks that sharp and irreversible changes might arise due to a greater degree of warming increase.

Adaptation and mitigation of the impact on the climate system are mutually reinforcing strategies of climate change reduction and risk management. Significant reduction of emissions during next decades might reduce climate risks in the 21st century and improve prospects of efficient adaptation in the future, reduce costs and simplify problems associated with mitigating impacts on the climate system in a long term. It will also allow contributing into development of such ways of sustainable development that are hardly subject to influence of the climate change.

It's possible that waves of increased temperature will repeat more frequently and become more prolonged, while maximum precipitation will be more intense and frequent in many regions

Efficient decision making in order to restrict climate change and its impact might be based on a wide range of analytical approaches to assessment of expected

Industrial development has led to rapid growth of CO_2 emissions

Source: pravdaurfo.ru

risks and benefits that take into account the importance of management, ethical aspects, equality, value judgments, economic assessments and differences of perceptions and reactions to risk and uncertainty.

Without taking additional measures for mitigation of impacts on the climate system, by the end of the 21st century warming will lead to large or even huge risk of dangerous, widespread and irreversible impacts on a global scale. Mitigation of impacts on the climate system is also inherent in some co-benefits and risks because of negative side effects.

There are many ways to mitigate impacts on the climate system that could limit warming to the value of 2 °C or less against pre-industrial values. These ways will require to reduce emissions significantly during next decades and to achieve a next to none level of CO_2 and other long-lived greenhouse gas emissions by the end of the century. To ensure such reduction means to create significant technological, economic, social and institutional problems that only grow as long as extra measures aimed at impact mitigation are put off. Restriction of warming with lower or higher values is related to similar problems, though of another time scale.

Efficiency of actions on adaptation and mitigation of impacts on the climate system depends on the policy and measures taken on various levels – international, regional, national and subnational ones. Political activity on all levels that supports the technological advance, distribution and transfer of technologies, as well as funding measures on responding to changes in the climate system can complete and add to efficiency of the policy that immediately enables adaptation and reduces effects on the climate system.

In the works of IPCC the term 'projections' is mostly used as a synonym of the term 'forecast', though in a more careful meaning of 'one of possible scenarios of development. Projections for the following decades show a geographic picture of climate changes similar to the forecast for the end of the 21st century, but with lower values. A natural inherent variability will remain the main factor that influences the climate, particularly in a short term and on a regional scale. By the middle of the 21st century the projected changes will largely depend on the choice of a greenhouse gas emission scenario.

For the fifth report by IPCC [1, 2] scientific experts have chosen a set of four new scenarios, so-called Representative Concentration Pathways (RCP). They set approximate accumulative values of radiative forcing (impact) in 2100 in comparison with 1750: 2.6 W/m² for RCP2.6

Global warming threatens with more floods and droughts

Source: amp.politeka.net

scenario; 4.5 W/m² for RCP4.5 scenario; 6.0 W/m² for RCP6.0 scenario; 8.5 W/m² for RCP8.5 scenario.

These four RCPs include one emission reduction scenario that implies quite a low impact level (RCP2.6); two stabilization scenarios (RCP4.5 and RCP6.0) and one scenario with quite high levels of greenhouse gas emissions (RCP8.5). Thus, RCPs can present results of several directions where political measures in field of climate are taken in the 21st century.

Chemical production is one of the main sources of hazardous substances emissions into the atmosphere

Source: investicniweb.cz

According to RCP6.0 and RCP8.5, radiative forcing will continue growing up to 2100. It is to reach its peak in RCP2.6 and then to decrease; and in RCP4.5 it is to stabilize by 2100. Each RCP scenario provides sets of data with a high spatial resolution on changes in land use and air pollutant emissions by sectors of economy, and determines annual concentration of greenhouse gases and anthropogenic emissions until 2100.

Fast glacier ablation in Greenland can cause significant discharges of fresh water in North Atlantic. Light fresh water prevents convection and weakens circulation

RCP scenarios were suggested based on a combination of joint assessment models, simple climate models, models of chemical processes in the atmosphere and the global carbon cycle. Though RCPs present a high range of values for additive effects, they don't cover the entire spectrum of emissions described in literature, especially when it comes to particulate pollutants.

The climate model of the RAS Computing Centre includes the atmospheric general circulation model (GAC) with parameterization of some subgrid-scale processes, a global model of the ocean and a model of sea ice evolution [5, 6]. Blocks of the climate model are thoroughly described in [5–7], here we present its main features only .

A GAC model is a set of programs that describes many physical processes [3]. There are two major blocks of the program: a block of GAC model dynamic, where currents of atmosphere described with primitive equations are calculated, and block of physics, where solar and radiative heat fluxes are determined; adiabatic, humid and convection processes are considered. Results obtained in this block are used in the block of dynamics to calculate currents and thermodynamic properties of the atmosphere.

A set of equations for the ocean model is examined in geostrophic approximation with a friction term in horizontal impulse equations [5, 6]. Values of temperature and salinity satisfy an advection diffusion equation which allows describing thermohaline circulation of the ocean. Also, the procedure of convective adjustment is taken into account. Dynamic equations of the sea ice evolution model are solved to determine ice consolidation and average thickness. In the model ice growth and ablation depend on the difference between a heat flow from the atmosphere toward the sea ice and a heat flow from ice to the ocean.

A diagnostic equation is solved for the temperature of ice surface.

Blocks of the model are interconnected with impulse, heat and water exchange. Impulse exchange is using the speed of the upper layer of the ocean for sea ice advection. All other exchanges are ignored by the impulse.

Heat flows between adjacent clocks can be changed with phase transfers on borders (evaporation, ablation, etc.) Continental aqueous run-off is added to oceanic cells at every time step.

The flow of fresh water to the atmosphere is calculated taking into account evaporation from the earth surface and sea ice sublimation. Precipitation is supposed to get straight to the ocean without any consideration of ice, and evaporated or sublimated water is removed from ocean or ice respectively. The ocean model based on rigid-lid approximation which is used here states that the ocean is an inexhaustible source of fresh water for sea ice and atmosphere. The depth of the ocean is represented on a logarithmic scale in the form of eight levels up to 5,000 m.

According to this joint global model, calculations for the climate forecast up until 2100 have been carried out using CO_2 growth scenarios RCP8.5 and RCP4.5 (Fig.1) suggested by IPCC. Some results are summarized in Table 1.

The forecasts of warming can be influenced with specificities of the climate system that are not taken into account during modelling. They include, for instance, fast ablation and destruction of continental ice sheets in Greenland that can cause significant surficial discharges of fresh water in North Atlantic. Lighter fresh water prevents convection and significantly weakens meridian thermohaline circulation. Respective model experiments show that the maximum value of the meridional flow is reduced approximately twice in 25 years. The flux attenuation effect remains for up to 200 years though fresh water discharges stop. Blocked thermohaline circulation results in decreased air temperature, no higher than 3.4°C in a respective area, covers Europe, a part of Asia and influences the global climate. An extremely wide variety is typical for the Russian climate because of huge territorial expanse of the country. In the context of the global warming regional changes of the Russian climate will hardly be the same, and their influence on certain kinds of economic

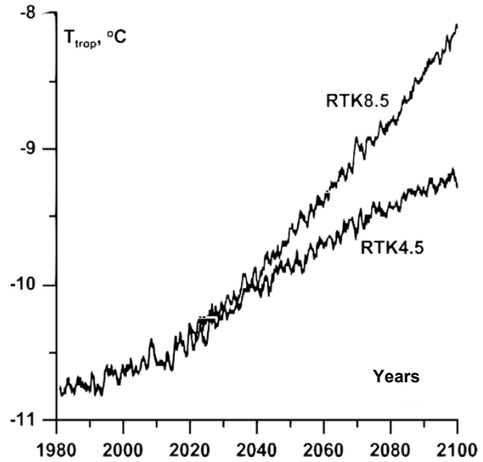

Fig. 1. The forecast of troposphere temperature change in case RCP8.5 and RCP4.5 scenarios are implemented.

Table 1. Results of calculations for RCP8.5 and RCP4.5 scenarios. Changes in comparison with 2010.

Change:	Atmospheric temperature	Atmospheric humidity	Sea ice thickness	Permafrost area	Sea ice areas in summer
RCP8.5	+2.7°C	+11.5%	- 0.3 m (– 25%)	- 22%	Almost completely
RCP4.5	+1.4°C	+8%	- 0.15m (–12.5%)	- 10%	

Softened climate shifts the area of comfortable living closer to the north and reduces electrical energy costs. Warming, however, threatens with biological changes, a greater number of drought and floods

activities can be either favorable or malign.

Softened climate might shift the border of comfortable living closer to the north and reduce electrical energy costs in a heating season. On the other hand, warming threatens with substitution of some species for others, a growth of drought repetition in some regions and floods in others, etc. Meanwhile, there's a huge uncertainty of how the future climate change will influence the Russian agriculture, its water resources, plant and animal life, and demographic situation.

Results of the model calculations show that in the 21st century the territory of Russia (arctic and subarctic regions in particular) will be an area of significantly greater warming in comparison to global warming. An average rise in temperature by the end of the 21st century can reach +4.8°C against the early 20th century. The most significant warming is expected in winter, particularly in Siberia and Arctic. By 2010 average annual precipitation on the territory of Russia will increase by 8.2%. However, in the south-west of Russia precipitation will be reduced. In the regions where agriculture is particularly well-developed (North Caucasus, the Volga territory) significant humidity reduction of the active layer and run-off reduction might take place. Another danger of future climate change is related to the melting of permafrost. The area of permafrost soils is about 60% of the Russia's territory. In case of warming they will degrade and the depth of seasonal thawing will increase. Permafrost soil degradation might lead to deformation or even destruction of transport routes, pipelines,
buildings, etc.

The most important sequences of the global warming for Russia are associated with possible reduction of the ice sheet of the Arctic Ocean. They are not only numerous, but also critical for eco-systems, as well as for economy, social area and even security of Russia.

Increased duration of summer navigation will lead to development of maritime industry. The Northern Sea Route opens up unprecedented prospects for maritime shipping and tourism. Meanwhile, increased floe drift speed and a high degree of inconsistency of the ice situation might hamper many kinds of marine operations.

Tornado in the USA

Source: bagira.guru

Climate warming might have an unpredictable effect on the biological diversity of the planet

Source: OndrejProsicky / Depositphotos.com

New opportunities for the economy along with challenges associated with ecology, arise due to easier sea access to natural resources of the Arctic, including oil and gas fields on the shelf of the Arctic Ocean. At the same time, many facilities used for economic activities that are located near shore will face increased impact of storms in combination with reduced ice sheet of Arctic seas. Expected sea ice ablation will likely be disastrous for many species, such as polar bears.

Conclusion

The influence of human beings on the climate system is extremely significant, and anthropogenic greenhouse gas emissions observed reach the highest level in the entire post-industrial period. A natural inherent variability is also an important factor that influences the climate, particularly in a short term and on a regional scale. The forecasts of warming can be influenced with specificities of the climate system that are not taken into account during modelling.

Climate warming in Russia unfolds 2.5 times faster than on the planet in average. An extremely wide variety is typical for the climate of the country because of its huge territorial expanse. In the context of the global warming regional changes of the Russian climate will hardly be the same, and their influence on certain kinds of economic activities can be either favorable or malign.

Climate warming might expand the borders of the area for comfortable living, reduce electrical energy costs. However, it can lead to uncertainty in the situation with agriculture, water resources, demography and biological world.

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Африка: большие интересы, большие риски

Africa: big interests, big risks

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The population of many oil-producing African countries does not have access to energy and water

Source: vlad_k / Depositphotos.com

Africa's population may grow to 3 billion people by 2100

Source: muha04 / Depositphotos.com

Аннотация. В статье описываются основные тренды развития нефтегазового комплекса Африки. Автор провел анализ работы российских компаний на этом континенте и выделил основные риски для реализации новых нефтегазовых проектов в Африке.
Ключевые слова: добыча нефти и газа, рост потребления нефтепродуктов, геополитические риски.

Abstract. The article describes the main trends in the development of the oil and gas complex in Africa. The author analyzed the work of Russian companies on this continent and identified the main risks for the implementation of new oil and gas projects in Africa.
Keywords: oil and gas production, growth in consumption of petroleum products, geopolitical risks.

> From 1999 to 2018, proved oil reserves of African countries increased from 84.7 bln bbl to 125.7 bln bbl or 7.5 % of global reserves

Energy demand

If you look at the current forecasts of the United Nations (UN), a lightning fast speed of the global population growth becomes obvious. By the middle of the century, there will be 9.9 billion of us. By 2053, the number of people on the planet will have overpassed the 10 billion milestone. For comparison, in 2018 the population of the Earth was about 7.6 billion people. Moreover, in the XX century the population grew mostly in developed countries but the sign of the XXI century is a growth in the developing economies of South-East Asia and Africa. The number of inhabitants of the latter will double up to 2.5 billion and by 2100 it will already be 3 billion people, that is, a third of the total population of the planet. Today the share of the African population is only 15%. The UN believes that, for the most part, population will keep growing mainly in poorer countries south of the Sahara desert, such as the Democratic Republic of the Congo, Tanzania and Ethiopia, as well as in the more prosperous South Africa.

At the same time, in the late XX and early XXI century African countries have shown that they have enough energy resources, otherwise they wouldn't be able to sustain the life of such a large population. According to British BP[1], proved oil reserves of African countries increased from 84.7 to 125.7 billion barrels from 1999 to 2018, accounting for up to 7.5% of global oil reserves. In general, over the past 100 years Africa has managed to significantly improve its energy security and acquire new resources for economic development.

[1] BP Energy Outlook 2020.

Africa is where a unique situation is emerging when a certain country can be among the world leaders in oil or gas production, but at the same time a significant part of its population does not have an uninterrupted supply of electric power.

At the same time, according to BP, the demand for energy among the population provided with energy is growing by 2-3 percentage points per annum, having changed from 3.32 to 4.1 million barrels per day from 1999 to 2019. This is at least 2 times higher than the worldwide average rate (1.3 percentage points). This fact poses an ambitious problem for the leaders of African nations and external investors to find new available resources in order to balance supply and demand in countries to lead by population growth in the future.

According to analysts, by 2050 the region has every chance to close the gap between the consumption (3% on the global scale) and production (12% on the global scale) of energy. African countries will have to annually increase the rates of drilling and oil and gas production so as not to face a dependency on imported energy resources in one day.

The energy balance of power sources, say, of Russia and African countries taken together is quite similar. Natural gas in Russia accounts for up to 48% of all the generation, while in Africa this share is 42%. The situation with coal is similar: 19% and 23%, respectively (see Table 1).

It is natural gas that the International Energy Agency and the US Energy Information Agency attach the leading role as the most promising, fastest growing

There is a unique situation in Africa where countries may rank among world leaders in production of oil or gas but at the same time a significant portion of their population is deficient in energy

source of primary energy for the period up to 2040. Agencies expect that the demand for natural gas might grow from 43% to 57%. The demand will mainly grow in developing economies of Asia, Africa, Latin America and the Middle East. According to the calculations of RAS (Russian Academy of Science) IES (Institute for Energy studies), African countries will have to increase the total production of liquid hydrocarbons by 50 million tons in total by 2040 (see Table 1), provided that the existing levels of oil exports to China (79.5 million tons in 2019) and India (30.2 million tons in 2019) remain. For comparison, only African countries (mainly Libya, Nigeria, Angola, Algeria and Sudan) produce 399 million tons of oil annually, averaging at 8.1 million barrels per day. Of these, the lion's share, 6.8 million barrels per day, is exported. That's more than 10% of the global daily level. Oil volumes remaining on the domestic market are actually subsidized by these exports. Domestic retail prices

Table 1. Share in percentage of generating capacities in the energy balances of the world regions

Source: data of McKinsey

	gas	coal	nuclear power	others (including RES)
Middle East	62	0	0	38
USA	45	26	9	19
Africa	42	23	1	34
Russia	48	19	11	22
Europe (OECD)	24	15	11	49
Latin America	23	2	1	74
India	8	61	2	29
China	4	58	2	36

for gasoline and diesel, where it is basically available, often tend to be close to the prime cost of the product.

In fact, a low development of the oil refining infrastructure is one of the typical features of almost every producing country in Africa. Most of the refineries there were built in the 1960s and 1970s and, as a rule, have not been upgraded with new secondary installations since. Poor equipment of processing facilities does not allow a full utilization of existing plants, therefore the average load rate in the region does not exceed 60%. At the same time, the region as a whole is characterized by a persistent shortage of petroleum product supply, despite the vast resource base and oil exports.

OIL out LUK

At the moment, almost every more or less large oil producer in Africa faces the difficult task of attracting new investments into their production under the conditions of relatively low hydrocarbon prices, declining production and limited consumption caused by the coronavirus pandemic. According to BP, the region has lost 2.1% of annual crude oil production over the past 10 years with a reduction in the yield from 9.92 to 8.4 million barrels per day. This trend only escalates the competition between countries for an investor, as only Congo has a stable production growth (from 276 to 339 thousand barrels per day) out of the 12 oil-producing states monitored by BP and oil production in 5 countries is in steady decline (Algeria, Angola, Egypt, Equatorial Guinea and Tunisia).

They can't develop the production using their our own means and technologies. Africa remains one of the few continents on Earth where resources of the national oil companies are insufficient for this. The same factor once made possible a massive arrival of large multinational companies such as ExxonMobil (assets mainly concentrated in Nigeria) and Royall Dutch Shell (assets in Nigeria, Egypt, Tanzania). The explosive growth in production and new projects in the 2000s–2010s changed to a decline in interest and the abandonment of projects already under development in 2019–2020. Today, American ExxonMobil and Chevron are looking for new owners for a part of their assets in Nigeria and Marathon Oil and Occidental Petroleum are searching new partners for shares in Libyan projects.

Russian LUKOIL is one of the "oldies" and pioneers of the African oil and gas business. Due to the difficulties in expanding the resource base in Russia, the company started to actively buy shares in foreign offshore projects back at the dawn of its operation.

In the mid-1990s, when LUKOIL first entered the continent, it was believed that the most promising projects were in the western part of Africa: in the Gulf of Guinea and further south along the deep-marine shelf of the country's shore. Having started from shallow waters of Egypt in cooperation

Oil fields in Libya are regularly shelled in the course of civil war
Source: Paindoo.com

with the large Italian Eni on the Meleiha project, the company found sites for itself in Cote d'Ivoire, Sierra Leone, Cameroon, Congo, Nigeria and Ghana already in the 2000s. The "shale revolution" in the United States and the subsequent collapse of oil prices exposed weaknesses of the projects and forced LUKOIL to make a quicker investment decision regarding work on them. In 2015, the company showed a loss on dry wells for 2014 in the amount of 9 billion rubles and promptly abandoned projects in Sierra Leone (block SL-5-11) and on the Ivory Coast shelf (a total of five blocks in the Gulf of Guinea). In parallel, the American Panatlantic had left the shelf of these and other countries, and then

completely closed. Exploration, indirectly related to the management of LUKOIL, we can only guess about its losses. The beginning exodus from the African continent fueled rumors about both the reform of offshore production in Russia and the sale of LUKOIL's Italian refinery ISAB that is also focused on crude products from Africa.

Taught by bitter experience, the "water extraction" company of Vagit Alekperov (as he himself called it in an interview at the end of 2019) tightened its approach to the selection of fields, actually abandoning its participation in risky projects and deciding to enter well-studied sites only, in partnership with experienced majors.

At the moment, the announced exit of ExxonMobil from Africa in favor of the shale projects of the USA and Canada becomes another chance for LUKOIL to gain a foothold in the local market and potentially become a major investor into oil and gas projects on the continent. Now, according to V. Alekperov, the company is considering for itself the already yielding Zafiro field (90 thousand barrels per day) in Equatorial Guinea and a number of gas projects owned by ExxonMobil. LUKOIL signed a basic agreement on cooperation with the country's authorities back at the Russia-Africa summit in 2019.

They can't develop oil production using their own means and technologies. Africa remains one of the few continents on Earth, where resources of the national companies are insufficient for this

In fact, the Vagit Alekperov's company began to reassemble its "African package". The latest purchases here include 25% in the Marine XII project in Congo for $ 768 million, and a 40% stake in the RSSD (Rufisque, Sangomar and Sangomar Deep) project in the Republic of Senegal for $ 300 million. The company still has two facilities in Ghana within the framework of a deepwater project in the Tano block (Deepwater Tano/Cape Three Points),

Amateur oil production and refining in Nigeria
Source: wognews.net

which received the first oil inflows in 2018, as well as the Cameroon project Etinde (LUKOIL's share in the project is more than 30%), which the company entered at the end of its first round of the African campaign in 2015 for $200 million. The investment decision regarding this project will not be made until 2021. By the way, besides Zafiro, the Russian company has already entered in Equatorial Guinea into a project for EG-27 block development on the country's shelf, involving the construction of a floating LNG plant.

The ambitious LUKOIL expects to expand its business in Nigeria, the largest oil producer on the continent. At the end of November 2019, the company increased its stake in geological exploration block 132 from 18 to 40%, while continuing to work at block 140 simultaneously (the total reserves of the two blocks are estimated at 3.3 billion barrels of oil) and hold negotiations with Eni on entering the existing Aba project.

It is symbolic that LUKOIL kept its first purchase in Egypt, the WEEM, WEEM Extension and Meleiha projects, and keeps developing them in accordance with the agreement.

Participation of Russian companies in the Egyptian oil industry expanded at the end of 2019 when Zarubezhneft signed its first African Production Sharing Agreement for the South East Ras El Ush (SEREU) and East Gebel El Zeit (EGZ) blocks offshore Egypt.

In the future, according to sources, Zarubezhneft does not mind considering projects in the Republic of Congo, where the oil product pipeline Pointe Noire – Ye – Oyo – Ouesso is already under construction with the participation of the Russian GK RusGazEngineering JSC.

There are oil prospects in South Africa that began in 2018 a cooperation with Rosgeologia JSC on exploration and development of the E-CB and E-BK parts within the 9th southern shelf block.

Liquefied hopes

But if the oil production is still increasing solely with the aim of increasing supplies to foreign markets, the production of blue fuel is focused primarily on the domestic market. It is assumed that the demand for gas will be warranted by the developed countries of northern and central Africa, where an increase in power consumption is expected. According to BP, gas consumption in Africa has grown more than 1.5 times over the past 10 years, from 95 to 150 billion cubic meters per year. During the same time, the Africans were also able to significantly increase their proved reserves from 11 to 14.9 trillion cubic meters at the end of 2019. However, production dynamics is gradually starting to lag behind the demand. Over the past 10 years, it has grown by only a quarter from 192 to 238 billion cubic meters.

At the same time, the export of African pipeline gas under competition with Russian gas in the European market decreased by almost 40% between 2009 and 2019.

Due to the volatility in oil prices and increased competition with "freedom molecules" from the United States, as well as with Russia, the export of liquefied gas also remained unstable and actually grew only slightly – from 56 million tons in 2009 to 61.2 million tons in the last year.

Natural gas reserves in Africa, according to the International Energy Agency, amount to 487.8 trillion cubic meters[2], while natural gas production accounts for up to 6.1% on the global scale.

Gas reserves in Africa are 487.8 trillion cubic meters and production of gas accounts for up to 6.1% on the global scale. In 2019, investments into new projects for its production reached 103 billion dollars

In 2019, investments into new gas production projects hit the $ 103 billion mark. However, the overwhelming part of the funds will probably be spent on recovery, cleaning and transportation of associated gas that is still being flared most often, as it is cheaper than exploring a new

[2] Africa Energy Outlook 2019 – IEA.

Oil production in the Gulf of Guinea

Source: pipelineoilandgasnews.com

Gas production at the shelf of Mozambique *Source: mozambiqueoilmining.com*

gas project on a deep-marine shelf.

Algeria is rightfully considered to be the gas-richest country in Africa. This country is the largest African exporter of pipeline gas to Europe having a share of 1/5 of total gas import. As of the beginning of 2018, proved reserves of natural gas in Algeria were as high as 4.34 trillion cubic meters. Over the last year, this country has been actively attracting foreign companies to work in its hydrocarbon sector, which is supported by permanent production growth, which, by the fact, no other major gas-producing country on the continent can boast of. At the end of 2019, Algeria has changed laws to facilitate access to natural resources because in recent years the investments decreased due to bureaucratic complexity.

Gazprom is an old partner of Sonatrach, a local state-owned company that participates in all projects of foreign companies in the country as a matter of law. The national Algerian company conducts exploration activities with Gazprom in the El Assel area in the Berkin oil-and-gas basin. Also, Rosneft is involved that won the tender for hydrocarbon exploration in Algeria together with Stroytransgaz as far back as in 2001. Algeria has signed memorandums on cooperation with all Russian major companies. This openness is reasonably explainable: the Algerian economy is largely based on export of hydrocarbons, 97% of export revenue is received from hydrocarbons. With explored oil reserves of 1.5 bln tons, Algeria is the fourth largest country in the region. However, the production is mainly provided by old fields and its level decreases gradually. Today it is less than 61 mln tons per annum, so the country bets on the gas.

After discover of the Prosperidade field by Anadarko and Eni with reserves of 29 tln m^3 of gas at the deep-marine shelf of Mozambique, this country became the 14-th largest holder of blue fuel reserves in the world

By the way, it was Algeria that became the first country in the world to export LNG in 1964. Today Algeria produces LNG on 14 processing trains at four plants with a total capacity of 34.4 billion cubic meters per annum.

The last investment decisions taken in Nigeria, Mozambique, Egypt, and in other countries count in favor of LNG. Liquefied gas is considered as one of top-priority for the development of fuel and energy sector in Africa. Nigeria, along with Algeria and Egypt, is the main source of gas (49 bln cub. m, producing up to half of the total LNG exported from the continent (29 mln. tons in the total export amounted to 61 mln. tons in 2019). The potential of Nigerian LNG was noticed by Gazprom at the right time – within the period from 2010 to 2015 its trading subsidiary purchased 35 lots of Nigerian LNG with a consolidated volume of 2.1 mln. tons. Nigeria has extensive capabilities to increase these supplies. As of the beginning of 2019, proved reserves of natural gas in the country were as high as 5.35 trillion cubic meters. It is the top position in Africa and the world's tenth largest reserves.

A probable competitor of Nigeria in this market is economically poorer Mozambique. Year 2010 became a turning point in the history of this country when Anadarko, an American oil and gas company, and Italian Eni discovered huge reserves of natural gas at the country's deep-marine shelf. This raised Mozambique in a jiff to the 14-th line in the list of countries with largest gas reserves in the world. Its biggest gas field was named Prosperidade (Prosperity) with 29 trillion cubic meters of the blue fuel. It is expected that from 2022 gas from this field will be liquefied to LNG and exported to neighboring countries of the continent. According to the Energy Center of Skolkovo Business School,
the cost of liquefaction here will be lower than, for example, in new Australian projects.

Russian Rosneft plans to occupy its place in the history of African LNG market development. "The company rates Africa as one of its three future oil and gas hubs",
said to "Izvestiya" in June, 2016 Christopher Einchcomb, Deputy Chief Geologist of Rosneft, who is in charge for upstream projects support. However, the company has not succeeded in finding a suitable project for investment so far. EG-27 block at the shelf of Equatorial Guinea might be a good choice, but the auction was won by LUKOIL. Today the company already has a 12-year contract for LNG supply to Ghana with a volume of 1.7 mln tons annually, but no source for the supply is found near Ghana up to now. It was previously expected that Rosneft can practice LNG export using its joint gas project with Eni at Zohr field in Egypt, which is the largest field in the Mediterranean region (reserves estimated as exceeding 850 bln. cubic meters of gas). However, the decrease in gas production within the country makes all the gas to be directed to the domestic market so far.

Drilling a well at the Etinde block offshore Cameroon
Source: wognews.net

"Pitfalls" of the Gulf

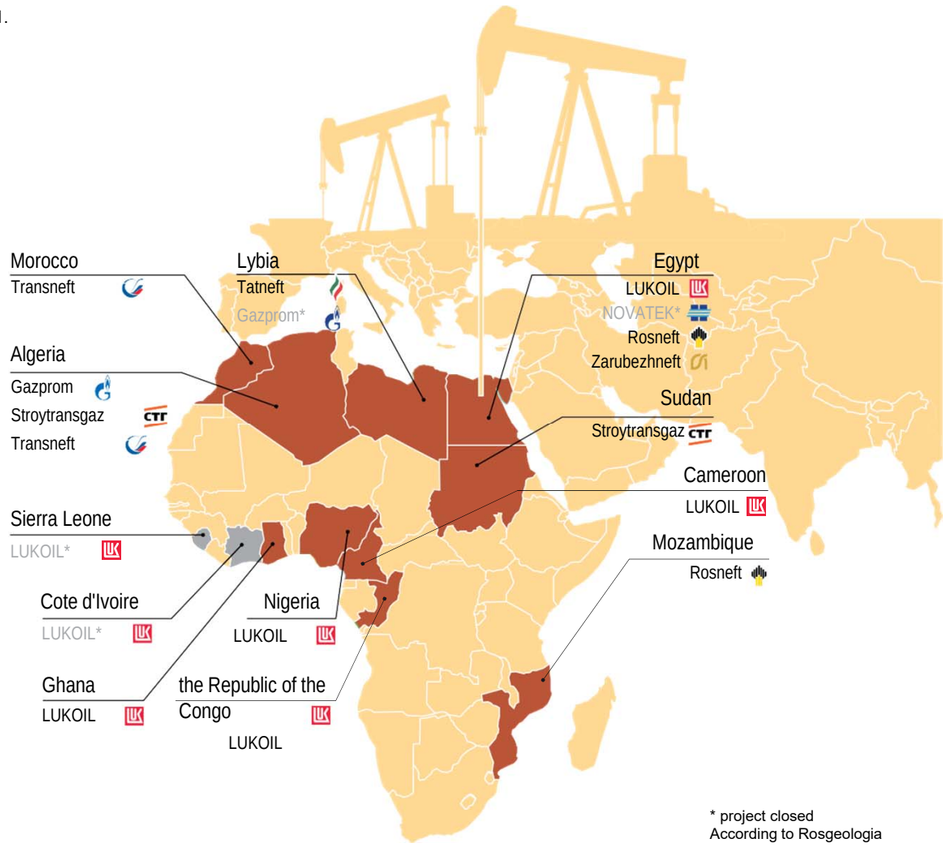
Increased interest of African countries in Russia is reasonably explainable: the shale "renaissance" has weakened western investments to a significant extent, while disappointment in the Chinese who remain major foreign investors in the African economy is only growing. But opposed to Chinese companies having inexpensive credit resources to invest in doubtful African projects, Russian companies, bearing in mind the experience of LUKOIL and a number of intergovernmental negotiations, become more careful.

The most common problem when entering the African market is tax conditions and royalties for a project. Difficulties in agreeing royalty and contract terms were one of the reasons behind Gazprom's withdrawal from promising projects in Algeria at the El Assel site where the company discovered two oil fields and two gas condensate fields. Typically, the cost of exploring and acquiring mining rights and not production CAPEX constitutes a major portion of the expenses for “entering” an African project (see Figure 1). In this context, the lack of skilled and technical workers to meet the requirements of the governments of East African states for local workforce involvement in project implementation is not so important.

Another reason behind a frequent lack of information on a project, including public projects, is African authorities simply dragging out negotiations, trying to “sell” a poorly explored project instead of negotiating on more explored projects, among others, or on developing mature fields, according to a source in one of the companies. Sometimes local authorities simply stop communicating or participating in talks, the source adds. In such a case the partnership was ruptured, even if an intergovernmental agreement featuring a joint venture creation had already been signed between the countries. There were also cases when the authorities delayed payments under the already registered concession for the operator, which did not inspire hope for a continued successful cooperation either.

Thus, a consortium of Rostec, Telconet Capital, VTB Capital, Tatneft and South Korean GS Engineering & Construction won a tender in 2015 for the construction of the first oil refinery in Uganda with a capacity of 3 million tons per year. A year later, the consortium was forced to abandon the project due to the unwillingness of the Ugandan government to fulfill its tender obligations.

Fig. 1.



Drilling wells offshore Cameroon *Source: stockinfocus.ru*

However, no one can guarantee that the current or new authorities won’t come up with tax claims against the concessionaire or production license owner as part of an unexpected anti-corruption investigation at some point, as it happened, for example, in Angola with the Gazpromneft subsidiary Serbian NIS in 2013–2014.

Compared to other oil and gas markets, it is African market that remains the least studied and promising, as well as closest to the future epicenter of hydrocarbon consumption

But the most common risks, the ones that hardly anyone can insure you against, are a coup d'etat or a war with neighboring state. Thus, oil production in, and export from Libya have been partially disrupted since the military coup of 2011. In the context of these news, the oil price at the end of September fell to $ 40 per barrel. Relations with Russian oil workers also fell victim to an armed conflict. Gazpromneft has already abandoned a project in Algeria and Tatneft, which has 4 contract areas in the country, still cannot return its workers to the projects. For example, country's proximity to a military conflict is preventing a full-scale cooperation between Russia and Sudan, although private Russian investors were ready to build a plant for associated petroleum gas processing there. Nevertheless, compared to other oil and gas markets, it is African market that remains the least studied and promising, as well as closest to the future epicenter of hydrocarbon consumption. Since no large coal deposits left on the continent, there is no doubt that the share of oil and gas in the region's energy balance will keep growing. The competition for these hydrocarbon resources and for the consumer has already begun. As the prices remain relatively low, a window of opportunity is opening for Russia right now to overtake the same China seeking to stake out a good source of energy for the needs of its economy. Today, Russia is head and shoulders above the United States and China in the nuclear sphere on this field, building one nuclear power plant and having agreed to elaborate several other NPP projects[3] in Africa. With due care and preservation of political ties between countries at the highest level, Russia can really secure the position of leading operator in the oil and gas future of Africa.

[3] Deutche Welle: African countries mull nuclear energy as Russia extends offers; 27.09.2020.

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Перспективы нефтегазового комплекса на Востоке России

Prospects for the oil and gas complex in the East of Russia

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Vankorskoye oil and gas field *Source: vmp-protect.ru*

Аннотация. В статье рассмотрены вопросы формирования нефтегазовой отрасли на Востоке России в рамках развития энергетического сотрудничества со странами Восточной Азии. Показаны роль Восточной Азии в современном мире и основные факторы, которые будут определять важнейшие направления энергетического сотрудничества в этом регионе. Сделан вывод: после ограничений, вызванных эпидемией коронавируса, и спада экономики, основные страны региона продолжат наращивать спрос на энергоносители. В этих условиях объём экспорта углеводородов из России будет ограничен не столько спросом на них со стороны азиатских рынков, сколько возможностью их производства и транспорта в нашей стране.
Ключевые слова: энергетическое сотрудничество, Восточная Азия, Россия, нефть, природный газ, спрос и потребление энергоресурсов, прогнозы развития.

Abstract. The article deals with the formation of the oil and gas industry in the east of Russia in the framework of the development of energy cooperation with the countries of East Asia. The role of East Asia in the world and the main factors that will determine the most important areas of energy cooperation in this region are shown. It was concluded that after the restrictions caused by the coronavirus epidemic and the economic downturn, the main countries of the region will continue to increase demand for energy. In these conditions, the volume of export of hydrocarbons from Russia will be limited by the possibility of their production and transport in our country.
Keywords: energy cooperation, East Asia, Russia, oil, natural gas, energy demand and consumption, development forecasts.

> **The energy landscape of East Asia constitutes a set of separate markets insufficiently interacting with each other**

Northeast and Southeast Asia is one of the largest macro-regions on the planet and, at the same time, the most dynamically developing geopolitical space that is consistently attracting the center of gravity of the world economy and politics. This region is a virtually limitless market for energy products and services. It is difficult to imagine a better example of a potential mutual assistance on the global scale in the field of economy and energy than this geographical space of East Asia where some countries are rich in energy, minerals and other natural resources while others have the most advanced technologies and still others have vast labor resources[1]. The potential of such a cooperation is far from being effectively used.

Regional fuel and energy crossflows provide only a minor portion of East Asia's energy consumption. According to the energy, this region today is a set of isolated markets that have little interaction with each other and don't have a deep regional cooperation. For Russia, whose east is rich in various natural resources[2] but has not been sufficiently developed yet, a cooperation with the neighboring states of East Asia is particularly interesting in general.

[1] The same papers provided a detailed analysis of the energy supply at the Northeast Asia countries and the solution to the energy security problems there in the context of new challenges; some of its results fully apply to East Asia as a whole.
[2] In the context of this article, the East of Russia refers to Eastern Siberia and the Far East.

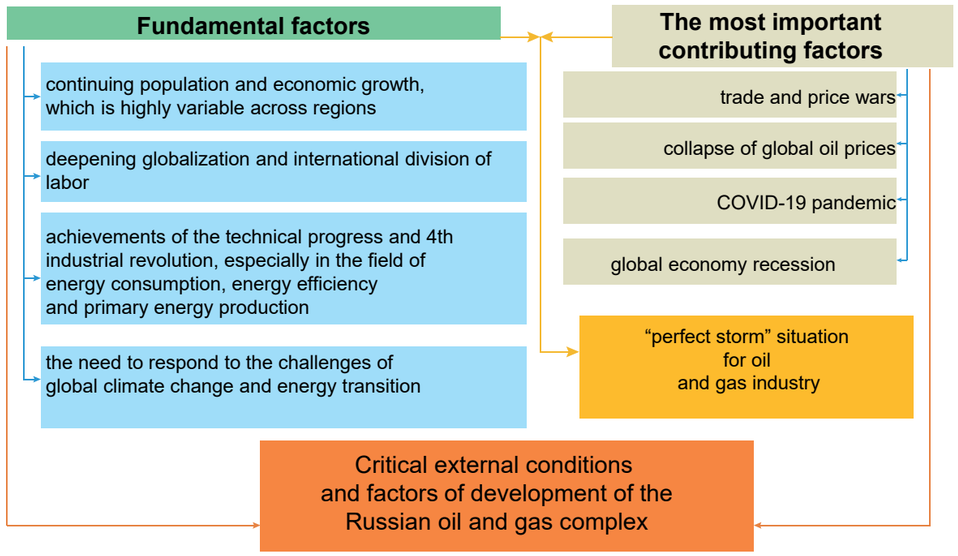


Fig. 1. The main factors defining energy cooperation of the countries in North-East and South-East Asia in the long term

The most important area of the energy policy of most East Asia countries is an improvement of the existing energy consumption structure, which has become especially relevant in the last decade. There are many reasons for this, but the most important are the following:

- the need to reduce the dependence of Asian economies on oil imports from traditional suppliers in remote regions. The instability in the Middle East, the explosive situation in Nigeria and Libya, the sanctions against Iran have given a particular significance to this reason;
- the need to respond to the challenges that humanity faces in connection with the climate change, to achieve the goals set by the Paris Climate Agreement, to form a low-carbon energy industry;
- the need to improve the environment, reduce harmful emissions into the atmosphere, improve the quality of air basins and use cleaner power resources.

Energy cooperation between East Asia countries in the long term will be determined by the totality of fundamental and temporary factors (Fig. 1).

The notable fundamental factors in terms of the need to respond to the challenges of environmental pollution and global climate change include the continued growth of the population and economy.

The temporary factors that will impact the global economy development at least for the next 3 to 5 years include the notorious “gray and black swans”: trade and price wars, the collapse of global oil prices, the coronavirus pandemic and the global economy recession. It was them, together with fundamental factors, that created a “perfect storm” situation for the oil and gas industry, which, in all likelihood, will persist in the short and medium term.

The notable fundamental factors in terms of the need to respond to the challenges of global climate change include the continued growth of the population and economy.

Together, these processes and phenomena will be the most important external conditions and factors for the development of the oil and gas complex of Russia.

An analysis of the available estimates and forecasts of energy consumption in East Asia suggests that after emerging from the current crisis and overcoming the economic downturn, the main countries of the region will keep increasing their demand for energy. And they will demand not only renewable sources adequate to the energy transition but also hydrocarbons.

For the developing economies, and most of the East Asia countries belong to this category, it is not the problems of global climate change that come to the fore, but the problems of economic growth and overcoming energy poverty. Therefore, the support for a complete rejection of carbon power resources in favor of political ambitions, and the energy transition is primarily a political goal, means additional difficulties in solving pressing problems for most developing countries. The shortage or high cost of power resources can negate the very prospect of economic growth for them and the achievement of at least a minimum level of well-being for their population.

For the East Asia countries , it is not the global warming issues that come to the fore, but economic growth problems. A complete rejection of hydrocarbons for them presents additional difficulties

Moreover, a consumption of hydrocarbons will not collapse overnight in developed economies either. A rejection of hydrocarbon energy is a process stretched out in time and developing unevenly,

The typical feature of Asian countries is a rapid population and population density growth

Source: GostonMoris / Depositphotos.com

therefore, oil and especially natural gas will remain one of the main sources of energy in these countries for a long time to come.

As a first approximation, the possible scale of the prospective growth in the energy needs of East Asia countries can be judged by such indicators as population growth and its average per capita energy consumption.

Thus, according to estimates by the UN Department of Economic and Social Affairs, published in 2019, the total population in East Asia by 2050 may increase compared to the expected population in 2020 depending on forecast option[3] in the range of 64.6 to 171.7 million people [5] (Fig. 2).

Even with the current level of per capita primary energy consumption in these countries (roughly about 2 tons of oil equivalent), this is equal to an increase by 2050 of 130-340 million tons of oil equivalent a year, respectively. Shall we assume that per capita energy consumption in the region will reach the current level of developed OECD member countries (4.12 toe/person [7]) by 2050, then the total consumption of primary energy in East Asia will be about 9.9-10.4 billion tons of oil equivalent, taking into account the expected population growth. At the same time, the entire population of the planet is currently consuming about 14.3 billion tons of oil equivalent [7].

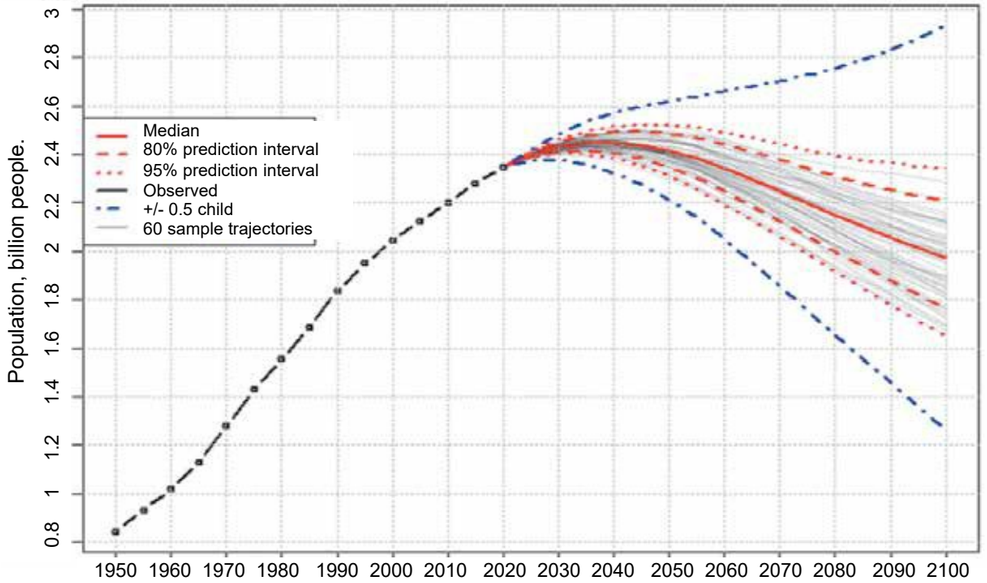
The growing demand for energy at East Asia countries in the context of an insufficient resource base will be increasingly satisfied by imports of oil and gas.

As a result, the volume of hydrocarbon exports from Russia will be limited not so much by the demand from Asian markets as by the possibility of their competitive production and transport in our country. It is this premise that underlies further analysis of the development opportunities

[3] The methodology for elaboration of these forecasts and predictive estimates is given in [6].

Fig. 2. The range of possible trajectories of prospective dynamics in the total population of East Asia countries

Source: United Nations [5]



Explanation by UN experts: This chart shows estimates and probabilistic projections for the total population in this region. Demographic forecasts are based on probabilistic projections for total fertility and life expectancy at birth, which were prepared using the Bayesian hierarchical model. The figure shows the probabilistic median, 80 and 95 percent forecasting intervals for probabilistic population projections, and the determined high and low options (+/- 0.5 child).

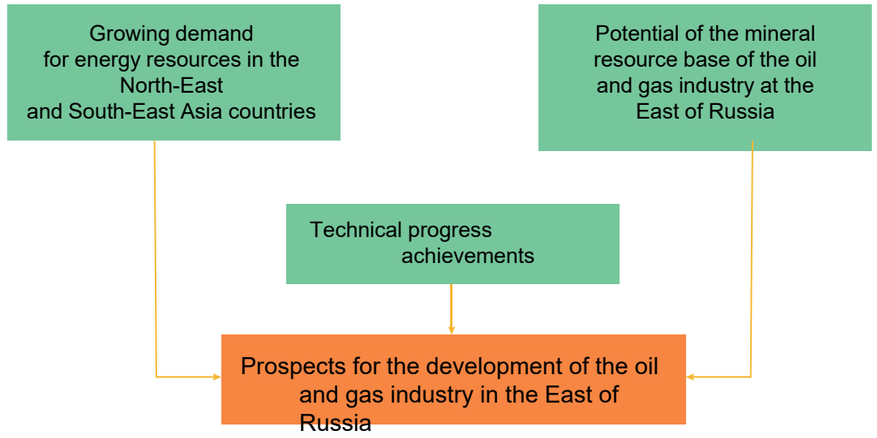


Fig. 3. Main factors determining the prospects for development of the oil and gas industry in the East of Russia

for the oil and gas complex at the east of the country. Other fundamental factors in the development of oil and gas production at the East of Russia are the possibilities of the mineral resource base of the industry to be discussed later and the successes of the technical progress (Fig. 3).

The prospects for the development of the oil and gas complex of Russia for the next fifteen years are determined by a number of adopted and developed regulatory legal acts of the country in the field of energy [8–11], including the Energy Strategy of Russia until 2035 approved by the government on June 9, 2020 [12].

The energy strategy is based on the need to accelerate the transition to a more efficient, flexible and sustainable energy characterized by optimizing the spatial distribution of energy infrastructure. As part of this optimization in Eastern Siberia, the Far East and the Arctic zone of the Russian Federation, it is planned to form oil and gas mineral resource centers, oil and gas chemical complexes and to expand the infrastructure for the transportation of energy resources. As a result of implementation of all these measures, Russia will become a leading player in the markets of the Asia-Pacific region, whose share by 2035 should reach 50% in the total volume of exports of Russian energy resources.

The main indicators of development of the country's oil and gas complex in accordance with the Energy Strategy are shown in Table 1.

Table 1. Some indicators of the oil and gas industry development in accordance with the Energy Strategy of the Russian Federation until 2035

Source: according to data [12]

Indicators	2024	2035
Volume of oil and gas condensate production, mln tons	555–560	490–555
The ratio of oil and gas condensate production in Eastern Siberia, the Far East and the Arctic zone of the Russian Federation to the basic level of production in these regions	1.075	1.1–1.15
Volume of natural gas production, bln m^3	795–820	860–1000
LNG production, mln t	46–65	80–140
The ratio of gas production in Eastern Siberia and the Far East to the base level of production in these regions	2.6	4.2
The capacity of export gas pipelines, bln m^3 including:	363	405
– in westerly direction	325	325
– to the countries of the Asia-Pacific region	38	80

There are still no official documents defining the areas, goals and objectives of the country's oil and gas complex development for the period up to 2050. There are only some elaborations and predictive estimates of research institutes, consulting structures and experts, whose results vary in a wide range and do not provide a complete picture of the future development of the industry. The main, most reasoned of them fit into the range of two scenarios: current policies and conditions, high resources and high capabilities.

Drilling platform, Irkutsk Oil Company
Source: invest.irkobl.ru

The current policies scenario assumes that the economic situation in Russia will not undergo significant changes, economic sanctions and the high volatility in global oil prices will remain, with an average of $45-60 per barrel at permanent prices. At the same time, the developed countries of the world will actively implement the energy transition concept.

The high opportunity scenario assumes that the forecast period will feature:

- the necessary funding will be provided for geological exploration resulting in qualifying as reserves at least a half of the already known oil and gas resources at the East of Russia;
- the necessary transport infrastructure (a network of main oil and gas pipelines, seaports and transshipment points, development of the Northern Sea Route, etc.) will be provided at the east of the country and in Russia as a whole;
- there will be consistently high global oil prices (at least $80 per barrel at permanent prices);
- Western sanctions on Russia will be lifted and the country will receive free access to the world financial resources, technologies and competencies;
- as a result of global warming, navigation over the Northern Sea Route will become year-round.

The high uncertainty of the upcoming development makes the estimates at the level of 2040–2050 rather unreasonable. In both scenarios, the strategic objectives of ensuring the development of the oil and gas industry throughout the entire considered projection i.e. the period until 2050 are:

- structural transformation of the industry in terms of increasing the share of hydrocarbons produced using secondary and tertiary methods with an growth in recovery rates; increase in the structure of products with a high degree of processing; changes in the structure of investments towards an increase in the share of expenditures for R&D and innovation;
- development of transport and industrial infrastructure of the Far East, Eastern Siberia and the Russian Arctic zone;
- minimization of the negative impact of extraction, production, transportation and consumption of hydrocarbons on the environment, climate and human health.

Possible levels of prospective development of the oil and gas industry at the East of Russia primarily depend on capabilities of the industry's mineral resource base.

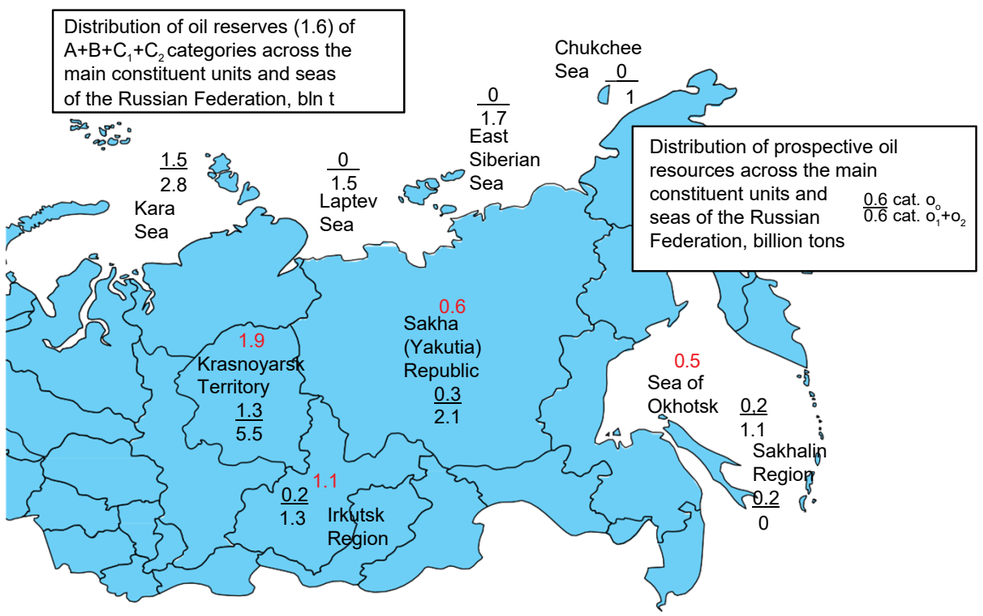
According to the data and estimates of the Ministry of Natural Resources and Environment of Russia (State reports “On the condition and use of mineral resources of the Russian Federation” [13, 14]), the

Vankorskoye oil and gas field *Source: vmp-protect.ru*

Russian reserve base of liquid hydrocarbons allows the country to look into the future with confidence. Technologically recoverable reserves in Russia as of the beginning of 2019 amounted to 29.8 billion tons oil and 4.1 billion tons of condensate. Prospective D_0 category resources are estimated at 13.9 billion tons of oil and 1.9 billion tons of condensate. According to the Ministry of Natural Resources, it can be expected that about a quarter of these resources in the future will be moved to commercial categories of reserves, based on the results of geological exploration Prospective resources of oil and condensate of D_1+D_2 categories, whose reliability is much lower, are estimated at 43.9 and 11.3 billion tons, respectively.

A significant part of the explored oil reserves and resources is just at the east of the country. Their distribution over the main regions and seas of Russia is shown in Fig. 4.

Fig. 4. Explored reserves and resources of oil at the East of Russia *Source: Ministry of Natural Resources of Russia [14]*



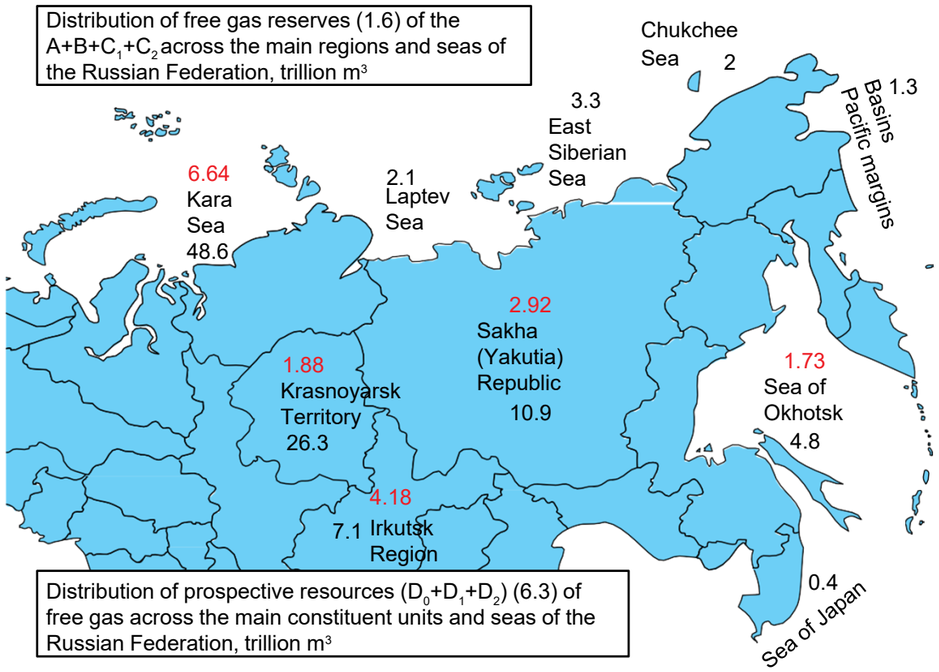


Fig. 5. Explored reserves and resources of natural gas at the East of Russia

Source: Ministry of Natural Resources of Russia [14]

In accordance with such a territorial distribution of resources, the relocation of the main oil and gas producing centers of the country will continue in the eastern and northern directions in the years of the considered projection. The main part of the explored reserves and resources of natural gas is also located at the east of the country (Fig. 5). It is here, at the East and North of Russia, where new export-oriented oil and gas production centers will be formed on the basis of the resources of the Gydan and Yamal peninsulas, the water zone of the Kara Sea, the Leno-Tunguska, Leno-Vilyui, East Arctic, Laptevo-Sea, Okhotsk and other oil and gas basins. Oil production in Russia at the level of 2040–2050 with a favorable situation at the global and domestic markets, i.e. under the scenario of high resources/high opportunities, may amount to about 570–590 million tons per year, including about 120 million tons at the East of Russia (Table 2). To ensure this level of production, it will be necessary to significantly increase oil reserves, particularly in Eastern Siberia and the Far East.

Oil production growth will allow increasing its exports.
By 2050, they may reach 340 mln t, including exports to countries of the APR – up to 170 mln t. The delivery of petroleum products to this region will also grow

Such an increase in oil production will make it possible to keep increasing the scopes of its export, which may reach 340 million tons by 2050, including up to 170 million tons per year to the Asia-Pacific countries. Supplies of petroleum products to this region will also grow significantly.

Naturally, the volume of oil production and exports will be significantly lower under the scenario of current policies and conditions. In terms of gas production,

	Actual		Forecast		
	2000	2019	2035	2040	2050
Oil production	323.5	561.2	490/555	450/570	380/590
inc l.—East of Russia	3.9	76.3	98/110	105/120	75/120
Oil refining	173.8	289.8	240/295	250/270	240/250
inc l.—East of Russia	19	22.4	45/50	50/65	65/70
Oil exports	144.4	267.5	244/252	200/300	140/340
incl. APR		91.3	109/120	100/165	70/170
Petroleum product exports	62.6	142.8	126/155	90/130	90/120
incl. APR	0.4	18.5	35/40	40/45	40/45

**Forecast estimates are based on the following materials:*

2020–2035 – according to the Energy Strategy of Russia for the period until 2035;
2040–2050 – according to expert estimates: the numerator means the scenario of current conditions and the denominator means the scenario of high opportunities; 2020–2050, indicators for the East of Russia and exports to the Asia-Pacific region – according to expert estimates.
The resources of the high opportunity scenario include both coastal hydrocarbon resources of Eastern Siberia and the Far East, and the northern territories of Western Siberia (the Yamal and Gydan peninsulas), as well as the shelf of the adjacent waters of the Arctic Ocean.

Table 2. Main indicators of oil industry development in Russia, mln t*

Russia currently has no constraining factors in terms of the resource base. The strategic objective of the gas industry development for today and in the long term is a comprehensive development of existing gas production centers and creation of new ones. Prospective levels of production will be determined by the needs of the main energy and gas markets in Europe and Asia Pacific countries, as well as by domestic demand for gas fuel.

However, a significant increase in natural gas production across Russia as a whole is not to be expected beyond 2035, not even under the high opportunity scenario. At the same time, gas production at the east of the country under this scenario may increase by 2050 by more than one and a half times compared to the level of 2035 recorded in the Energy Strategy.

With regard to liquefied natural gas, in accordance with the logic of the development of gas markets during the considered period, its production is expected to grow at a rate that significantly exceeds the growth in gas production.

The export of natural gas, both pipeline gas and LNG, will significantly increase in the high resource/high opportunity scenario, especially to the Asia-Pacific countries.

Sakhalin-1 project, Berkut platform

Source: recyclemag.ru

Regasification terminal TEPCO LNG, Japan *Source: power-eng.com*

Moreover, a rapid growth of export gas supplies to the east is also expected under the scenario of current policies and conditions (Table 3).

In general, a large-scale economic, scientific and technological cooperation of Russia with the countries of East Asia and the Asia-Pacific region may significantly alter the entire economic map of the East of Russia in the future (Fig. 6).

The main areas of such cooperation could be:

- development of oil and gas production and processing in Russia, in particular, through implementation of large international projects;
- development of export-oriented transport infrastructure;
- joint creation of technologies that ensure an efficient development of various oil and gas types, transfer of unconventional hydrocarbons from the category of resources to the category of reserves, as well as a deep hydrocarbon refining.

Naturally, first of all we count on such cooperation – both bilateral and multilateral – with our neighbors at the East of Russia.

The high uncertainty of the upcoming development makes the estimates at the level of 2040–2050, provided in the article, rather approximate. Depending on combinations of various conditions and the considered scenarios, the production and export of oil and gas, including those to the countries of East Asia, may widely vary. But these assessments show the main thing: the capabilities of Russia. Time will show how these capabilities will be realized.

Table 3. Main indicators of gas industry development in Russia, bln m³

	Actual		Forecast		
	2000	2019	2035	2040	2050
Gas production	583.9	737	860/1000	900/1040	950/1100
incl.—East of Russia	6.1	44.6	75/100	85/140	95/155
LNG production, mln t	-	29	80/140	85/150	100/170
Export of pipeline gas	193.9	227.9	255/301	300/360	355/390
incl. APR	-	0.2	80/91	110/130	130/160
Export of LNG	-	41.4	108/189	115/202	135/230
incl. APR	-	17.7	-	-	-

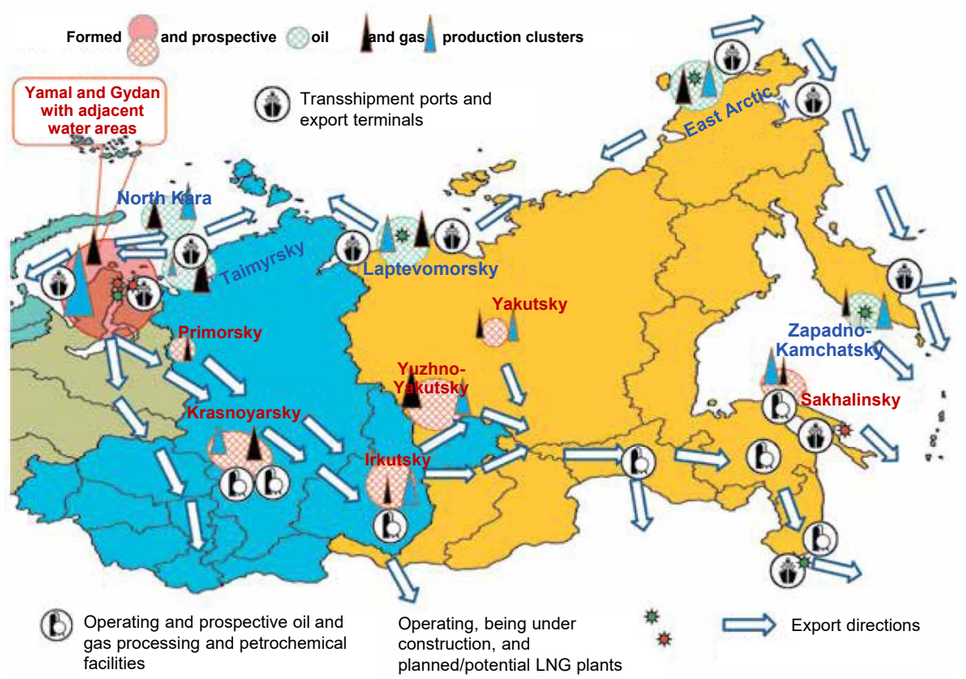


Figure: 6. 2050: what the economic map of the East of Russia could look like

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Инфраструктурные накопители в энергетике

Infrastructure storage in the energy sector

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North-West CHPP

Source: amp.energybase.ru

Аннотация. В статье проанализированы необходимость и место применения систем накопления энергии. Подробно рассмотрены основные виды систем накопления энергии и изучены возможности локализации их производства на территории России. Кроме того, поставлена задача о необходимости развития центра испытаний и сертификации накопителей энергии.
Ключевые слова: системы накопления энергии, энергетическая система, хранение энергии, виды накопителей.

Abstract. The article analyzes the need for and place of application of energy storage systems. The main types of energy storage systems are considered in detail and the possibilities of localizing their production on the territory of Russia are studied. In addition, the task was set on the need to develop a center for testing and certification of energy storage devices.
Key words: energy storage systems, energy system, energy storage, types of storage.

> **Development of energy storage systems will result in greater bidirectional flows, while now they are distributed in a unidirectional manner**

HPP-1 named after Smidovich
Source: MOSENERGOPROJECT

Prospects of the Electric Energy Storage Technology

Currently, the development of electric power sector is influenced by several technological trends. First, the process of infrastructure digitalization goes on, i.e. deployment of smart metering systems or energy flows, distributed automation systems, systems for monitoring of equipment operational state and power supply quality, building-up digital models to achieve optimum control of power system functioning and development.

Second, deep decentralization o energy production takes place, i.e. large-scale involvement of distributed energy resources into the power system. (including renewable energy sources), optimum combination of main, distributed and stand-alone generation, the use of potential of multifunctional generating facilities (for example, co-generating and tri-generating plants).

Third, migration to smart management and engineering takes place, i.e. implementation of smart cyber-physical devices, the use of methods and tools of artificial intelligence to automatically manage production processes and commercial relations, as well as to automatically engineer, adjust, recover management systems.

Energy storage units improve reliability of the power system.

Source: AtomicSummer / Depositphotos.com

The newly forming technological model of electric power industry will be characterized by increased complexity of power systems, considerable share of distributed generation, new type of players - active consumers who combine functions of energy consumption and production, increased requirements to accessibility, quality, and reliability of power supply.

A technological method to limit this complexity is massive application of energy storage systems that breaks the basic paradigm of power system building-up: simultaneous and synchronous energy production and consumption.

The new technological model provides the Russian power industry with a unique opportunity to improve its effectiveness dramatically andto support competitiveness of power-intensive industry

As a result, electric energy becomes a normal article of merchandise. In addition, the development of energy storage systems will lead to increase in bidirectional electric energy flows, while now the flows are mainly distributed in a unidirectional manner over the following hierarchy path: “backbone networks - distribution networks - consumer”. In general, electric energy storage units are one of key elements in the new paradigm of “smart” power industry.

Potential areas of energy storage application include: smoothing the irregularity of power generation and consumption (including RES-generation), voltage and frequency control, provision of standby capacity, emergency power supply to prevent development of emergency situations in the system (with power system islanding) and to recover the power system after such emergencies. A particular importance of energy storage units lies in the fact that they can perform the above listed functions simultaneously.

The new technological model provides the Russian power industry with a unique opportunity to improve its effectiveness dramatically and to support competitiveness of power-intensive industry, which will continue to make a major contribution to the economy within the next 15 years even in the case of successful shifts towards refusal of raw-materials model of development. It will yield significant improvement of capacity factor of the existing generation in power systems, reduce the need for construction of new capacities, improve operating efficiency of energy producers and infrastructure organizations. In general, this will allow to hold electric energy price increases to a minimum within the new investment cycle in the electric power sector, which will be started in Russia in the first half of the 20-ies.

However, modern regulatory documents in the field of electric power sector do not consider to a significant extent the peculiarities of energy storage system

Operation with minimum power margin, increase in number of high-performancebut low-cycling power units, arrearage of grid construction complicatedthe problems of stability

Traction substation

Source: electroinfo.net

functioning and the opportunities created by them. It is built up mainly due to the need to ensure continuity and synchronism of electric energy production and consumption, passive role of the end user, «procurement» model of electric energy sales. Moreover, the applicable regulations provide strict role separation in the industry between production, transmission, sales, consumption of electric energy.

Existing systems for electric energy storage

The electric power sector in Russia has changed quantitatively and qualitatively over the last years. Operating modes of power systems became more severe. Operation with minimum power margin, increase in number of high-performance but low-cycling power units, arrearage of grid construction and increase in number of weak interconnections complicated significantly the problems of static and dynamic stability, survivability of power systems, reliability and quality of electric power supply despite the successes made in the field of automated systems of dispatching management, automatic control systems and automatic protection.

Currently, the Unified Energy System of Russia is still running with heavy operation modes, with quite complicated fuel problem. Management of power systems becomes more difficult due to big share of low-cycling large power units o thermal power plants. Strict requirements imposed on the electric power industry dictate its radical restructuring - from the principles of its structuring and management to its hardware. The need to reduce non-productive fuel consumption imposes strong requirements to cost-effectiveness of operation modes.

Currently, formation of large electric power systems is characterized by increased share of units working on the basis of daily load schedules. This is promoted to some extent by the existing practice of generating capacity upgrade when cycling units with a capacity of

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50–200 MW are consistently dismantled on power plants. As a result, under loads equal to 50% of rated load fuel consumption grows by 16–26 g/kW h. Statistical analysis of performance of united power systems shows that along with the improvement of power supply reliability and reduced expenses for redundancy, no daily load schedule compression is observed. Also, objective consideration of trends in development of fuel and energy complex indicates that in the nearest 30-40 years thermal power plants will continue to be major electric energy producers, fuel cost will continue to grow, and intersystem connections will continue to be classified as "weak" for many years ahead. Consequently the introducing into the electric power system the energy storage units that allow separating in time the processes of energy production and consumption (provided that these units have high efficiency) is of great importance for the national economy. Energy storage will allow increase in capacity and operation time of basic electric power plants thus improving performance of large power units thanks to significantly reduced operating expenses, compress load schedules and compensate for peak load variations. In addition, energy storage units can substantially improve stability of large power plant while keeping the balance of power in the electric power system. Introducing energy storage into the power system as an independent structural unit is an objective necessity, and for the nearest years there are no an alternative solutions for powerful TPPs and NPPs with energy storage units. It can be expected, that more than 10% of all generated energy, before delivery to the consumer, will be passed through energy storage systems. At the current development phase of the Unified Energy System dynamic properties of power pools became so complex and system automation achieved such a high level of complexity that problems can arise in relation to stability, control of frequency and active power [1,2]. It is the complexity of dynamic properties of power pools and absence of holistic comprehension of the controllability problem have resulted in the situation when some scientific and research organizations and experts consider as unavoidable necessity that interconnection of subsystems can only be made via DC links to sectioning the power pools based on the channels of disturbance propagation that provide either complete separation of the system for disturbances, or intensive attenuation of disturbances as they are translating.

Transient processes in complex power pools are a mutually conditioned set of motions of local (in subsystems) and intersystem (exchange) character. The interactions result in the process of disturbance propagation and distribution, which is manifested in the situation that the motion initiated by the disturbance in one subsystem is consistently and gradually, through intermediate subsystems, translated over the power pool causing transient processes in regions far away from the point of disturbance. Disturbances

Modern power system is based on disturbance control
Source: cboswell / Depositphotos.com

acting on the UES can be classified by the frequency spectrum as high-frequency (with a period of less than 1 minute), low-frequency (with an oscillation period of up to 5 minutes) and infralow-frequency (with an oscillation period greater than 5 minutes). As a rule, high-frequency components of power fluctuations (so called "noises"of the system) have low amplitude, but can threat the stability of connection, especially weak one. Low-frequency power fluctuations have large amplitude and related to actual power exchanges.

Thus, the need arises to resolve the problem of control of disturbance propagation processes, to form a set of protection measures and system automation. Solution of the problem of disturbance localization by means of regulation and protection controls is dependent to a significant extent on the reliability indicators of lengthy power pools performance. For this purpose, it is reasonable to separate concepts of circuit reliability and mode reliability in the definition of electric power system functioning reliability. Circuit reliability is mainly connected with structure of the system. Mode reliability is a complex function of structure, dynamic and static parameters, range of modes being implemented, static parameters of disturbing impacts. Ensuring circuit reliability, i.e. building up a system with adequate level of redundancy for element failures, does not automatically result in a system with high level of mode reliability in the entire space of states. Mode reliability is determined by technological restrictions (including those related to stability), processes of disturbances propagation and development of emergency states.

Numerous system tests conducted in united power systems by Central Dispatch Administration of UES, VNIIE, NIIPT, Energosetproject, SibNIIE, VEI, NII Electromash allowed to detect a key common feature of transient phenomena in united power systems. The lower are spectrum frequencies of the motions under consideration, the more systematic is the nature of these motions. In other words, the low-frequency motions are defined by properties of the system in general rather than regional parameters of the area of disturbance [3].

Power transmission line breaks in winter
Source: images.helionews.ru

The holistic approach to analysis of dynamic properties of power pools allows estimating efficiency of traditional control means (automatic excitation control, automatic speed control, automatic load frequency control), as well as determining the need to create conceptually new electric hardware packages — energy storages and flexible (controllable) alternative current transmission systems (FACTS)

The development of static compensators of reactive power opened new opportunities (STC and STATCOM), that, besides

Solution of the problem of disturbance localization by means of regulation and protection controls is dependent to a significant extent on the reliability indicators of lengthy powerpools performance

the ensuring required balance of reactive power and keeping required voltage level, with appropriate regulation laws can effectively damp both local and system fluctuations. For the purpose of system tests analysis, all disturbances are divided into three groups: disturbances related to deviation of load schedule from prognosed schedule; short-term, random variations not exceeding 2–5% of total power;
large disturbances.

Quantitative characteristics of these disturbances are the input to determine allowed values of crossflows, as well as to

Energy storage technologies require serious investments
Source: cienpies / Depositphotos.com

impose requirements to system automation and to regulating plants including regulation range and required speed of change in power of plants.

When there is a need to engage large units to regulate variable part of the load schedule, fuel consumption is increased significantly.

Intensive implementation of energy storage systems (ESS) in power systems will allow overcoming the above-mentioned problem to some extent. Proposed energy storages can be ranked by power from several kW to thousands MW. Discharge time can also vary from hundredths of second to several days. Energy storage systems can be controlled locally or remotely, from control centers. They can be designed to quickly react to control commands. Energy storage units can consume and output active power, and being connected with components of power electronics they can process reactive power as well. Depending on needs of the power system, they can provide frequency and voltage regulation, time shift between consumption and generation, power regulation at the output of RES+ESS system, expand capabilities of the dispatch control. They can be designed for the needs of distributing and/or transmitting system, for single-purpose or multipurpose use, or for the purpose of control at the consumer side. Each energy storage technology is characterized by capital expenses required for its implementation, as well as operating expenses. Currently, some energy storage technologies are not cost-effective, and in future we need first of all to reduce capital expenses. Cost of various energy storage systems and benefits from their application are largely depend on the discharge power (MW) and energy capacity (MW h). Independent system operators (ISO), power production companies, vendors and providers of energy storage technologies should be active in forming the rules of the developing energy storage market, as well as the operational requirements in order to achieve maximum cost effectiveness of the use of energy storage units. Ideally markets and rates should be designed in such a way as to allow benefiting from the advantages of the energy storage systems without additional unnecessary expenses.

Managing the modes of power systems

The load of any node point of electric energy system is unambiguously determined by voltage and frequency in this point.

To ensure required values of frequency and voltage, correct planning of balances of active and reactive power at the point is required. The balance of active and reactive power consists of input part that includes available capacities of the power plant and energy storage units, and output part, that includes power of loads and capacities of energy storage units because they allow independent changing of active and reactive power. Solutions for interconnections of energy storage units with power system based on state-of-the-art power electronic components allow practically immediate changing of active and reactive power. Thus, distributed energy storage system is a basis to build up a coordinated system to localize disturbances in a node for active and reactive power of any spectrum. It is economically reasonable to limit the spectrum of active power changes of energy storages by 25-minute period of fluctuations. Fluctuations beyond 25 minutes are economically reasonable to be imposed on the generating sources, for example, on gas turbine power plants that will be cost-effectively and reliably working with such a spectrum of disturbances. Economic parameters of multifunctional fast-acting system to control the modes of power systems can be considerably improved by getting the energy consumers involved in the control.

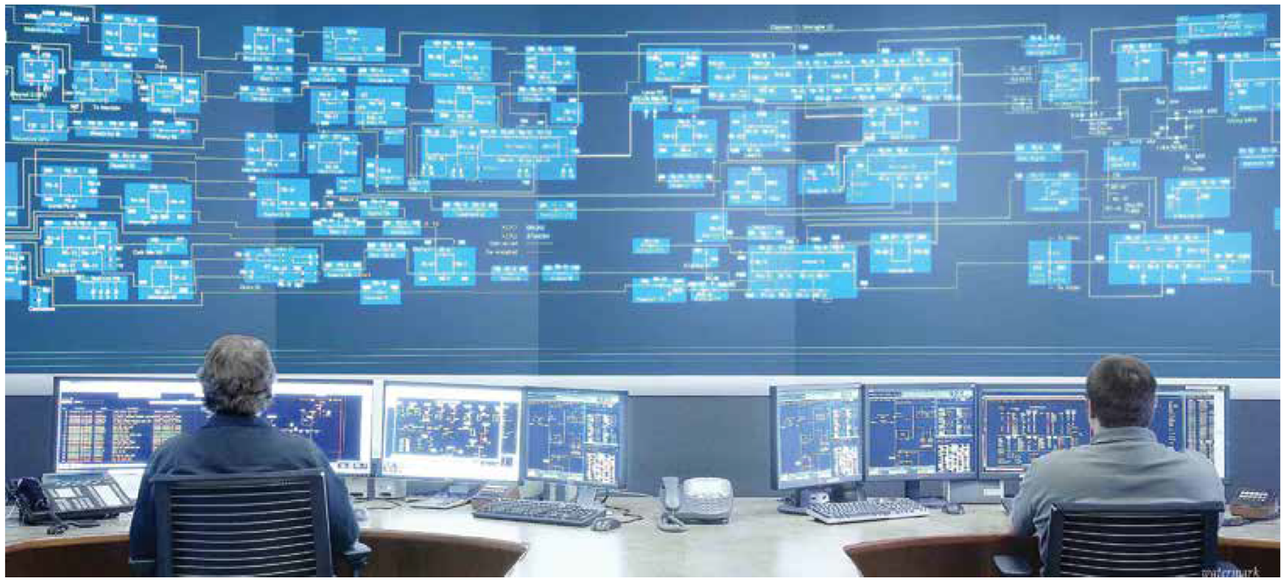
All disturbances are divided into three groups: disturbances related to deviation of load schedule from prognosed schedule; short-term, random variations not exceeding 2–5% of total power; large disturbances

Thus, grid energy storages with appropriate control system will allow ensuring quality of electric power in terms of its frequency, RMS voltage, waveform, symmetry and voltage pulses. Electric power quality improvement has significant effect for the economy because consumers work in their rated modes (increased service life of electrical equipment), normal functioning of electric receivers is improved, there are no voltage dips and higher harmonic components of current and voltage.

Thus, distributed arrangements of energy storage are a top-priority task for implementation of energy storage systems into the unified energy system.

Rosseti dispatching center

Source: electrocentr.info



Required power of energy storage systems is about 30 GW. Capacity of energy storage systems is about 15 GW h. Preliminary analysis shows that payback period of system like this is 5-6 years due to localization of disturbances of active and reactive power of loads, stable quality of electric power, fuel saving at generating power plants, increase in time to failure of generating equipment and equipment of energy consumers.

Main types of energy storages

There are many different classifications of electric energy storage systems. To all practical purposes the most suitable seems to be a classification into electrochemical and physical energy storage systems. Systems of the first type convert electric energy to chemical energy of substances, and systems of the second type convert it to mechanical energy.

Electrochemical energy storage systems include accumulator batteries, energy storage units based on molecular capacitors, etc. All types of electrochemical energy storage systems are connected to the grid via converters (invertors). Physical energy storage systems include two types of
systems:

- kinetic energy storage systems (flywheels);
- gravity energy storage systems.

Pumped-storage hydroelectric power plants (PSHPP) are one of the earliest technologies to store large volumes of energy. It is worth to note that, main factors determining the possibility of PSHPP construction, its maximum capacity and capital expenses are features of the terrain, as well as the need to flood significant areas.

Hydraulic gravity energy storage unit (HGES) is an evolution step of hydraulic energy storage units widely used now in pumped-storage hydroelectric power plant (PSHPP) arrangements. The idea is to use water as a hydraulic jack for heavy weight lifting.

Tesla manufactured one of the biggest energy storage system
Source: shazoo.ru

Gravity energy storage system includes the following components:

- working weight (disc or piston);
- casing of the chamber were he piston moves;
- jack using water as hydraulic liquid;
- energy conversion system (hydraulic pumps, hydraulic turbines).

The most suitable seems to be a classification into electrochemical and physical energy storage systems. Systems of the first type convert electric energy to chemical energy, and systems of the second type convert it to mechanical energy

There are numerous issues related to methods of construction, compression, structural integrity, safety, energy conversion, piston control. Preliminary analysis shows that obtaining practical, real solutions with the modern level of technique development is very difficult because it requires very high pressures, while energy density of the lifted weight is very low.

Gravity energy storage by Energozapas uses vertical lifting/lowering of solid blocks of packed soil instead of water.

To store potential energy, the drive lift soil in engine mode. In generating mode, the soil is lowered by gravity, while the drive outputs electric power to the grid in generator mode. There are no requirements to relief and water sources. The works is in its initial stage. Creating an effective storage system is a difficult challenge.

Superconducting magnetic energy storage (SMES) has already found some practical use. Especially in the context of mobile energy storage units with relatively small (up to 10^6 J) capacity. SMES systems can find a wide use after development and creation of high-temperature superconductors on their basis. Their practical use is expected for 2025.

Federal unitary enterprise, RF state scientific center Troitskii Institute of Innovative and Thermonuclear Research has suggested and tested a new type of superconducting winding known as “compact torus” [9,10].

The Ministry of Energy confirmed readiness of Rosseti Center for the heating season
Source: Rosseti Center

Traditional winding supported by external bandage is inevitably deformed under the effect of ponderomotive force. Such a deformation is accompanied by thermal disturbances causing the winding to change to normal state under currents that are considerably lower than critical currents (degradation in the laminar structure where each turn is glued to a rigid bandaging plate). The deformation is reduced depending on rigidity of the plate and is elastic. Disturbances do not arise. There is no degradation in the laminar winding. Structural plates are used as cold conductors. The energy is stored inside the torus with a constant density.

A prospective fuel of the future is hydrogen. Hydrogen, as well as Aluminium, can be delivered to the place of consumption and converted to useful electric and thermal energy

There is no field out of the winding. Homogeneity of the energy density is provided by the distribution of the winding within the torus volume.

In traditional windings, the stressed state of wire and the bearing structure grows along with the increase in winding size. Consequently, the amplitude of mechanical-thermal disturbances becomes higher. The amplitude is unpredictable.

Therefore simulation of windings does not yield reliable results.

To avoid overheating of wire under the effect of disturbances, good heat sinking is required.

There are no disturbances in laminar windings, so they do not require large heat sinking capacity and indirect cooling can be applied.

In laminar windings the conditions of wire operation are only dependent on the field used and are independent on winding size. This makes it possible to apply to any size of windings the results obtained through modelling. Advantages of laminar windings are checked multiple times with various superconducting magnets.

Compact torus is the most advantageous form of energy storages with closed flow.

Compact torus is unrivaled thanks to homogeneous density of the energy stored in the inner volume.

Unit cost of toroidal winding SMES with an energy capacity of 10 GW·h is $300/kWh, which is more cost-effective than PSHPP.

Fig. 1. NPP with 10-GWh SMES
Source: E.Yu. Klimenko

Alumo-Hydrogen Energy

A prospective fuel of the future is hydrogen. Hydrogen, as well as Aluminium, can be delivered to the place of consumption and converted to useful electric and thermal energy.

Hydrogen can be produced through direct electrolysis of water by electric current. So, the problem of energy storage can be resolved in this way. This energy storage arrangement can be used to regulate performance of power plants of traditional type and those based on RES due to higher flexibility of water electrolyser as compared to Aluminium electrolyser that requires buffer storage because of its high sensitivity to changes in operation modes. However, there are serious restrictions for transportation of hydrogen in cylinders because of fire and explosion hazard. There is an option of cryogenic hydrogen storage, but it is not completely safe as well and connected with expenses for gas liquefaction and further losses during transportation because of evaporation.

Quite common is the method of storing hydrogen in hydrides of intermetallic and metal-hydride compounds, however its significant drawback is low hydrogen capacity of these compounds (1-3%), high cost and low number of hydrogenation/dehydrogenation cycles.

Aluminium is very close to hydrogen (which is considered as a prospective fuel today) in terms of energy potential. At the same time Aluminium is free from drawbacks inherent to Hydrogen (extremely low density of the gas and explosiveness). Storage and transportation of hydrogen arises a lot of issues related to safety. Also, there is no so far simple and inexpensive method to produce hydrogen in massive amounts from renewable resources.

Aluminium is the first widespread metal in nature and the third, after oxygen and silicon, common chemical element. In normal conditions Aluminium is chemically inert. And products of its oxidation can be reused to recover metal, so there is no need for considerable extension of aluminum-containing minerals mining.

Joint Institute for High Temperatures of the Russian Academy of Sciences (JIHT RAS, Moscow) developed a series of air-aluminium fuel cells.

Thus, Aluminium can participate in the distribution of environment-friendly (as compared to fossil fuels) energy from renewable sources and NPPs and in regulating their generating capacity.

Aluminium is very close to Hydrigen in terms of its energy potential. At the same time Aluminium is free from drawbacks inherent to Hydrogen : extremely low density of the gas and explosiveness

Plant to produce “green” hydrogen *Source: laptrinhx.com*

In this case the produced oxides are returned to the Aluminium plant for recovery.

The main goal of energy storage units is nomere provision of power supply during interruptions of external powering, but formation of a new power sector infrastructure, which is free from restrictions.

Traditional option of the use of diesel fuel, besides its environmental impact, has a “power industry” disadvantage, i.e. the density of stored energy is less than that in the case of Aluminium. In addition, Aluminium, as opposed to Hydrogen and diesel fuel, is more convenient for transportation (not flammable, not fluidal, does not volatilize).

The alumo-hydrogen power industry technologies being developed can be applied in both the “hydrogen economy” of future as an effective and safe method of hydrogen and stored energy transportation, and as a supplement to existing power systems in regions without centralised gas network or local types of fuel. The use of Aluminium to generate hydrogen and energy allows reducing the environmental burden. The effectiveness of plants like this is determined to a significant extent by the cost of raw materials and by-products of the reaction, as well as by presence or absence of competitive solutions for centralized power supply to consumers.

Creating a center to test and certify energy storage units

Testing of electric energy storage units is the only method to receive information on units’ rated parameters and behavior in various possible non-standardized conditions of operation, operating cycles, that can not be performed on the basis of in-house resources of equipment manufacturers, especially in case of high capacities. These operating modes include short circuits, sudden breaks, disconnections of inductive consumers, non-linear sources and receivers of electric energy, four-quadrant (recuperative),

According to experts, in the nearest 10 years the market of energy storage systems will grow at average annual rates exceeding 30% with a trend to lower unit cost of the stored energy

leading/lagging loads, unbalanced loads/generators, generators with variable frequency and frequency change rate. Energy storage systems are electrical engineering assemblies of interconnected elements with significantly divergent control time constants. For example, characteristic times for accumulating element are minutes and hours, while for converter these time constants are up to several milliseconds, and for measurement and monitoring tools the characteristic time constants are equal to several periods of grid voltage or up to several seconds. All these elements have identical parameters for elements of the same type or parameters varying as a function of time that are defined by duration of operation, temperature behavior. Under the effect of extreme factors, such as short circuits, overloads, the degree of equipment operation reliability and adequacy of overload capacity margin can be detected. Also, it is possible to use special loads in the form of non-linear consumers or consumers with leading current. Quality of control system performance, local control algorithms of power equipment and general behavior of the entire system can be verified. For example, the study can cover transient processes, presence of static error for pre-defined command signals, both variable and constant, presence of dynamic errors and the degree of reaction to them, overshooting, excessive variations, presence of non-linear effects, exceedance of allowable performance parameters of energy storage units. System will be subject to: research, type, acceptance, check, periodic tests:

The center is created to improve functioning reliability and safety parameters of electric power sector facilities by means of comprehensive quality improvement of the applied energy storage systems and implementation of new technologies at companies of the Russian fuel and power industry.

Hydrogen energy storage unit

Source: energydelta.org

- provision IT-system manufacturers with services to conduct comprehensive tests and quality control of products for conformity with requirements of applicable regulatory documents (qualification, certification);
- testing energy storage systems for conformity with electromagnetic compatibility requirements;
- conducting special tests to determine limits of allowable values of system parameters;
- conducting tests for fault tolerance in case of significant deviations of parameters;
- conducting tests with inadmissible values of commands, errors in the information support and change in topology of the power system and control system due to internal breaks and short-circuits, including errors in the information support in the form of deadlocks and other problems with computer.

Potential users of center's services are:

- manufacturers and suppliers of products applied at companies of the electric power sector, system integrators, designer organizations;
- operating organizations of electric power sector players;
- developers and integrators of solutions using energy storage systems;
- participants of coordination of appropriate scientific-research and development activities in the field of center's activity.

Localizing manufacture of energy storage units in Russia

Some manufacturers offer complete solutions of power plants with energy storage units in a wide range of capacity and power based on Lithium-ion batteries.

The use of backbone-modular principle to create energy storage units and electric energy converters with large capacity and high voltage based on Lithium-ion batteries currently is most advanced and widespread solution for fixed and transport applications.

The first in China high-capacity 100-MW energy storage system was manufactured in 2018 by Zhongtian Yipin Technology, a company of ZTT Group.

Solid-state accumulating power plant in Novosibirsk
Source: energozapas.ru

The system installed at Danjiang Dagang substation in the city of Zhènjiāng is composed of two types of block-containers: 1 MW / 2 MW h (system block-containers / battery block-containers).

The energy storage system by ZTT (battery modules) uses Lithium-ion Iron Phosphate cells (accumulators) of ZTT27173200 type with a voltage of 3.2 V and a capacity of 86 A/h. Energy capacity of one energy storage group is up to 2.7 MW h.

In recent years ZTT Group was permanently increasing its investments in the field of energy storage, and thanks to continuous research activities, developments and innovations the Group has developed a series of new products to meet the market demand.

Price indicator of cost of energy storage systems in container with a power of 1 MW/capacity of 1 MW h is 100 mln rub taking into account deliveries, erection and commissioning activities.

Currently ZTT Rus is looking for partner to localize manufacture of container-type and block-modular type energy storage units in Russia.

ZTT Rus plans to supply commercially produced PCS-converters (subsystem of energy conversion) and battery racks with battery modules (subsystem of energy storage), including DC distribution cabinets, from China, while other subsystems will be manufactured in Russia.

Installed power of the energy storage system built in San Diego is 30 MW, and its capacity is 120 MW h. The system is composed of 24 containers accommodating 400 thousand Lithium-ion batteries (Samsung SDI) assembled into 20 thousand modules.

Fig. 2. 100-MW energy storage system by Zhongtian Yipin Technology

Conclusion

Electric power sector is a typical example of holistic system having all its parts (generation, grid, loads) structurally and functionally interconnected to form an integrated system.

The main goal of energy storage units is no mere provision of power supply during interruptions of external powering, but formation of a new power sector infrastructure, which is free from restrictions of continuity of one type of electric processes, and in fact - considerable extension of type and form of power pools allowing integration of stand-alone, distributed and centralized systems, including new centers of generation and consumption, into a common power “system of systems”.

According to experts, in the nearest 10 years the market of energy storage systems will grow at average annual rates exceeding 30 % with a trend to lower unit cost of the stored energy.

Fig. 3. 30-MW energy storage system in San Diego with a capacity of 120 MWh

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Создание систем гарантированного энергообеспечения с использованием комбинированных источников энергии

Creation of guaranteed energy supply systems using combined energy sources

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Rostov NPP *Source: Rosatom*

Аннотация. Использование возобновляемых источников энергии связано с необходимостью решения проблем гарантированных поставок. В существующей практике эти вопросы решаются либо за счёт подпитки систем с ВИЭ от существующих энергосистем, либо при создании дублирующих автономных источников на ископаемом топливе, или за счёт применения систем аккумулирования с накопителями электроэнергии большой ёмкости. В работе рассматриваются перспективы комбинированного использования ВИЭ с созданием вспомогательных источников энергии на биомассе.
Ключевые слова: возобновляемые источники энергии, биоэнергетические ресурсы, распределённая энергетика, конверсия биомассы в энергию.

Abstract. Renewable energy sources using is associated with the need to solve problems of guaranteed energy supply to consumers. In current practice, these issues are resolved either by feeding systems with renewable energy sources from existing energy systems, or by creating duplicate autonomous sources on fossil fuels, or by using storage systems with high-capacity electricity storage devices. In this article the prospects for the renewable energy sources main types combined using with the creation of additional energy sources based on biomass are considered.
Keywords: renewable energy sources, bioenergy resources, distributed energy, biomass-to-energy conversion.

> **NPP construction is 1.5–2 times more expensive than steam turbine TPP and 2–3 times more expensive than modern TPP with combined cycle technologies**

Introduction

In Russia the main power supply to consumers is provided by the Unified Energy System (UES) of Russia. Fig. 1 illustrates the structure of generating capacities. The biggest volume of power supply to consumers (67%) is provided by traditional thermal energy sector, which at the same time is the biggest man-caused source of harmful emissions to atmosphere, soil, hydrosphere. efficiency of major portion of existing large steam turbine thermal power plants is 38–40%. New TPPs with combined cycle technologies have efficiency of 55–60%. That is, 40–60 % of energy of the fuel fired at a TPP is wasted into the environment in the form of heat in any case. This results in significant negative consequences for the environment.

Construction of large hydraulic power plants is associated with negative environmental impact as well. Water storage basins required to control HPP performance occupy significant areas withdrawn from agricultural use. Often these water storage basins are arranged by flooding forests and even settlements. Dams across rivers result in reduction of hydrobionts in river water areas.

NPPs are power plants causing the greatest environmental problems and public protests in Russia and all over the world. Especially after major radiation accidents at Three Mile Island NPP in the USA in 1976, at Chernobyl NPP in the USSR in 1986, at Fukushima NPP in Japan in 2011.

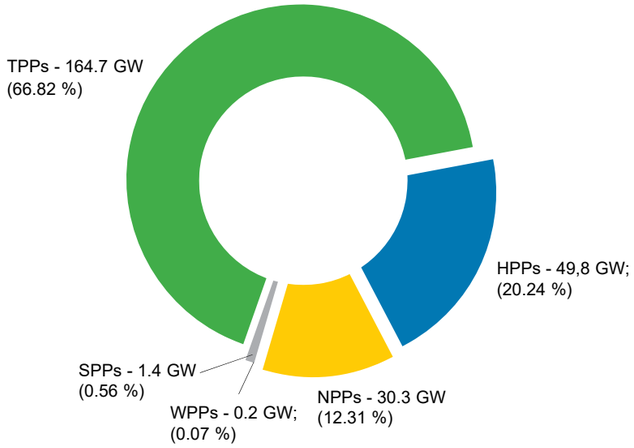


Fig. 1. Structure of generating capacities in the Russian Federation as of 01.01.2020.

NPP construction is 1.5–2 times more expensive than steam turbine TPP and 2–3 times more expensive than modern TPP with combined cycle technologies [1].

The share of nuclear power generation in the global electric energy production has reduced from 17.6% in 1996 down to 10.7% in 2015 [2]. Peak of nuclear power generation was observed in 2006 (2660 TW·h). According to Bloomberg New Energy Finance, the total NPP share in the world will drop down to 4% by 2040.

Neither construction of new plants, nor reconstruction of existing large traditional TPPs, HPPs and NPPs are considered as rational in the practice of modern power sector development in the world.

At the same time, a significant growth is observed in power generating capacities using RES.

According to many experts, now construction of NPPs and TPPs already becomeseconomically unreasonable inEU countries, in Chine and India, and in southern regions of Russia.

Before 2010–2012 high prices for photovoltaic modules undercut the case for wide use of solar generation. Currently, with the cost of photovoltaic modules about $300–600 per kW they become the cheapest equipment for electric power generation. According to many experts, now construction of NPPs and TPPs already becomes economically unreasonable in EU countries, in Chine and India, and in southern regions of Russia.

Carbon-neutral power industry - the main direction of development

The main direction of development of the world power system now is migration to carbon-free power industry. According to forecasts published in the global report of REN21 Center on the state of renewable generation [3], the use of brown coal will be stopped by 2035, hard coal – by 2045, oil, gas, nuclear fuel – by 2050. The trends under consideration are governed by the intention of governments of all countries to ensure competitiveness of national economies and accelerate their economic growth through access to cheaper energy, improve security of energy supply through the use of local low-carbon sources and to reduce dependence on imported hydrocarbons.

Solar power plant -stand-alone hybrid power plant in Zabaykalsky Krai *Source: Hevel Group*

The stable economic background for widespread use of RES allows constructing new power sector in Russia as well, with lower specific investments in 1 kW of installed capacity and with cheaper electric power generation. To make this statement not seeming unsubstantiated, we provide results of comparison calculations of key parameters for traditional and non-traditional electric power plants in the existing Russian conditions (Table 1).

The stable economic background for widespread use of RES allows constructing new power sector in Russia with lower specific investments in 1 kW of installed capacity

The comparison made for NPP, coal-fired TPP, natural gas-fired TPP, HPP, as well as wing and solar utility-scale power plants without energy storage.

The basis for comparison is taken as a reference NPP with an installed capacity of 1000 MW operated in the basic mode with mean unit capacity factor (UCF) equal to 80%, which is equivalent to 7000 hours of installed capacity usage time per annum. All other generating capacities have average UCF values less than that of NPP, as can be seen in Table 1.

Calculated output of electric power from the reference NPP is 6650 TW h/year (or mln kW h/year). For adequate comparison the same calculated electric power output is assumed for all other types of electric power plants to be compared. To meet this condition under a significant difference in UCF for various generation technologies, it was necessary to take the following values of installed electric generating capacities:

— for coal-fired TPPs – 1268.4 MW;
— for natural gas-fired TPPs – 1536.7 MW;
— for HPPs – 1737.2 MW;
— for WPPs – 2283.1 MW;
— for SPPs – 3474.3 MW.

Wherein calculated investment volumes (CAPEX) to construct the power plants in question were as follows:

— for NPPs – 371 bln rub;
— for coal-fired TPPs – 266.4 bln rub;
— for natural gas-fired TPPs – 247.4 bln rub;
— for HPPs – 364,8 bln rub;
— for WPPs – 207.8 bln rub;
— for SPPs – 206.7 bln rub.

Table 1. Comparison of facility parameters for traditional and renewable power industry

Parameter values	Unit of measurement	Parameter description					
			TPP			RES	
		NPP	coal-fired	gas-fired	HPP	WPP	SPP
Unit capacity factor - UCF	%	80	63	52	46	35	23
Normalized installed capacity – N	MW	1000	1268.4	1536.7	1737.2	2283.1	3474.3
Design service life – T_{sl}	years	30	40	40	40	30	30
Period of engineering and construction – T_{constr}	years	6	3	3	4	2	1.5
Planning horizon: $T_{plan} = T_{sl} + T_{constr}$	years	36	43	43	44	32	31.5
Specific investments in construction – K_{spec}	US$/kVt	5300	3000	2300	3000	1300	850
Total sum of required investments (CAPEX): K_s = N * ksp / 1000	**mln US$**	**5300**	**3805.2**	**3534.4**	**5211.5**	**2968.1**	**2953.2**
The same in rubles based on the current US dollar exchange rate - 1US$ = 70 rub: K=70 * K_s /1000	bln rub	371	266.4	247.4	364.8	207.8	206.7
Operation hours of installed capacity: T= $365_{day/year}$ * $24_{h/day}$ * UCF	h/year	7000	5518.8	4555.2	4029.6	3066	2014.8
Power output: W = N*T/1000	TW·h/year	7000	7000	7000	7000	7000	7000
Auxiliaries and losses of electric energy – 5%: W_{aux} = 0.05 * W	TW·h/year	350	350	350	350	350	350
Electric power output to consumers: Wout = W – W_{aux}	TW·h/year	6650	6650	6650	6650	6650	6650
Depreciation rate – a	%	4	3	3	3	4	4
Depreciation sum: A = a * K	bln rub	14.84	7.99	7.42	10.94	8.31	8.27
Expenses for fuel - EF:							
- NPP: 0.46 rub/kW h * W /1000	bln rub/year	3.22	-	-	-	-	-
– TPP, coal-fired: 0.32 kg/kW·h * 5 rub/kg * W/1000	bln rub/year	-	11.2	-	-	-	-
- TPP, gas-fired: 0.30 std m³/kW·h * 6 rub/std m³ * W/1000	bln rub/year	-	-	12.6	-	-	-
Number of operating and repair personnel - P	people	1000	880	1200	500	300	280
Average salary of the personnel – SP	thous. rub/month	45	45	45	45	45	45
Total payroll: TP = 12 * SP * P /10^8	bln rub/year	0.54	0.48	0.65	0.27	0.16	0.15
Charge on payroll 30%: C=0.3 * TP	bln rub/year	0.16	0.14	0.19	0.08	0.05	0.05
Overhead costs – 40%: OC = 0.4 * TP	bln rub/year	0.22	0.19	0.26	0.11	0.06	0.06
Total payroll costs: TPC = TP+C+OC	bln rub/year	0.95	0.81	1.1	0.46	0.28	0.26
Maintenance of fixed assets and procurement of spare parts – 2%: MFA = 0.02 * K	bln rub/year	7.42	5.33	4.95	7.3	4.16	4.13
Other expenses – 1%: OE = 0.01 * K	bln rub/year	3.71	2.66	2.47	3.65	2.08	2.07
Total operating expenses: TOE = A + EF + TPC + MFA + OE	bln rub/year	30.11	27.99	28.55	22.35	14.82	14.73
Cost of output electric power C = 1000 OE / W_{out}	rub/kW h	4.53	4.21	4.29	3.36	2.23	2.21
Planned equivalent flat rate for power output – T_{el}	rub/kW h	6.5	6.5	6.5	6.5	6.5	6.5
Volume of electric power sales: R = T_{el} * W_{out} /1000	bln rub/year	43.2	43.2	43.2	43.2	43.2	43.2
Gross profit: GP = R - OE	bln rub/year	13.12	15.24	14.68	20.88	28.41	28.5
Property tax – 2.2%: PT = 0.022 * K	bln rub/year	8.16	5.86	5.44	8.03	4.57	4.55
Taxable income : TI = ВП – PT	bln rub/year	4.96	9.38	9.24	12.85	23.84	23.95
Income tax – 20%: T = 0.2 * TI	bln rub/year	0.99	1.88	1.85	2.57	4.77	4.79
Net profit: NP = TI – T	bln rub/year	3.96	7.5	7.39	10.28	19.07	19.16
Discrete payback period: PP = K / (NP+A)	years	19.7	17.2	16.7	17.2	7.6	7.5
Total payback period : TPP = CO + T_{constr}	years	25.7	20.2	19.7	21.2	9.6	9
Net profit for the period of calculation: NV = NP * T_{serv}	bln rub	118.9	300	295.5	411.3	572.1	574.8
Net present value – NPV (approx.)	bln rub	10.8	23.1	22.7	31.6	52	52.3
Profitability index : PI = (K + NPV) / K	-	1.03	1.09	1.09	1.09	1.25	1.25
Return on investment: ROI = 100 / TPP	%	3.89	4.95	5.07	4.72	10.43	11.07

Despite the required WPP and SPP capacities are considerably greater than those for all other types of power plants, construction of WPP and SPP requires the smallest investment in the currently formed market situation. At the same time the cost of electric power output from WPP and SPP is the lowest as well.

It is worth noting that wind and solar generation, as compared with other facilities, have considerably shorter payback periods of investments - PP (discrete payback period) and TPP (total payback period), considerably higher net profit values (NP) and net present values over the period of calculation (NV and NPV), the highest profitability index values (PI) and return on investment (ROI).

Many power generating companies came to a conclusion that economic considerations make unreasonable construction of NPPs, TPPs and large HPPs, and priority should be given to RES-based technologies. World-renowned SIEMENS company today already reduces manufacture of its gas turbines due to significant drop of demand for them.

Today construction of new TPPs and NPPs in Russia, even with improved parameters, will only enlarge arrearage of our energy sector from the world level of development. By using traditional power generating equipment we doom our country to use old energy technologies for at least next 40 years, i.e. for a period equal to service life of this equipment. But in 10-15 years an urgent need will already arise to construct substitution power plants based on RES that have (as can be seen from Table 1) considerably better parameters of cost, profitability, cost-efficiency. And constructed today traditional TPPs and NPPs with investment payback periods of 20–25 years will be non-competitive in power output to consumers. This will lead to the need to put them out of service without complete return of the investments made in their construction. Similar phenomena in EU countries already have resulted in loss of about $20 tln in the power sector [4]. And if as far back as 3–4 years these issues weren't so sensitive, now it is inadmissible to loose time without large-scale implementation of new technologies based on RES.

Our country has significant reserves to improve energy efficiency because specific power consumption of Russian GDP is 1.5–2.5 times higher than in the USA, Japan, some EU countries. By now main directions of upgrading the existing power system in Russia are defined by the Energy Strategy of the Russian Federation [5] and the General Layout Plan of Power Facilities until 2035 [6]. Development of renewable generating is conceptually planned as well. However, activities in this part of the Strategy are defined in an unclear and unspecific manner.

Chirkey HPP
Source: staff-online.ru

That's exactly why construction of large WPPs, SPPs, GeoTPPs, biomass-fired TPPs, small HPPs, etc. develop spontaneously in Russia, on arbitrarily chosen local areas within the country by suggestions of individual domestic and/or foreign investors – without interconnection with general program of power sector development in Russia.

It is evident that geographic (large distances), climatic (long heating season with wide fluctuations in temperature), and resource base (proximity to cheap

hydrocarbon resources) features pre-define specific way for development of electric power and heat supply systems. Taking into account huge territories with low density of population, it is reasonable to develop specifically decentralized power sector [7]. The more so because up to 70% of the RF territory with a population of about 20 million people today is not covered by centralized power supply [8]. In these remote areas consumers use mainly diesel power plants of various capacity for power supply. Cost of energy at these DPPs usually is quite high – about 15–40 rub/kW h, and sometimes even greater than 100 rub/kW h [7].

The use of cost-effective energy storage units increases the costof RES-based systems by 1.5–1.8 times. It can believed that manufacture of cost-effective energy storage unitsrequires at least 5–10 years.

Long distances and absence of centralized power supply often preclude construction of utility-scale power plants based on RES and receiving make-up from the grid to ensure guaranteed electric power supply to consumers as, for example, in EU countries. Also, it is not always possible to construct backup generating plants fired by fossil fuel: either due to difficult delivery of this fuel, or due to high prices. In these cases, the solution would seem to be the use of electric energy storage. But despite the promising results achieved in research and development of high-capacity energy storage of various types [7–8], their widespread implementation is precluded by a number of problems related to unsatisfactory specific weight/dimension parameters, complexity of control systems, insufficient stability of characteristics in time, and still high cost.

Today the use of cost-effective energy storage units increases the cost of RES-based systems by 1.5-1.8 times. It can believed that manufacture of cost-effective energy storage units requires additionally at least 5-10 years.

Solutions for the problem of creating system of guaranteed power supply.

Meanwhile an effective method of guaranteed power supply to consumers can be proposed for the Russian conditions based on RES only, i.e. without energy storage systems. This method consists in solving two main tasks:

1) the use of optimum RES combinations to ensure as uniform as possible power output during day, month, season, and all the year around with minimum need for additional power support to provide guaranteed power supply to consumers.
2) the use of biomass, which is present in one form or another everywhere over the RF territory, with its conversion to electric and heat energy to create an energy source that supplements performance of the main power facility when needed.

The main most high-potential types of RES are considered non-standard (solar and wind energy, energy of currents and waves, tides, etc.), that do not provide for sustainable power supply in time. Creating systems of guaranteed power supply based on these RES is technically possible with additional use of biomass energy, however it requires intelligent, well-justified application of various RES combinations depending on the regions in question.

To minimize requirements to systems of additional energy generation from biomass, main power supply systems can be built up with the following combinations of RES types: SPP–WPP, SPP–HPP, WPP–HPP, SPP–TiPP [1]*, WPP–TiPP, HPP–TiPP, SPP–WPP–HPP, SPP–WPP–TiPP, etc., depending on types of RES available at the area planned for placement of power plants.

[1] TiPP – tidal power plant.

Biomass in Russia is themost widespread type of renewable energy sources.
Our country holds about 48% of world turf reserves and 23–24 % of wood reserves

Biomass in Russia is the most widespread type of renewable energy sources. Our country holds about 48% of world turf reserves and 23-24% of wood reserves And it is the field of biomass energy use, where new effective technical solutions are proposed in Russia that can bring the country at the leading edge [8–13]. Novelty of these solutions is protected by a number of RF patents [14–22]. Patent holder is Joint Institute for High Temperatures of the Russian Academy of Sciences (JIHT RAS).

Potential generation of electric power from biofuel in the RF is more than 150 TW·h/year, heat energy – more than 340 GW·h/year [5].

Electric power plant fueled by biofuel
Source: mrrestavrator.ru

Key features of biomass-fired power generating systems:

— presence of biomass sources everywhere in all RF regions in one form or another that are suitable for conversion to electric and heat energy;
— the possibility of long-term continuous operation in the specified capacity range if there are stocks of raw materials;
— considerably lower specific capital investments in construction of generating plants as compared with traditional options and low cost of the energy generated from biomass.

To illustrate efficiency of the proposed method of guaranteed power supply with combined use of RES, we consider as an example the project developed by Rostovteploelectroproject and JIHT RAS for non-traditional system of power supply for the Shakhty-Don Water Conduit (SDWC) in Ust-Donetsk area of Rostov region. SDWC provides water supply to the city of Shakhty by pumping water from water intake at Don river over two 33-km long pipelines with diameters of 1000 mm and 1200 mm. All pumping stations consume a power of 9500 MW in case of continuous round-the-clock operation. Payment for the electricity consumed from the grid to run the pumping stations is up to 1 bln rub per annum.

Since Ust-Donetsk area of Rostov region is characterized by good solar and wind energy potential, these types of RES can be used to generate cheap electric power. Two options for the Shakhty-Don Water Conduit power supply were developed:

Option 1 – the use of solar energy with solar power plant design installed capacity of 41.4 MW – with 165.5 thousand photovoltaic modules of FSM-250P type, 250 W each manufactured by SunWays, Moscow;

Option 2 – combined use of solar and wind energy with a sum power plant installed capacity of 32.3 MW (solar part is 16.5 MW – with 66 thousand photovoltaic

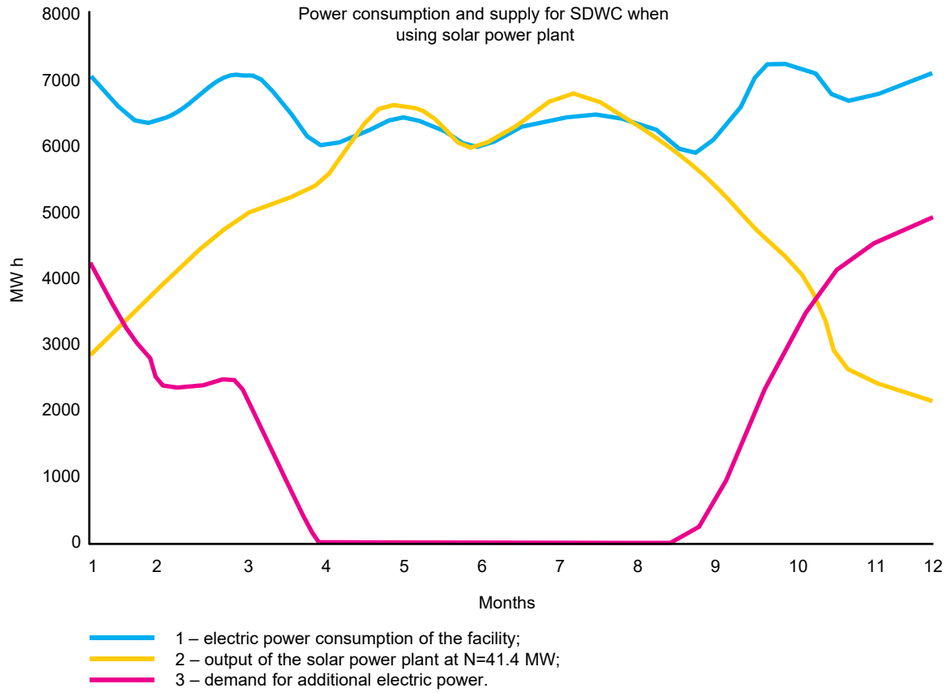


Fig. 2. Resulted values of parameters for Option 1

modules of FSM-250P type, 250 W each, wind part – 15.8 MW – 5 wind power generating units of SWT-3.15–142 type by Siemens (Germany), each with a capacity of 3.15 MW, with a wind turbine diameter of 142 m and a tower height of 165 m).

Results of parameter calculation for the power plants in question are presented in Fig. 2 for option 1 and in Fig. 3 for option 2. In these figures electric power consumption of Shakhty-Don Water Conduit (curves 1) corresponds to actual mean annual values. Electric power output by solar and wind components is calculated by standardized methods [8]. Input climatic actinometric data for the calculations are taken from National Aeronautics and Space Administration of the USA (NASA) for the considered area of Rostov region. The presented calculation results allow making the following conclusions:

Option 1 can provide completely the required power consumption only in the period from April to August when solar radiation input is at its maximum.

During other periods considerable energy will be required from additional source (curve 3 in Fig. 2).

Option 2 allows solving this problem with less expenses. Solar energy provide electric power for consumers of Shakhty-Don Water Conduit mainly in summer, while wind energy meets the demand in winter, autumn and spring.

Combined use of RES has its advantages as compared to the monogeneration option based on solar energyonly.
Installed capacity of combined electric power system is 20% lower.

Total generation of solar and wind power change a little during a year (curve 2 in Fig. 3). The demand for electric power from additional source (curve 5 in Fig. 3) in this case appears many times less than in option 1.

Table 2 shows comparison of obtained results.

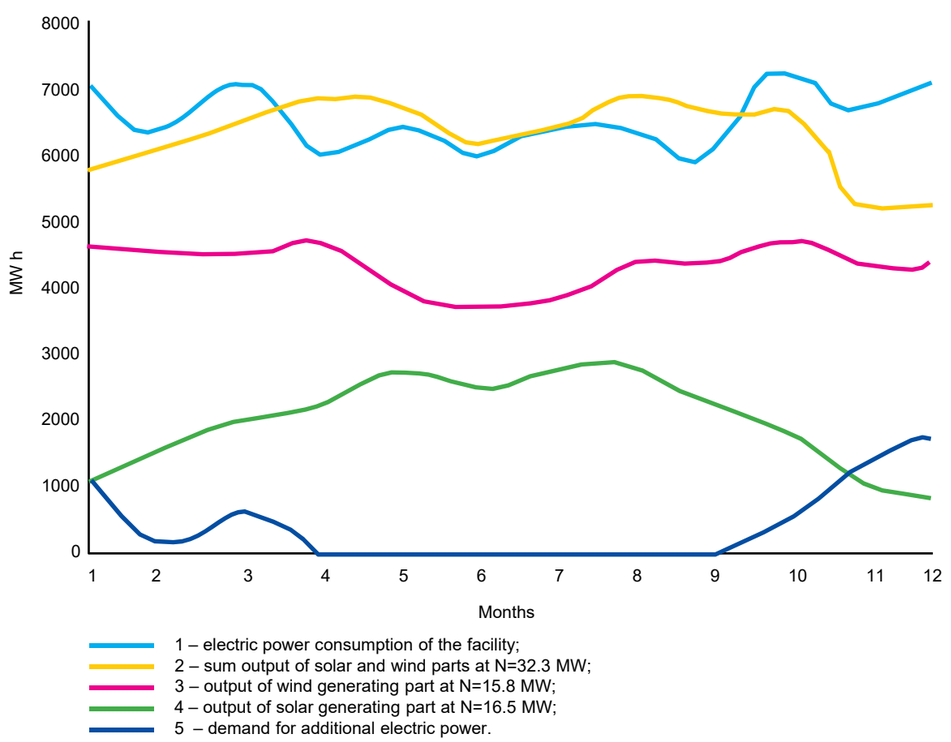
The option with combined use of RES (option 2) has clear advantages as compared with the option of monogeneration based on solar energy only (option 1). The required installed capacity of electric power plant in option 2 is more than 20% lower than in option 1. This is reflected in the volume of required capital expenses, investment payback period, cost of generated electric power. At the same time, volume of the additional generation to completely meet the demand of the facility for electric power in option 2 is 3.7 times less than in option 1.

This also results in lower required additional investments.

The described advantages allow unambiguously define option 2 as priority, which confirms effectiveness of the proposed method of guaranteed power supply using RES.

Development of renewable energy sector can be based on creationof systems with combined use of RESand local biological energy resources that supplement each other.

Fig. 3. Resulted values of parameters for Option 2



Parameter description	Symbol	Unit of measurement	Parameter value for options under consideration	
			Option 1 (monogeneration)	Option 1 (hybrid arrangement)
Annual electric power consumption by SDWC	W_C	MW·h/year	78 828	78 828
Installed capacity of solar part of the power plant	N_C	MW	41.4	16.5
Installed capacity of wind part of the power plant	N_C	MW	-	15.8
Total installed capacity of the SDWC power plant: $N_S + {}_{NW}$	N	MW	41.4	32.3
Annual output of electric power by the SDWC power plant		MW·h/year	57 017	77 696
Demand for additional power to completely meet the demand of SDWC		MW·h/year	21 501	5 764
Ratio of additional power and annual output by main generating sources of the power plant: $(W_{AD}/ W_Y) * 100$		%	37.7	7.4

Table 2. Results of main parameter calculations for the power plant of SDWC

To provide additional electric power, the described project makes use of the system of biomass conversion to electric and heat energy proposed by JIHT RAS. Today these system are already well approved [17–21] and leave behind all other methods of additional power generation in terms of financial and commercial efficiency. For the project of Shakhty-Don Water Conduit power plant a system developed by JIHT RAS was adopted to produce high-calorific energy syngas by method of two-stage thermal conversion of wood biomass wastes with further use of the generated gas to fuel gas-reciprocating machines to generate electricity and heat [10, 12, 13]. The project of independent power supply of Shakhty-Don Water Conduit in its final version is based on the use of three types of RES: solar energy, wind energy and biomass energy, and provides guaranteed power supply to consumers of the water conduit without interconnection with the territorial power system and without fossil fuels use.

Turf mining

Source: format35 / Depositphotos.com

Mutnovskaya geothermal power plant

Source: Rushydro

Effective domestic technology of biomass conversion proposed by JIHT RAS allows generating combustible gases by reversed gasification method followed by thermal decomposition of volatile gases with their conversion to syngas practically without resins and ash. This allows using the generated syngas without additional purification as a fuel for gas reciprocating machines. Properties variation of high-calorific energy gases depending on temperature of the biomass conversion process is shown in Table 3.

The main advantage of the technology developed by JIHT RAS is high degree of conversion of the processed biomass to the energy gas. For existing technologies this value is not greater than 25%, while for JIHT RAS technology it achieves 78%. Sum output of combustible gases is 1.4 m^3 per 1 kg of biomass, while mean calorific value is about 11.5 MJ/m^3.

The described plant for two-stage thermal conversion of wastes to syngas (SGP) is the most effective when processing wood organic wastes, i.e. sawdust, cuttings, chips, bark, crushed wood from timber processing and wood processing wastes, etc. At the same time, effective use of SGP is possible with solid wastes of agricultural processing that contain large quantity of lignin, cellulose, hemicellulose: nuts, hazel, fruit kernels, sunflower/rice seed hulls, grain crops straw, etc., as well as organic part of solid household waste (SHW).

It's becoming apparent that currently valid Energy Strategy until 2035 [5] and General Layout Plan of Power Facilities until 2035 [6], where future structure of generating capacities is practically kept at the today level – with big share of power generation based of fossil organic fuels and nuclear fuel -

Table 3. Parameters of gas mixtures obtained at various process temperatures

Temperature of process running, °C	Share of combustible components by volume			Calorific value, MJ/m3		Specific volume,m^3/kg	Conversion efficiency, %
	H_2	CO	C_nH_m	Q_B	Q_H	V	η
850	0.4	0.27	0.08	11.7	10.6	0.76	42
950	0.43	0.4	0.02	11.3	10.4	1.1	60
1000	0.49	0.41	0.01	11.7	10.6	1.39	78
Standard pyrolysis	0.23	0.19	0.13	10.4	9.6	0.29	15

RES systems shall be developed with clearly defined organization and planning of conversion of the entire power industry inRussia, and this development shall be harmonized with goals and objectives of national projects

are already out of the world trends, social/economic and environmental needs of the country and require complete rethink.

The United Nations Climate Change Conference (December 2015, Paris) recommended to limit the use of fossil fuels by 2050 so as to use no more than 10% of available reserves, for the goal of limiting global warming to well below 2 °C by this time.

Within the specified limits about 80% pf world reserves of coal, 50% of natural gas and 30% of oil should be left unused.

Today we need to finance the research activities aimed at creation of new methods of power generation without fossil fuel use. We have no more than 10-15 years to find sources of budget revenues other than export of natural hydrocarbons.

Conclusions

Currently, we need to develop new approaches to ensuring guaranteed power supply to consumers for various purposes. Development of small renewable power sector can be based on creation of the proposed systems with combined use of various RES types and local bioenergy resources supplementing each other and ensuring guaranteed power supply to consumers at minimum required investments.

Systems with the use of RES shall be developed with clearly defined organization and planning of conversion of the entire power industry in Russia, and this development shall be harmonized with goals and objectives of the implementation program of main national projects and growth of the national economy.

WPP in Ushakovo
Source: Yantarenergo

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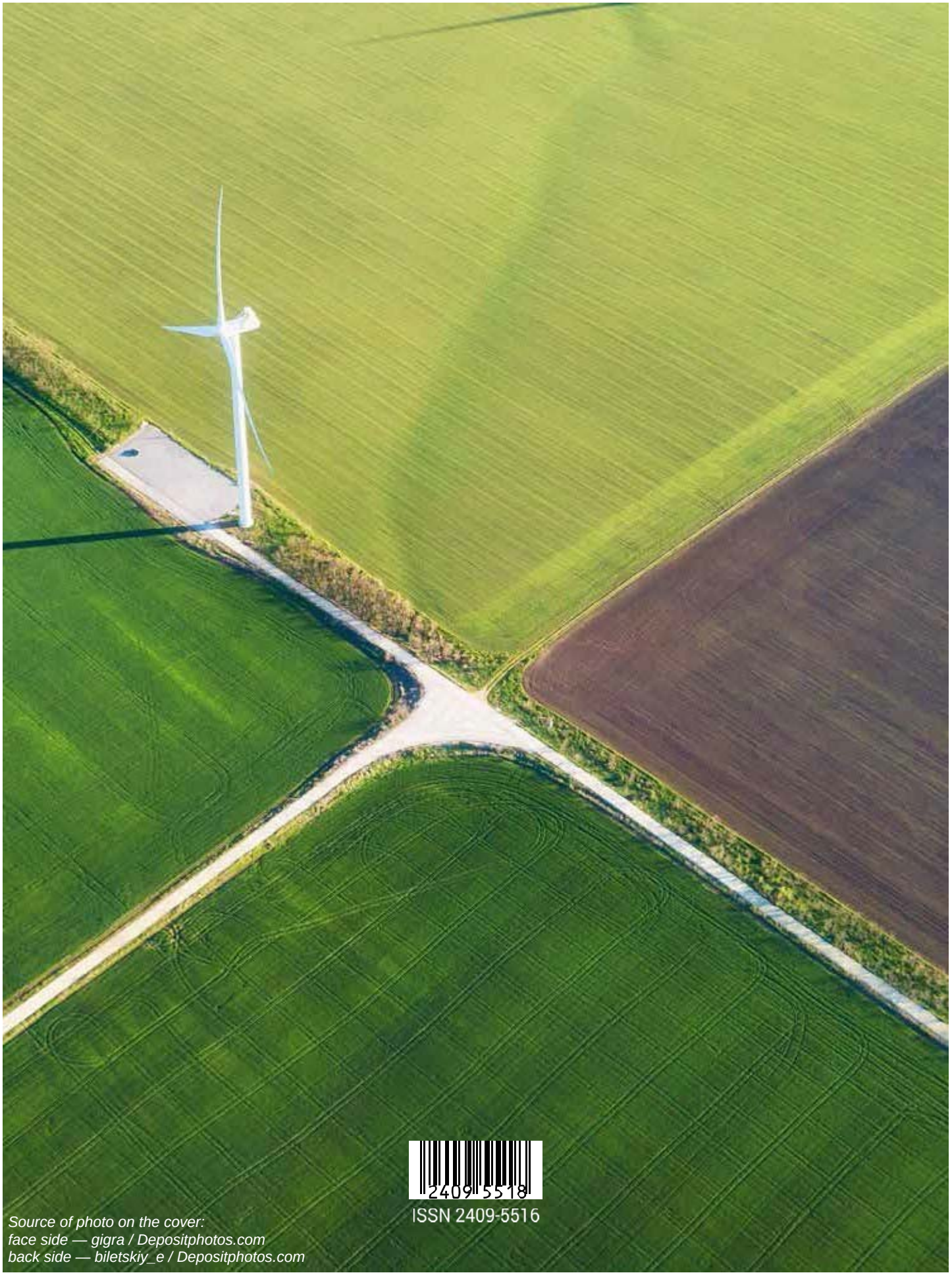

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